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ADVERSE PREGNANCY OUTCOMES AMONG COSMETOLOGISTS

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16. Abstract (Limit: 200 words): An epidemiological study was conducted of the risk of spontaneous abortion among cosmetologists using more refined exposure data than the job title alone. The results suggest moderately increased risks of spontaneous abortion among cosmetologists who worked full time and who performed a large number of chemical services. The use of formaldehyde (50000) and working in salons where manicuring and nail sculpturing was performed were also associated with an increased risk of spontaneous abortion. The authors suggest that areas for future study should include those exposed to nail sculpturing; a two fold increased risk of spontaneous abortion was associated with this background. The more than two fold increased risk of spontaneous abortion among cosmetology school students should also be examined further.

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SPONTANEOUS ABORTIONS AMONG COSMETOLOGISTS

by

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SIGNIFICANT FINDINGS

Licensed cosmetologists with a spontaneous abortion (cases) were compared to licensed cosmetologists with a single live birth (controls) with regard to occupational exposures and other potential risk factors for spontaneous abortion.

Women who worked 35 or more hours per week in cosmetology during the first trimester of pregnancy had a 30% increased risk of spontaneous abortion (OR=1.3, 95% CI=0.8-2.2) compared to women who worked 35 or more hours per week in other professions. No association was found for women who worked less than 35 hours per week in cosmetology (OR=1.0, 95% CI=0.6-1.8). Adjustment for previous pregnancy loss, gravidity, mother's age at conception, family income, mother's cigarette smoking during pregnancy, and mother's alcohol consumption during pregnancy did not alter the risk estimates.

Categorizing women with full-time work (35+ hours per week) in cosmetology by several measures of chemical exposure, the adjusted odds ratios for the high exposure categories were 1.6 (95% CI=0.7-3.7) for 60 or more customers per week, 1.7 (95% CI=0.9-3.7) for 10 or more permanents, 1.5 (95% CI=0.8-2.4) for 3 or more hair dyes, and 1.5 (95% CI=0.6-3.1) for 3 or more bleaches. For cosmetologists who performed 3 or more hair dyes and 10 or more permanents per week, the adjusted odds ratio was 1.8 (95% CI=0.8-3.1). For the performance of more than 10 chemical services (hair dyes, permanents, or bleaches) per week, the adjusted odds ratio was 1.6 (95% CI=0.8-2.9).

Among cosmetologists with full-time work in cosmetology, low levels of chemical exposure were not associated with spontaneous abortion. Dose response gradients were found for the weekly number of customers, bleaches, dyes, permanents, and the total number of chemical services.

Positive associations were also found for the use of formaldehyde to sanitize implements (OR=1.8, 95% CI=1.0-2.4) and work in salons where manicuring (OR=1.5, 95% CI=0.8-2.4) or nail sculpturing (OR=1.9, 95% CI=1.0-3.9) were performed.

Personal use of hair dyes and permanents during the first trimester of pregnancy did not increase the risk of spontaneous abortion.

For women who attended cosmetology school during the first trimester of pregnancy, the adjusted odds ratio was 2.6 (95% CI=1.2-6.0).

ABSTRACT

Over half a million women work in cosmetology in the United States, but little is known about adverse reproductive outcomes associated with chemical exposures in this industry. In order to investigate this possible relationship, a mail survey was conducted among 8,356 female cosmetologists, aged 22-36 years, who were licensed in North Carolina in 1988. Pregnancies between 1983 and 1988 were identified by a brief screening questionnaire. With a 74% response, 1,429 single live births and 145 spontaneous abortions of less than 20 weeks gestational age were reported among the most recent pregnancies conceived between 1983 and 1988. An additional 122 spontaneous abortions were identified among previous pregnancies conceived from 1983 to 1988.

Seventy-four percent of cosmetologists with an eligible pregnancy completed a second, more detailed questionnaire. Occupational exposures and other risk factors during pregnancy were compared for 188 women with a spontaneous abortion (cases) and 1,058 women with a single live birth (controls). Cosmetologists who worked 35 or more hours in cosmetology during the first trimester of pregnancy had a 30% increased risk of spontaneous abortion (OR=1.3, 95% CI=0.8-2.2) compared to cosmetologists who worked 35 or more hours in other professions. Adjustment for previous pregnancy loss, gravidity, mother's age at conception, family income, mother's cigarette smoking during pregnancy, and mother's alcohol consumption during pregnancy did not alter the risk estimates. For women categorized by several measures of chemical exposure, the adjusted odds ratios ranged from 1.3 to 1.9, with dose response gradients found for the weekly number of customers, bleaches, dyes, permanents, and the total number of chemical services. For the highest exposure levels, the adjusted odds ratios were 1.6 (95% CI=0.7-3.7) for 60 or more customers per week, 1.7 (95% CI=0.9-3.7) for 10 or more permanents, 1.5 (95% CI=0.8-2.4) for 3 or more hair dyes, and 1.5 (95% CI=0.6-3.1) for 3 or more bleaches. Positive associations were also found for the use of formaldehyde (OR=1.8, 95% CI=1.0-2.4) and work in salons where manicuring (OR=1.5, 95% CI=0.8-2.4) or nail sculpturing (OR=1.9, 95% CI=1.0-3.9) were performed. No increased risks were found among part-time cosmetologists who worked less than 35 hours per week and among full-time cosmetologists with low levels of chemical exposure. Personal use of hair dyes and permanents during the first trimester of pregnancy did not increase the risk of spontaneous abortion. For respondents who attended cosmetology school during the first trimester of pregnancy, the adjusted odds ratio was 2.6 (95% CI=1.2-6.0).

Despite incomplete response and limitations of self-reported exposure and disease information, these data suggest that full-time work in cosmetology may be associated with an increased risk of spontaneous abortion. The results warrant further research into reproductive hazards in cosmetology.

I. SIGNIFICANCE

Current knowledge of adverse reproductive outcomes associated with maternal exposures at the workplace is limited, despite the growing concern about occupational hazards (Barlow and Sullivan, 1982; Office of Technology Assessment, 1985; Lindbohm et al., 1985a; Kline, 1986, Saurel-Cubizolles and Kaminski, 1987). There has been a substantial increase in the number of women participating in the paid labor force, many of whom are of childbearing age and are employed before and during pregnancy (Office of Technology Assessment, 1985). According to the 1980 National Natality Survey, 62% of married mothers of live born infants were employed at some time during the year before delivery (Shilling and Lalich, 1984). Employed women are concentrated in specific occupations with different potential hazards than traditionally male occupations (Stellman, 1978). The high frequency of reproductive failure and the growing experimental and human evidence of the vulnerability of the reproductive system to environmental agents warrants investigation of maternal occupational exposures.

Cosmetology is a predominantly female employment sector with women representing about 90% of all licensees (US Bureau of the Census, 1984) and is among the 20 leading occupations of employed women (Murphy, 1986). There are over half a million women employed in cosmetology, accounting for about 1.2% of the female labor force (US Department of Labor, 1983). Cosmetologists, also referred to as hairdressers, hair stylists or beauticians, are exposed to multiple chemical substances through daily contact with a wide variety of cosmetic products. They constitute a potentially high-risk group with frequent and largely unmonitored chemical exposure.

Health effects associated with occupational exposure to cosmetology have not been adequately assessed. Acute toxicity such as skin, eye, nose, and lung irritation and effects on the central nervous system have been related to the use of specific cosmetic products or specific chemical substances contained in cosmetics (Ostton et al., 1988; Heacock and Rivers, 1986; Calnan, 1986). Severe allergic reactions to chemicals are forcing some cosmetologists to leave their profession (Ostton et al., 1988). Laboratory studies have demonstrated mutagenic and carcinogenic effects associated with exposure to hair dyes. Occupational studies have suggested an increased risk of cancer among cosmetologists although the evidence is equivocal (Kinlen, 1985; Kalopissis, 1986).

Epidemiologic evidence on adverse reproductive outcomes associated with chemical exposures in cosmetology is very limited. Although anecdotal reports have suggested an excess of spontaneous abortions among cosmetologists (Shulman, 1988), no prior epidemiologic studies have specifically been conducted to examine the risk of spontaneous abortion associated with occupational exposure to cosmetology.

Given the presence of demonstrable toxic chemicals, including mutagens, contained in cosmetic products, which may affect the risk of spontaneous abortion, and the fact that over half a million women employed in cosmetology in the United States, the assessment of reproductive hazards in cosmetology is warranted.

II. REVIEW OF THE LITERATURE

2.1. Work environment in cosmetology

Cosmetologists constitute a potentially high-risk group with frequent chemical exposure through daily contact with a variety of cosmetic products such as hair shampoos, rinses, conditioners, permanent wave solutions, hair dyes, hair relaxers and straighteners, hair sprays, make-up, perfumes, nail polish, polish remover, artificial nails, soaps, detergents, antiseptics, and solutions for sterilization. Although cosmetologists may specialize in certain areas of hair care, such as hair dyes or permanents, most perform a variety of tasks and therefore use many cosmetic products simultaneously. Most cosmetologists work in small establishments, with 76% of beauty salons employing fewer than five employees (NIOSH, 1980).

Cosmetic products consist of thousands of chemicals. A comprehensive review of major chemical substances is provided by NIOSH (1980). Dyes and solvents are common ingredients and are contained in many different cosmetic products (Appendix 1).

Cosmetologists are exposed to these chemical substances through inhalation and dermal absorption, the two major exposure pathways. Quantitative assessment of chemical exposure in this industry, however, is very limited and has been conducted only for personally used cosmetic products. Hair dye compounds have been found to be excreted into urine, presumably by their systemic absorption through the skin of the scalp (Kiese and Rauscher, 1968; Marshall and Palmer, 1973; Maibach et al., 1975). Ames et al. (1975) estimated that up to 1% of the applied hair coloring product is absorbed through the scalp. More recent studies estimated the penetration rate at less than 0.2% (Wolfram and Maibach, 1985). Absorption and systemic retention of lead acetate contained in "metallic" hair dyes used to darken gray hair has been reported by Marzulli et al. (1981).

Laboratory studies have demonstrated acute toxicity, mutagenesis, and carcinogenesis for a number of cosmetic ingredients, thus raising concern about the safety of cosmetic products (NIOSH, 1980; Marzulli et al., 1981). Cosmetic products are not as strictly regulated by the Food and Drug Administration (FDA) as food additives and drugs. Cosmetic manufacturers are responsible for assuring the safety of cosmetic products. They are, however, not required by the FDA to conduct premarketing safety testing of cosmetic products or their ingredients, to submit data of their safety testing to FDA, nor to notify the FDA when new cosmetic products are introduced. In 1972, the FDA created a voluntary program through which manufacturers may register their raw materials, product formulations, and consumer reports on adverse reactions to cosmetics. The Cosmetic, Toiletries and Fragrance Association, a national trade association representing cosmetic manufacturers and distributors, has created the Cosmetic Ingredient Review (CIR) which consists of an independent expert panel of scientists who review the

safety of cosmetic ingredients. The CIR, however, does not conduct any safety testing.

Ingredient labeling of cosmetic consumer products has been required since 1976 under the Fair Packaging and Labeling Act (Hopkins, 1975). Ingredients of fragrances and flavors and ingredients which are claimed as trade secrets are not required to be listed. However, products sold to business establishments, such as beauty salons, have been exempt from this regulation.

In 1983, the Occupational Safety and Health Administration (OSHA) issued the Hazard Communication Standard, also known as "Worker Right-to-Know", which requires the evaluation of chemical hazards and dissemination of hazard information to employers and exposed employees by means of container labeling, material safety data sheets, and employee training. Initially limited to chemical manufacturing employers, the Hazard Communication Standard was expanded in 1987 to include all employers, including beauty salon owners. This standard requires chemical manufacturers, importers, and distributors to label containers of hazardous chemicals and to develop a material safety data sheet for each chemical. By May 1988, employers, including salon owners and cosmetology schools, were required to establish a written hazard communication program in the salon or school, to prepare an inventory of all hazardous chemicals used in the salon, to provide employee training on hazardous materials at the workplace, and to request material safety data sheets and container labeling for all cosmetic products used in the salon (National Cosmetology Association, 1988; Baget, 1989).

ACGIH threshold limit values, OSHA promulgated standards, and NIOSH recommended criteria have been summarized for some of the chemical agents commonly encountered in cosmetology, including acetone, acetonitrile, ammonia, benzoyl peroxide, butyl acetate, cadmium (dust and salts), ethyl acetate, ethyl ether, ethyl methacrylate, hydrogen peroxide, isopropyl alcohol, methacrylic acid, methylene chloride, methyl ethyl ketone, p-Phenylenediamine, selenium compounds, toluene, respirable nuisance dust, and total nuisance dust (NIOSH, 1980; Hiipakka and Samimi, 1987; HESIS, 1989).

2.2. Cosmetology in North Carolina

In North Carolina, training in cosmetology is provided by about 130 establishments, including private cosmetology schools, high schools, and community and junior colleges. Between 5,000 and 6,000 students are trained in cosmetology each year. The North Carolina State Board of Cosmetology issues separate licenses for cosmetologists and manicurists. There are currently about 55,000 licensed cosmetologists and 700 licensed manicurists (State Board of Cosmetology, personal communication). The cosmetology license requires 1,500 hours of training, including

20 hours in chemistry pertaining to cosmetic art and 10 hours in cosmetics. To be licensed as a manicurist, 150 hours of training are required (North Carolina State Board of Cosmetic Art Examiners, 1980).

The operation of a beauty salon requires licensing and regular inspections by the North Carolina State Board of Cosmetology. There are currently about 12,000 licensed beauty salons in North Carolina. Beauty salons and schools are inspected according to the sanitary rules and regulations three or four times a year. The focus of the inspection is on cleanliness and sanitation, and a sanitation rating is issued by the inspectors. Storage and labeling of cosmetic products are checked. With regard to ventilation, the salon regulations require that "necessary ventilation shall be provided at all times". The regulations regarding sanitation require that combs and brushes be covered for 20 minutes in 5% phenol, 70% alcohol, 10% lysol or chlorine solution, or for 30 minutes in other sanitizing solutions approved by the Board. Until 1988, the use of paraformaldehyde tablets or 5% formaldehyde solution was required to sanitize tools and implements. Since 1989, the inspectors also check the Hazard Communication Standard issued by OSHA, but the data in this study pre-date this standard.

Manicurists and nail sculptors working outside of licensed beauty salons are currently not required to be licensed in North Carolina. Furthermore, nail salons are not required to be licensed in North Carolina. Although no published data could be identified on the number of nail salons in North Carolina, it is likely that several thousand unlicensed nail salons are operated, employing a large number of unlicensed manicurists.

2.3. Adverse health effects in cosmetology

2.3.1. Reproductive effects

Information on the risk of adverse reproductive outcomes associated with maternal employment in cosmetology is sparse. In the 1958 British Perinatal Mortality Survey, twice the number of expected perinatal deaths from congenital malformations occurred among hairdressers, although the number of expected deaths was small (N=5) (Peters et al., 1984).

In the Collaborative Perinatal Project, which included 123 pregnancies with maternal work as a hairdresser during the first trimester of pregnancy, no increased risks were observed for stillbirths, infant deaths, and malformations (Hartz and Jaques, 1978).

The 1980 National Natality and National Fetal Mortality Surveys included 69 live births and 33 fetal deaths (28 or more weeks gestation) with maternal work in barbering, hairdressing,

and cosmetology during the year before delivery (Shilling and Lalich, 1984). Computations based on the data presented yielded odds ratios of 0.9 for malformations, 0.8 for fetal deaths, and 1.7 for birth weight of less than 2,500 grams.

In a Washington State study of fetal deaths and live births from 12 target occupations, which included 650 fetal deaths among hairdressers, a relative risk of 1.4 (95% CI=1.2-1.7) was reported (Vaughan et al., 1984).

In a recent case-control study of 227 stillbirths (20 or more weeks of gestation) matched to 227 live births, women employed as hairdressers-beauticians had significantly fewer stillbirths than expected (OR=0.01, 95% CI=0.01-0.34) (Goulet and Theriault, 1989).

In a case-control study comparing couples who have been examined or treated for infertility problems with couples who conceived a healthy child within one year, occupational exposure to hair spray or hair dyes was associated with female hormonal disturbances (OR=1.4, 95% CI=0.9-2.0) and female idiopathic infertility (OR=1.3, 95% CI=0.7-2.4) (Rachootin and Olsen, 1983). Sperm abnormalities (OR=1.1) and male idiopathic infertility (OR=0.7) were not associated with occupational exposure to hair spray or hair dyes. Comparing couples who conceived a healthy child within one year with couples who took longer than one year to conceive, delayed conception was not associated with occupational exposure to hair spray or hair dyes among males (OR=0.6) and females (OR=1.0). Female occupation as a hairdresser was not associated with an increased risk of idiopathic infertility, hormonal disturbance or delayed conception.

In the New York study of spontaneous abortion (less than 28 weeks of gestation), no increased risk of chromosomally normal or chromosomally abnormal spontaneous abortion was found for maternal exposure to cosmetology before pregnancy (Silverman et al., 1985) or during pregnancy (Kline et al., 1982). However, the number of spontaneous abortions with maternal exposure to cosmetology before and during pregnancy was small (25 and 17, respectively).

The study with the largest number of spontaneous abortions among hairdressers was conducted in Montreal, Canada (McDonald et al., 1987a). Over 56,000 women were interviewed regarding their most recent and all previous pregnancies, a total of 104,649 pregnancies. The interviews took place soon after delivery (N=51,885) or hospitalization for spontaneous abortion of less than 28 weeks gestation (N=4,127) from 1982 to 1984.

The study included 458 current and 417 previous pregnancies with maternal employment in hairdressing at the time of conception. Odds ratios were 1.05 for current spontaneous abortions (hospitalized only) (N=34) and 1.08 for previous spontaneous abortions (hospitalized and non-hospitalized (N=102) (McDonald et al., 1986).

Restricting the analysis to pregnancies of women who worked 30 or more hours per week at the time of conception, an odds ratio of 1.02 was found for both current and previous spontaneous abortions combined (N=106) (McDonald et al., 1987a). For stillbirth, the odds ratio was 0.43 (N=2).

An analysis restricted to previous pregnancies of women who worked 30 or more hours per week at the time of conception found no increased risk of spontaneous abortion (hospitalized and non-hospitalized) among hairdressers (McDonald et al., 1988a). Odds ratios were similar for spontaneous abortions less than 16 weeks gestational age (OR=1.09, N=76) and those between 16 and 27 weeks gestational age (OR=0.6, N=6).

Besides spontaneous abortions and stillbirths, the Montreal study also examined the effect of occupational exposures on the risk of malformation, low birth weight, and preterm delivery. For current and previous pregnancies combined, employment in hairdressing was not associated with congenital defects (OR=0.94, N=17) among women who worked 15 or more hours at the time of conception (McDonald et al., 1988b). Among women working 30 or more hours during their most recent pregnancy, no increased risks of low birthweight (OR=0.65, N=15) and preterm delivery (OR=0.78, N=19) were observed (McDonald et al., 1988c).

Although the risk of spontaneous abortion was not increased among hairdressers in the Montreal study (McDonald et al., 1986), there remains concern about chemical exposures in cosmetology. Increased risks of spontaneous abortion have been reported for occupational exposure to chemicals in the health care sector, dentistry, laboratories, pharmaceutical, metal, rubber, chemical, electronics, plastics, and dry cleaning industry (Lindbohm et al., 1985; Kline, 1986; Rosenberg et al., 1987).

Solvents, which are common constituents of cosmetic products, are widely used in various industries. A number of studies have reported increased risks of spontaneous abortion for employment in industries with solvent exposure (Hemminki et al., 1980a; Hemminki et al., 1980b; Heidam, 1984; Lindbohm et al., 1984; Lindbohm et al., 1985b; Taskinen et al., 1986; Pastides et al., 1988; McDonald et al., 1988a; Taskinen et al., 1989; Kyyronen et al., 1989; Lindbohm et al., 1990). Other reproductive effects associated with solvent exposure include menstrual disorders (reviewed by Eskenazi et al., 1988), congenital malformations (Meirik et al., 1979; Hansson et al., 1980; Holmberg and Nurminen, 1980; Holmberg et al., 1982; McDonald et al., 1987b; Tikkanen and Heinonen, 1988), and pregnancy complications (Eskenazi et al., 1988). Solvents have been reported to pass through the placenta (Dowty and Lasseter, 1976) and to cause abnormalities in experimental animals (Hemminki and Vineis, 1985).

Some of the solvents contained in cosmetics have been associated with reproductive effects. Methylene chloride, which has been commonly used as a propellant and solvent in hair sprays

since the late 1970s (Lecos, 1986), has been related to adverse pregnancy outcomes. Among women employed in the pharmaceutical industry, exposure to methylene chloride was found to be associated with a significantly increased risk of spontaneous abortion (Taskinen et al., 1986). A slight excess of spontaneous abortions was reported by Axelsson et al. (1984c) from exposure to methylene chloride among women working with laboratory solvents. The use of adhesive sprays which contain methylene chloride has been related to chromosomal damage (Anonymous, 1973) and congenital malformations (Silberg et al., 1979), though the evidence is equivocal (Gong et al., 1974; Hanson et al., 1976).

Vinyl chloride (VC), a former hair spray propellant, has been associated with a significant excess of fetal losses among wives of workers with occupational VC exposure, presumably due to paternal germ cell damage (Infante et al., 1976a). Studies on residential exposure to VC related to pregnancy outcomes yielded inconclusive results (Infante, 1976b; Edmonds et al., 1978).

Until recently formaldehyde has been used in cosmetology to sanitize implements and equipment. It is also contained in a number of products as a preservative. An increased risk of spontaneous abortion (OR=2.1, 95% CI=1.3-3.4) has been reported among French nurses who used formaldehyde to disinfect rooms and equipment (Stucker et al., 1990). No increased risk, however, was noted in a study among Finnish nurses (Hemminki et al., 1982).

Studies on teratogenic effects of hair dye formulations in experimental animals have yielded mainly negative results (Burnett et al., 1976; NIOSH, 1980; Burnett and Goldenthal, 1988). In humans, teratogenic effects related to hair dyes have not been investigated. Occupational exposure to textile dyes has been associated with an increased risk of female idiopathic infertility (OR=6.2, 95% CI=3.2-11.9) (Rachootin and Olsen, 1983). An increased risk of delayed conception was found for exposure to textile dyes among males (OR=2.2, 95% CI=1.1-4.2), but not among females (OR=1.0, 95% CI=0.4-2.2) (Rachootin and Olsen, 1983).

2.3.2. Mutagenic effects

Since chromosomal aberrations originating from exposures before or around the time of conception may produce spontaneous abortions (Kline and Stein, 1985), evidence regarding mutagenicity is pertinent to the assessment of reproductive risks among cosmetologists.

In 1975, mutagenic activity in bacterial systems was reported for 150 (89%) of 169 commercial permanent hair coloring products (Ames et al., 1975). Permanent coloring solutions consist of complex mixtures of aromatic amines, nitro compounds, phenols, and an oxidation agent, usually hydrogen peroxide. Of 18

compounds commonly used in permanent hair dye products, 9 were found to be mutagenic (Ames et al., 1975). Mutagenicity of specific hair dye components in both microbial and mammalian systems has been summarized by NIOSH (1980). An increased incidence of chromosome aberrations has been reported for cultured Chinese hamster cells exposed to hair dyes (Kirkland and Venitt, 1976).

Findings on chromosomal abnormalities related to occupational or personal exposure to hair dyes are inconclusive. The addition of hair coloring products to cultures of human blood lymphocytes resulted in considerable chromosomal damage (Searle et al., 1975). No increase in mutation frequency was found in the urine collected after hair dye application (Burnett et al., 1979). In a study of tinters and controls subjects, no increased chromosomal aberrations were found in peripheral blood lymphocytes. Personal use of hair dyes, however, was associated with a significant excess of chromosomal damage (Kirkland et al., 1978). No significant differences in chromosomal aberrations were reported for 10 volunteers who dyed their hair every 3-6 weeks and matched controls followed for 13 months (Hofer et al., 1983). Similarly, no increase in sister chromatid exchange levels was detected (Turanitz et al., 1983).

2.3.3. Carcinogenic effects

Following the reporting of mutagenic activity of many commercial hair coloring products in 1975 (Ames et al., 1975; Searle et al., 1975), many studies testing the carcinogenicity in experimental animals were conducted. Experimental evidence is inconsistent (IARC, 1978; NIOSH, 1980). Studies with exposure to hair dye preparations or specific hair dye ingredients through topical application have yielded mainly negative results (Burnett et al., 1975; Giles et al., 1976; Stenback et al., 1977; Searle et al., 1977; Jacobs et al., 1984; Burnett and Goldenthal, 1988). In feeding studies, tumors of the bladder, liver, thyroid, lymphatic system, and skin were noted (Weisburger et al., 1978; Flamm, 1985). Evidence of carcinogenicity in animals has led to the substitution of certain hair dye ingredients (i.e., 2,4-toluenediamine, 2,4-diaminoanisole). In humans, employment in cosmetology and personal use of hair dyes have been associated with various types of cancers, although both negative and positive findings have been reported. The case-control studies generally were limited by the small number of cases and controls employed as hairdressers or barbers. Occupational mortality surveys and incidence studies, which usually examined all sites of cancer, generally were limited by the lack of data on potentially confounding factors. Furthermore, the assessment of occupational exposure was limited by exposure classification based solely on the job title. The International Agency for Research on Cancer (IARC) concluded in 1982 that the evidence relating cancer to occupational exposure in hairdressing or to

personal use of hair dyes was inconclusive (IARC, 1982). Others concluded that there is not enough evidence of a carcinogenic effect from occupational and non-occupational exposure to hair dyes (Clemmesen, 1981), or that the existing data was largely reassuring (Kinlen, 1985). Except for bladder cancer among male hairdressers, no specific cancer was consistently associated with occupational exposure to cosmetology or personal use of hair dyes. Some of the positive and negative findings are briefly summarized below.

An increased risk of bladder cancer associated with occupational exposure to aromatic amines in the manufacturing of dyes has long been recognized (reviewed by Matinowski and Elliott, 1981). Several studies reported an increased risk of bladder cancer among male hairdressers and barbers (Wynder et al., 1963; Dunham et al., 1968; Anthony and Thomas, 1970; Howe et al., 1980; Silverman et al., 1983; Dubrow and Wegman, 1984; Guberan et al., 1985; Pearce and Howard, 1986; Baxter and McDowall, 1986; Malker et al., 1987; Lynge and Thygesen, 1988; Skov et al., 1990), although negative results have also been reported (Cole et al., 1972; Alderson, 1980; Glashan and Cartwright, 1981; Vineis and Magnani, 1985). Other reports of increased risks among male hairdressers and barbers include cancer of the larynx (Viadana et al., 1976), and leukemia (Spinelli et al., 1984).

For female cosmetologists, positive associations have been reported for lung cancer (Menck et al., 1977; Garfinkel et al., 1977; Teta et al., 1984; Kono et al., 1983; California Department of Health Services, 1987), although potentially confounding factors, such as smoking, were not controlled for. By contrast, no association was found by Osorio et al. (1986) and Lynge and Thygesen (1988).

Increased risks among female cosmetologists have been reported for a number of cancer sites, although no consistent patterns emerged from these mortality and incidence studies, which generally considered all sites of cancer. Reports of positive associations include cancer of the breast (California Department of Health Services, 1987), ovaries (Teta et al., 1984; Spinelli et al., 1984), genital organs (California Department of Health Services, 1987), bladder (Lynge and Thygesen, 1988; Skov et al., 1990), stomach (Kono et al., 1983), brain (Teta et al., 1984), lymphatic tissues (California Department of Health Services, 1987), leukemia (Walrath, 1977), and multiple myeloma (Spinelli et al., 1984).

The widespread non-occupational use of hair dye preparations led to several case-control studies which assessed the risk of cancer associated with the personal use of hair coloring products. Following a report of a possible association with breast cancer in 1976 (Shafer and Shafer, 1976), mainly negative associations were reported (Kinlen et al., 1977; Hennekens et al., 1979; Stavraki et al., 1979; Wynder et al., 1983; Green et al., 1987; Nasca et al., 1990). Positive associations in two

studies were limited to subgroups of hair dye users (Shore et al., 1979; Nasca et al., 1980).

Excess risks have also been reported for cancer of the bladder (Najen et al., 1982), cervix uteri, vagina, and vulva (Hennekens et al., 1979), multiple myeloma (Guidotti et al., 1982), acute non-lymphocytic leukemia (Markowitz et al., 1985), leukemia (Cantor et al., 1988), and non-Hodgkin's lymphoma (Cantor et al., 1988).

No associations with personal use of hair dyes were reported for bladder cancer (Jain et al., 1977; Neutel et al., 1978; Howe et al., 1980). In a large US case-control study of nearly 3,000 bladddder cancer cases, no association with personal use of hair dyes was found (Hartge et al., 1982).

Recent studies on childhood cancer reported an association of maternal use of coloring preparations during pregnancy with neuroblastoma (Kramer et al., 1987) and Wilms' tumor (Bunin et al., 1987). An increased risk of childhood leukemia was associated with father's occupational exposure to dyes or pigments (Lowengart et al., 1987).

Although much of the discussion on chemical hazards in cosmetology focused on hair coloring preparations, dyes and coloring agents are also present in other cosmetic products such as shampoos, rinses, conditioners, setting lotions, nail polish, make-up, and soap. Furthermore, besides dyes, cosmetic products contain other substances for which carcinogenic effects have been reported. Suspected carcinogenic substances include polyvinylpyrrolidone (IARC, 1979), a commonly used resin in hair sprays; methylene chloride (National Toxicology Program, 1985), a propellant and solvent used in hair sprays; nitrosamines (Spiegelhalder and Preussmann, 1984), found in shampoos and conditioners; and formaldehyde (Swenberg et al., 1980; Olsen et al., 1984), primarily used as a preservative in many cosmetics and for equipment sterilization. As styles and habits in hairdressing change over time, cosmetic products and their formulations change over time. Examples of carcinogenic substances in cosmetic products used in the past include para-Dimethylaminoazo-benzene (Clemmesen, 1981) found in brillantine, and vinyl chloride (Infante, 1976b; Holmberg, 1984), a formerly used hair spray propellant.

In summary, experimental studies have demonstrated mutagenic and carcinogenic effects for a number of chemical substances used in cosmetic products. There is evidence from human studies which suggests an increased risk of cancer among cosmetologists or users of hair dyes. Evidence, however, is equivocal. Information on adverse reproductive outcomes associated with occupational exposure to cosmetology is sparse. Epidemiologic studies of reproductive outcomes in this industry are clearly warranted.

III. METHODS

3.1. Research questions

The objective of this study was to assess whether female employment in cosmetology during the first trimester of pregnancy increases the risk of spontaneous abortion prior to 20 weeks gestational age. The study assessed whether the risk of spontaneous abortion varies with intensity of chemical exposure, measured by the number of hours worked per week in cosmetology, the number of customers per week, and the number of chemical services performed per week (including bleaches, hair dyes, and permanents). Other exposure variables included the use of formaldehyde to sanitize implements and equipment and salon characteristics, such as the number of cosmetologists in the salon, and the performance of manicuring and nail sculpturing in the salon.

3.2. Overview of study design

The study design included two components: a cross-sectional survey among licensed cosmetologists in North Carolina, and a nested case-control study of spontaneous abortions and single live births identified in the cross-sectional survey.

A cross-sectional survey was conducted among licensed cosmetologists in North Carolina in order to identify the study population for the case-control study, namely spontaneous abortions (cases) and single live births (controls) which were conceived over a five-year period from 1983 to 1988. Case and control identification was solely based on self-reported pregnancy outcomes, and eligibility for the case-control study was restricted to one pregnancy per woman.

In the case-control study, more detailed information on outcome, exposure, and potentially confounding factors was collected from licensed cosmetologists with an eligible spontaneous abortion or single live birth. Cases and controls were compared with regard to maternal employment characteristics during the first trimester of pregnancy. The exposed group included pregnancies of licensed cosmetologists who worked in cosmetology during the first trimester of pregnancy. The fact that not all cosmetologists actively work in their profession permitted the use of two internal reference groups, comprising unexposed licensed cosmetologists who worked in other professions or as full-time homemakers during the first trimester of pregnancy. The risk of spontaneous abortion was estimated by comparing cases and controls with regard to the proportion of licensed cosmetologists who worked in cosmetology, other professions or as fulltime homemakers during the first trimester of pregnancy, controlling for other potential risk factors.

3.3. Study population

The study population for the cross-sectional survey consisted of cosmetologists licensed in North Carolina. They were identified through the computerized cosmetology license register which contained names and addresses for all cosmetologists licensed any time from 1975 to 1988 (N=50,245). In April 1988, the register included 34,737 cosmetologists with an active license and a North Carolina address at the time of license renewal. Eligibility for the cross-sectional survey was restricted to female cosmetologists with an active license in April 1988 who were 22-36 years of age. Male cosmetologists were excluded from the study population on the basis of first and middle name. Non-computerized licensing records which contained information on birth date were reviewed to identify cosmetologists born between 1952 and 1966 (22-36 years of age in 1988). Except for an estimated eight per cent of all licensees whose licensing records could not be located, all female cosmetologists in North Carolina, aged 20-36, were invited to participate in the cross-sectional survey (N=8,356).

3.4. Screening for eligible pregnancies

A two-page screening questionnaire was sent to 8,356 cosmetologists, requesting information on demographic background, work experience in cosmetology, recent health problems, and reproductive history (number of pregnancies, number of miscarriages). For the most recent pregnancy, the screening questionnaire queried the date and outcome of the pregnancy, gestational age, birth weight, and work during pregnancy, which included four categories: Work in cosmetology, cosmetology student, work in another job, and full-time homemaker. For respondents who worked in cosmetology during the most recent pregnancy, information on the number of hours worked per week, and the weekly number of customers, hair cuts, hair dyes, permanents, and manicures was requested.

Screening questionnaires were sent in four waves over a four-month period from September to December 1988 (Wave 1: N=1,971; Wave 2: N=3,161; Wave 3: N=2,267; Wave 4: N=957). The survey was introduced as a general health study among cosmetologists to minimize nonresponse by those who had never been pregnant. Nonrespondents were followed-up using the Dillman recommendations (Dillman, 1978). One week after the initial mailing, a reminder/thank-you postcard was sent to the entire study population. Replacement questionnaires were sent to nonrespondents three and six weeks after the initial questionnaire was sent. The effect of a monetary incentive on the survey response was evaluated by enclosing a one dollar bill with the first or second mailing (John and Savitz, 1989).

For nonrespondents to the mail contacts in Wave 1 (N=234)

and Wave 4 (N=120), telephone numbers were sought through directory assistance and a brief screening interview was conducted by telephone. For cosmetologists with a non-deliverable address in Wave 1 (N=157), current addresses were sought through credit bureau records.

The purpose of the screening questionnaire was to identify cosmetologists with a single live birth or a spontaneous abortion of less than 20 weeks of gestation during the five-year period from 1983 to 1988. If more than one pregnancy was reported for the five-year period, only the most recent pregnancy was eligible for the case-control study, with the exception noted below. Spontaneous abortions and single live births were eligible if their last menstrual period prior to that pregnancy was between March 26, 1983 and March 25, 1988. The date of the last menstrual period was estimated based on the self-reported gestational age of the pregnancy.

During the first months of data collection, the reported frequency of spontaneous abortion among the most recent pregnancies was considerably lower than anticipated. To increase study power, all cosmetologists who reported a history of pregnancy loss in the screening questionnaire were subsequently contacted by telephone. For spontaneous abortions of previous pregnancies occurring from 1983 to 1988, information on the date of the spontaneous abortion and work during pregnancy was obtained. If more than one previous spontaneous abortion was reported, information on the most recent of these was requested. Previous pregnancies which ended in a spontaneous abortion were eligible for the case-control study if their last menstrual period was between March 26, 1983 and March 25, 1988. Hereafter, spontaneous abortion of the most recent pregnancy will be referred to as "current spontaneous abortion", whereas spontaneous abortion of a previous pregnancy will be referred to as "previous spontaneous abortion".

3.5. Data collection

Data collection for the case-control study included a 22-page questionnaire which was sent to all cosmetologists with an eligible current or previous spontaneous abortion (cases) or single live birth (controls). More detailed information was requested on the pregnancy outcome and work during pregnancy. The questionnaire included a detailed reproductive history, with questions regarding outcome and work for each pregnancy. A job history inquired about all jobs held during the previous 6 years. With regard to the eligible pregnancy, information was requested on the duration of work during pregnancy and physical activity (standing, sitting, heavy lifting or carrying) during each trimester of pregnancy. For those working in cosmetology, information was requested on the number of customers per week, the frequency of various services provided (shampoos, hair cuts,

dyes, permanents, bleaches, straightenings, manicures), work practices (wearing of gloves, sanitizing of implements and equipment), and salon characteristics (number of cosmetologists, performance of manicuring or nail sculpturing). The questionnaire further inquired about other potential risk factors for adverse pregnancy outcomes, such as active and passive smoking, alcohol and caffeine consumption, contraceptive practice, illnesses and medications taken during pregnancy, medical history, and father's age, smoking, and alcohol consumption prior to conception.

The following strategy was used to maximize the response to the detailed questionnaire, which took about 30-45 minutes to complete. A reminder/thank-you postcard was sent one week after mailing the initial questionnaire and a reminder letter was sent four weeks later. Persistent nonrespondents were contacted by phone, and replacement questionnaires were sent if requested. Telephone interviews using a shorter version of the questionnaire were conducted with a small number of nonrespondents who refused to complete the self-administered mail questionnaire (N=21).

Completed questionnaires were carefully reviewed and checked for internal consistency. Special attention was paid to the consistency of work-related information, which was addressed in several sections of the questionnaire as an internal check. Respondents with inconsistencies or missing data with regard to pregnancy outcome or work during pregnancy were re-contacted by telephone for clarification of the information.

3.6. Exposure assessment

The mother's working status during the first trimester of pregnancy was determined based on work-related information in various sections of the detailed questionnaire. Four exposure categories were considered: (1) work in cosmetology, (2) student in cosmetology school, (3) work in another profession, and (4) work as a full-time homemaker. Respondents who worked both in cosmetology and another profession were classified as working in cosmetology. Respondents who reported work as a homemaker or in other professions besides doing cosmetology work for family and friends at home, were classifed according to their main occupation in another profession or as a full-time homemaker.

Exposure to chemicals used in cosmetology was not directly measured but assessed by the self-reported number of hours worked per week, the weekly number of customers and chemical services (bleaches, dyes, permanents), and the use of formaldehyde for sanitizing implements and equipment. Background exposure in the salon was based on the number of cosmetologists working in the salon and the performance of manicuring and nail sculpturing. If frequency ranges were reported for the number of hours, customers or services, the mid-point of the range was coded.

3.7. Statistical analysis

Current and previous spontaneous abortions (cases) and single live births (controls) were compared with regard to mother's work during the first trimester of pregnancy. Three parallel sets of analyses were conducted, using different restrictions for the exposed group. The first set of analyses restricted the exposed pregnancies to those with 35 or more hours of work in cosmetology. A second set of analyses was restricted to a potentially more highly exposed group, including pregnancies with 35 or more hours of work in cosmetology and 45 or more customers per week. The third set of analyses was restricted to less exposed pregnancies, including those with less than 35 hours of work per week in cosmetology. In addition to these analyses using different restrictions for the exposed pregnancies, identical analyses were conducted for first pregnancies only and pregnancies conceived from 1983 to 1985 and from 1986 to 1988. Working and non-working women have been shown to differ in a number of potential risk factors for spontaneous abortion (Shilling and Lalich, 1984; Savitz et al., 1990). In particular, working women are more likely to have a history of adverse pregnancy outcomes compared to non-working women (Axelsson, 1984a; Savitz et al., 1990). To ensure similarity between the exposed and the referent group with regard to unmeasured risk factors, women working 35 or more hours per week in other professions were chosen as the referent for all analyses.

Odds ratios and 95% confidence intervals were calculated using test-based methods (Miettinen, 1976). Stratified analyses were performed for potentially confounding factors, and adjusted odds ratios and 95% confidence intervals were computed using the Mantel-Haenszel approach (Mantel and Haenszel, 1959). To adjust for multiple confounding variables, adjusted odds ratios were computed using unconditional logistic regression modeling (SAS Institute, 1988).

IV. RESULTS

4.1. Response to screening questionnaire

Of the 8,356 screening questionnaires sent in the cross-sectional survey, 5,960 (71%) questionnaires were returned completed (Table 1). Refusals accounted for one percent. For nearly 9% of the study population, the mail was returned by the postal service as non-deliverable. For nonrespondents to four mailings in Wave 1 and 4 (N=354), telephone numbers were obtained for 175 subjects (49%) through directory assistance. Of these, 148 (85%) agreed to a short screening interview by telephone. Address tracing efforts for non-deliverables in Wave 1 yielded an additional 85 completed questionnaires. Screening was therefore completed by 6,193 cosmetologists (74%) (including 5,960 mail respondents, 85 mail respondents following address tracing, and 148 phone respondents). Excluding cosmetologists with non-deliverable addresses from the denominator (N=740), 81.3% of those who presumably received the questionnaire participated in the screening.

4.2. Enumeration of eligible pregnancies

Sixty-five percent of the respondents to the screening questionnaire reported one or more pregnancies. For the five-year ascertainment period from 1983 to 1988, 1,866 respondents reported one or more pregnancies (Table 2). Considering only the most recent pregnancy of each respondent during the five-year period, 145 spontaneous abortions prior to 20 weeks gestational age were reported, accounting for 7.8% of the 1,866 pregnancies. The rate of spontaneous abortion was similar for three of the four waves of mailings, ranging from 6.9% to 7.2%. A somewhat higher rate of 9.7% was found for the fourth mailing wave. Among the 145 respondents with spontaneous abortions, 121 were white, 16 were black, 4 were American-Indian, Asian, or Hispanic, and 4 respondents did not provide information on their race. The rate of spontaneous abortion was somewhat higher for whites (7.9%) compared to blacks (6.5%).

Spontaneous abortions in previous pregnancies occurring from 1983 to 1988 were reported by 122 respondents whose most recent pregnancy was a single live birth (N=116), twins (N=5), or an induced abortion (N=1).

4.3. Pregnancy history among nonrespondents to the screening questionnaire

After four mailings of the screening questionaire, no response was obtained from 1,288 cosmetologists (15.4%).

Respondents and nonrespondents could not be compared with regard to education since the licensing records did not contain such information. Similarly, most records did not contain information on race. Although date of birth was available in the licensing records, this information was not computerized and thus not readily available to characterize nonrespondents.

Nonrespondents in Wave 1 and 4 were contacted by telephone, and asked to participate in a brief screening interview which inquired about their pregnancy history. Comparing mail (N=5,960) and phone (N=148) respondents, the proportion of cosmetologists who had never been pregnant (34%) was identical for mail and phone respondents. Among the mail respondents, 30.2% reported a pregnancy during the five-year ascertainment period, which compared to 27.7% among phone respondents. The proportion of pregnancies ending in a fetal loss (spontaneous abortion or stillbirth) was similar in both groups (9.2% among mail respondents, 8.3% among phone respondents).

4.4. Response to detailed questionnaire

For the case-control component of the study, detailed questionnaires were sent to 267 case mothers (145 current and 122 previous spontaneous abortions) and 1,429 control mothers whose most recent pregnancy was a single live birth, and who did not report any spontaneous abortion during the five-year ascertainment period. Overall, 74% of all licensed cosmetologists with an eligible pregnancy completed the detailed questionnaire. Variations in response proportions by age, race, education, and current work status are shown in Table 3. The response varied little by age (ranging from 73-76%), but was somewhat higher for licensed cosmetologists with 12 or more years of education (75%), compared to those with less than 12 years of education (65%). A markedly greater proportion of white cosmetologists (78%) completed the detailed questionnaire compared to black cosmetologists (52%). Slightly more licensed cosmetologists who currently worked as full-time homemakers (79%) completed the detailed questionnaire compared to those who worked in cosmetology (73%) or in other professions (73%).

Variations in the response proportions by pregnancy outcome are shown in Table 4. The response was similar for single live births (74%), previous spontaneous abortions (73.0%), and current spontaneous abortions (70.3%). Refusals ranged from 2.2% to 3.5% for the three pregnancy outcomes. Thus, the detailed questionnaire was completed for 1,058 single live births, 102 current spontaneous abortions, and 89 previous spontaneous abortions.

Response to the detailed questionnaire was similar for respondents who worked in cosmetology (74.6%), attended cosmetology school (76.5%), and those who worked as full-time

homemakers (75.5%) during pregnancy (Table 5). For those who worked in other professions, the response was slightly lower (71.3%). For exposure and outcome specific subgroups, the variations in the response to the detailed questionnaire were slightly larger (Table 5), ranging from 66.7% for respondents with a current spontaneous abortion and work in cosmetology to 90% for respondents with a current spontaneous abortion and attendance of cosmetology school.

4.5. Description of spontaneous abortions

Since the self-reported spontaneous abortions were not validated with medical records in this study, several questions were asked in the detailed questionnaire regarding the certainty and medical attention of the pregnancy and spontaneous abortion. Among the 191 self-reported spontaneous abortions with a completed detailed questionnaire, three appeared to be uncertain and were therefore excluded from the analysis. One exclusion concerned a spontaneous abortion for which the respondent stated that the doctors were not sure whether or not she was pregnant. The other exclusions concerned two spontaneous abortions of 3 and 4 weeks gestational age for which there was no reporting of a pregnancy test, medical care during pregnancy or following the spontaneous abortion, or symptoms of miscarriage such as first-trimester bleeding.

For the remaining 188 spontaneous abortions (100 current and 88 previous spontaneous abortions), the distribution by self-reported gestational age was similar for current and previous spontaneous abortions (Table 6). Nearly 40% of current and previous spontaneous abortions were between 11 and 19 weeks gestational age. Twenty-two percent of spontaneous abortions were of less than 7 weeks gestational age. The average gestational age was only slightly lower for previous spontaneous abortions (9.6 weeks) compared to current spontaneous abortions (9.9 weeks).

The majority of respondents were "absolutely sure" that they experienced a miscarriage (91% for current and 93% for previous spontaneous abortions) (Table 6). Thirteen respondents (7%) reported they were "pretty sure" about the spontaneous abortions. Two respondents reported they were "not sure at all", although the gestational age was 9 and 18 weeks, respectively, for these two spontaneous abortions.

Similar proportions of respondents with current and previous spontaneous abortions reported bleeding (73%), seeking medical attention after the spontaneous abortion occurred (97%), hospitalization (42%), or treatment by dilatation and curettage (64%) (Table 6).

The majority of respondents were aware of their pregnancy before the spontaneous abortion occurred (86% for current and 91%

for previous spontaneous abortions) (Table 6). Similar proportions of respondents with a current or previous spontaneous abortion reported an office pregnancy test. Seven percent of pregnancies were identified through a home pregnancy test only. No pregnancy test was reported for 8% of current and 1% of previous spontaneous abortions. The reporting of an ultrasound (47%) and symptoms of pregnancy, such as nausea (28%) and vomiting (18%), were similar for current and previous spontaneous abortions. Markedly more pregnancies ending in previous spontaneous abortions (64%) were reported to be planned compared to current spontaneous abortions (34%).

For two spontaneous abortions included in the analysis (9 and 13 weeks gestational age), no medical care but a home pregnancy test was reported. For the remaining spontaneous abortions some kind of medical care was reported, including an office pregnancy test, ultrasound, consultation with a doctor or hospital after the spontaneous abortion occurred, hospitalization, or a D&C. Given the similarities of current and previous spontaneous abortions, they were combined for subsequent analyses.

Table 7 presents the characteristics of spontaneous abortions by the respondents' work status during the first trimester. Only minor differences were noted between the four exposure groups.

4.6. Work patterns during pregnancy

Fifty-five percent of the respondents (N=689) worked in cosmetology during the first trimester of pregnancy (Table 8). Among them, 62% worked 35 or more hours per week in cosmetology. Five percent of the respondents attended cosmetology school during the first trimester of pregnancy (N=65), while 18% worked as full-time homemakers (N=227).

Twenty-one percent reported work in other professions (N=265), such as service industry (47%), office and clerical work (27%), and textile and other industries (25%). The majority of those working in other professions (84%) reported 35 or more hours of work per week.

Nearly two thirds of the respondents who worked as full-time homemakers (63%) or in other professions (65%) during the first trimester of pregnancy reported doing cosmetology work at home for family and friends. Thus, of the entire study population (N=1,246), only 84 (6.7%) respondents who worked as homemakers and 90 (7.2%) respondents who worked in other professions reported no exposure to cosmetology work.

4.7. Characteristics of work in cosmetology

Two thirds of the 689 respondents who worked in cosmetology during the first trimester of pregnancy worked in beauty salons with five or fewer cosmetologists (Table 9). Nine percent worked in salons with 10 or more cosmetologists. The performance of manicuring (38%) and nail sculpturing (25%) were reported for less than half of the salons.

Nearly two thirds of the respondents always wore gloves during hair dyeing (64%) or bleaching (61%). For permanents, only 16% of the respondents reported that they always wore gloves. Barbicide (91%) was most commonly used to sanitize implements and equipment, followed by formaldehyde (60%), and soap and hot water (59%). Alcohol (15%), lysol (8%), and chlorine solutions (3%) were less commonly used.

4.8. Case-control comparisons: Unadjusted odds ratios

4.8.1. Hours worked in cosmetology

Current and previous spontaneous abortions (cases) were compared to single live births (controls) with regard to the mother's work during the first trimester of pregnancy. Defining the unexposed reference category as women with 35 or more hours of work per week in other professions, no or weak associations were found for exposure to less than 35 hours of work in cosmetology (OR=1.0, 95% CI=0.6-1.8), 35-40 hours of work in cosmetology (OR=1.2, 95% CI=0.7-1.9), and full-time homemaking (OR=1.1, 95% CI=0.6-1.9) (Table 10). Two-fold increased risks were associated with more than 40 hours of work in cosmetology (OR=2.0, 95% CI=1.1-3.6) and attendance of cosmetology school (OR=2.5, 95% CI=1.3-4.8) during the first trimester of pregnancy.

4.8.2. Full-time work in cosmetology: 35+ hours per week

Compared to the odds ratio of 1.3 (95% CI=0.8-2.2) for 35 or more hours of work per week in cosmetology, stronger associations were found for subgroups with high levels of chemical exposure (Table 11). Except for exposure to hair dyes, the highest exposure levels were consistently associated with the greatest elevation in risk, with odds ratios ranging from 1.6 to 2.0 (Table 11). Odds ratios were 1.6 (95% CI=0.8-3.3) for cosmetologists with 60 or more customers per week, 2.0 (95% CI=1.0-4.0) for 3 or more bleaches per week, and 1.7 (95% CI=0.7-4.2) for 15 or more permanents. Odds ratios were 1.7 (95% CI=1.0-3.0) for 3-5 dyes and 1.4 (95% CI=0.6-3.1) for 6 or more dyes. For respondents who performed both 3 or more dyes and 10 or more permanents per week, the odds ratio was 1.9 (95% CI=1.0-3.7).

Summing the number of bleaches, dyes, and permanents performed per week, the odds ratio was 1.6 (95% CI=0.8-3.1) for those with 16 or more chemical services per week.

No associations with spontaneous abortion were found among cosmetologists with the lowest levels of chemical exposure, such as less than 30 customers per week, no bleaches, less than 3 hair dyes, less than 5 permanents, and less than 5 chemical services per week. Dose response gradients across 3 or 4 exposure levels were observed for the number of hours worked per week, the number of customers, bleaches, permanents, and the number of chemical services.

The use of formaldehyde to sanitize implements and equipment was associated with an odds ratio of 1.6 (95% CI=1.0-2.7), whereas no increased risk was observed among respondents who did not use formaldehyde.

With regard to background exposure variables, the risk of spontaneous abortion did not vary by the number of cosmetologists in the salon, with identical odds ratios of 1.4 for respondents working in small salons with less than 6 cosmetologists and those working in large salons with 6 or more cosmetologists. For salons with manicurists, the odds ratio was 1.5 (95% CI=0.8-2.6). Among all measures of chemical exposure examined in this study, the risk of spontaneous abortion was highest for work in salons where nail sculpturing was performed, with a two-fold significantly increased odds ratio (OR=2.0, 95% CI=1.1-3.5).

The wearing of gloves during hair dyeing did not appreciably modify the association with spontaneous abortion. For exposure to 3 or more dyes per week, the odds ratios were similar for respondents who always wore gloves (OR=1.7) and those who sometimes or never wore gloves (OR=1.5). Among respondents with 10 or more permanents per week, similar odds ratios were found for respondents who always wore gloves (OR=2.0) and those who sometimes or never wore gloves (OR=1.7).

Restriction of the analysis to first pregnancies did not alter the results (Tables 12 & 13). Among cosmetologists who worked 35 or more hours per week, the odds ratios associated with the highest levels of chemical exposure were similar to the odds ratios for pregnancies of any gravidity, although bounded by wider confidence intervals due to smaller numbers (Table 13).

4.8.3. Full-time work in cosmetology: 35+ hours and 45+ customers per week

Restricting the exposed group to potentially more highly exposed cosmetologists with 35 or more hours of work per week and 45 or more customers per week, slightly higher odds ratios were found (Table 14). For the highest levels of chemical exposure,

the odds ratios were 2.6 (95% CI=1.2-5.6) for 3 or more bleaches, 1.8 (95% CI=1.0-3.3) for 3 or more dyes, and 2.0 (95% CI=1.0-3.8) for 10 or more permanents per week. For cosmetologists performing both 3 or more dyes and 10 or more permanents per week, the odds ratio was 2.3 (95% CI=1.1-4.7). The use of formaldehyde was associated with an odds ratio of 1.7 (95% CI=0.9-3.1).

Odds ratios were similar for respondents who worked in small (OR=1.4) and large (OR=1.6) salons. Two- and three-fold significantly increased risks were found for respondents who worked in salons with manicuring (OR=2.0, 95% CI=1.0-3.9) and nail sculpturing (OR=3.1, 95% CI=1.5-6.5).

4.8.4. Part-time work in cosmetology: <35 hours per week

Compared to the referent group comprising respondents who worked 35 or more hours in other professions during the first trimester, the odds ratio was 1.0 for those who reported less than 35 hours of work per week in cosmetology. Only slight variations from the overall odds ratio were noted for specific work characteristics, with none of the odds ratios exceeding 1.3 (Table 15). For cosmetologists with less than 30 customers per week there was no association between work in cosmetology and spontaneous abortion (OR=1.0). For those with 30 or more customers per week, the odds ratio was 1.2 (95% CI=0.6-2.4). Odds ratios ranged from 0.8 to 1.2 for exposure levels categorized by the weekly number of bleaches, dyes, and permanents. The odds ratios were 0.8 (95% CI=0.3-2.6) for the performance of 2 or more bleaches per week, 1.2 (95% CI=0.5-2.6) for 3 or more hair dyes per week, and 1.0 (95% CI=0.5-2.0) for 5 or more permanents per week. Adding the number of bleaches, dyes and permanents performed per week, the odds ratio was 1.3 (95% CI=0.4-4.8) for those with 16 or more chemical services. The use of formaldehyde was associated with an odds ratio of 1.3 95% CI=0.7-2.5).

With odds ratios ranging from 1.0 to 1.2, spontaneous abortions were only weakly associated with salon characteristics such as the number of cosmetologists and the performance of manicuring or nail sculpturing. Overall, there were no or weak associations between spontaneous abortions and chemical services and salon characteristics among those with less than 35 hours of work in cosmetology.

4.9. Assessment of confounding: Potential risk factors

Spontaneous abortions and single live births were compared with regard to differences in potential risk factors for spontaneous abortion, such as mother's characteristics (age at conception, race, education, family income), pregnancy history

(gravidity, previous pregnancy loss, previous induced abortion), ascertainment of pregnancy (month of pregnancy test, month of first prenatal visit), pregnancy-related medical events during the first trimester (bleeding, nausea, vomiting), and mother's lifestyle factors before conception and during the first trimester (alcohol consumption, cigarette smoking, personal use of hair dyes and permanents) (Table 16).

Compared to mothers with a single live births (control mothers), those with a spontaneous abortion (case mothers) were more likely to be white (OR=1.6) and less than 20 years of age at the time of conception (OR=2.3). Surrogate measures of socioeconomic status were similar for spontaneous abortions and single live births. Case mothers were slightly more likely to have less than 12 years of education (OR=1.2) and were slightly less likely to have a family income of less than $20,000 (OR=0.8).

A history of pregnancy loss was most strongly associated with the risk of spontaneous abortion, with odds ratios of 4.2 for one previous pregnancy loss, and 7.8 for two or more pregnancy losses. Case mothers were more likely to have had three or more pregnancies (OR=1.8) and were slightly more likely to report a previous induced abortion (OR=1.3).

A pregnancy test during the first month of pregnancy was more frequently reported by case mothers (OR=1.7). Similarly, case mothers had their first prenatal visit more frequently during the first month of pregnancy than control mothers (OR=1.3). Bleeding was more commonly reported by case mothers (OR=14.2). Reporting of nausea (OR=0.4) and vomiting (OR=0.4) was less common among case mothers.

With regard to maternal life style factors during the first trimester of pregnancy, case mothers were more likely to consume alcohol at least once a week than control mothers (OR=1.7), although fewer than 4% of respondents were in this risk category. Case mothers were more likely to smoke 20 or more cigarettes per day (OR=1.6). Alcohol consumption and cigarette smoking before conception were not associated with spontaneous abortion. Personal use of hair dyes (OR=1.0) and permanents (OR=0.9) during the first trimester did not increase the risk of spontaneous abortion.

Based on prior knowledge regarding suspected risk factors for spontaneous abortion and the reported prevalence of such factors in the study population, the following attributes and exposures were selected for stratified analyses and examined for potential confounding and effect modification: History of pregnancy loss (yes, no), gravidity (1-2, 3+), maternal age at conception (<20, 20+ years), family income (<$20,000, $20,000+), maternal alcohol consumption (less than once per week, once or more per week), maternal smoking (yes, no).

4.11. Stratified analyses

Stratified analyses were conducted for those working 35 or more hours in cosmetology or other professions. Individual adjustment for the above noted potential risk factors (previous pregnancy loss, gravidity, maternal age at conception, family income, and mother's alcohol consumption and cigarette smoking during the first trimester of pregnancy) did not substantially alter the unadjusted odds ratios. Results of the stratified analyses are summarized in Table 17, which presents the range of adjusted odds ratios computed for each exposure measure. There was little evidence of confounding, with all adjusted odds ratios within 10% of the unadjusted odds ratios.

Effect modification was examined for exposure to 35 or more hours of work in cosmetology (Table 18). Stratum-specific odds ratios differed only slightly for respondents with and without a history of spontaneous abortion, and those with high and low gravidity. The odds ratio for respondents less than 20 years of age was highly imprecise (OR=0.9, 95% CI=0.1-7.5), based on 3 exposed spontaneous abortions. Elevations in the stratum-specific odds ratios were observed for respondents with a yearly family income of $20,000 or more (OR=1.6), and respondents who did not smoke (OR=1.7) or drink alcohol (OR=1.4). No associations were found for respondents with a family income of less than $20,000 (OR=1.1), and those who smoked (OR=1.0) and consumed alcohol (OR=0.8) during pregnancy. These stratum-specific odds ratios, however, are limited by the small numbers and tend to be imprecise. There is no obvious explanation for the enhanced risk of spontaneous abortion among respondents with a higher income and those who did not smoke and did not consume alcohol during pregnancy. Given the imprecise risk estimates, random variation may explain the differences in the stratum-specific odds ratios rather than effect modification.

4.9.2. Logistic regression analyses

Logistic regression analyses were performed in order to adjust simultaneously for the six potentially confounding factors. Table 19a presents unadjusted and adjusted odds ratios for respondents working in cosmetology or other professions, and for cosmetology students and fulltime homemakers. Unadjusted and adjusted odds ratios for respondents working 35 or more hours in cosmetology are shown in Table 19. Since respondents with missing information are excluded in logistic regression analyses, unadjusted odds ratios were computed for the reduced dataset, comprising respondents without missing information on the six potentially confounding factors (Table 19a and Table 19). Adjustment for the six risk factors did not substantially alter the risk estimates. Most adjusted odds ratios were within 10% of the unadjusted odds ratio.

For the highest exposure levels, the adjusted odds ratios were 1.6 (95% CI=0.7-3.7) for 60 or more customers per week, 1.5 (95% CI=0.6-3.1) for 3 or more bleaches, 1.5 (95% CI=0.8-2.4) for 3 or more dyes, and 1.7 (95% CI=0.9-3.7) for 10 or more permanents (Table 19). For the performance of both 3 or more dyes and 10 or more permanents, the adjusted odds ratio was 1.8 (95% CI=0.8-3.1). For the performance of more than 10 chemical services (bleaches, dyes, or permanents), the adjusted odds ratio was 1.6 (95% CI=0.8-2.9). Exposure to formaldehyde was associated with an adjusted odds ratio of 1.8 (95% CI=1.0-2.4). For salons with manicuring or nail sculpturing, the adjusted odds ratios were 1.5 (95% CI=0.8-2.4) and 1.9 (95% CI=1.0-3.0), respectively. For respondents who attended cosmetology school during the first trimester of pregnancy, the adjusted odds ratio was 2.6 (95% CI=1.2-6.0).

4.12. Assessment of response bias

As previously presented, the response to the detailed questionnaire varied somewhat by pregnancy outcome and work status during the first trimester of pregnancy (Table 4). To assess the potential effect of selection bias on the risk estimates, the unadjusted odds ratios for the respondents to the screening questionnaire were compared to the unadjusted odds ratios for the respondents to the detailed questionnaire.

This set of analyses, however, was limited to current spontaneous abortions and single live births. The screening for eligible spontaneous abortions of previous pregnancies was conducted by telephone, and thus no completed screening questionnaires were available which inquired about the weekly number of hours, customers, hair dyes, and permanents. Furthermore, since the screening questionnaire did not request information on the weekly number of hours worked in other professions, the reference group for this set of analyses included all respondents who worked in other professions during pregnancy, regardless of the number of hours worked per week. This is in contrast to all the previously presented analyses where the referent group included those who worked 35 or more hours per week in other professions.

Table 20 presents odds ratios and 95% confidence intervals for the respondents to the screening questionnaire (N=1,551) and the respondents to the detailed questionnaire (N=1,158) with a current spontaneous abortion or single live birth. For both groups of respondents, the exposure in this analysis was based on information provided in the screening questionnaire.

Among women who worked less than 35 hours per week in cosmetology (OR=0.6) or as homemakers (OR=0.4) during pregnancy, identical odds ratios were found for the respondents to the two questionnaires. For those who attended cosmetology school during

pregnancy, the odds ratio was slightly higher for the respondents to the detailed questionnaire (OR=2.0, 95% CI=0.9-4.4) compared to the respondents to the screening questionnaire (OR=1.7, 95% CI=0.8-3.6). In contrast, for respondents who worked 35 or more hours per week in cosmetology, the odds ratios were slightly lower for respondents to the detailed questionnaire compared to respondents to the screening questionnaire. This pattern was found for both the low and high chemical exposure levels, although the differences in the odds ratios were small.

These findings suggest that differential response to the detailed questionnaire for mothers with current spontaneous abortions and single live births may have slightly biased the risk estimates toward the null for those who worked 35 or more hours in cosmetology. The main results of this study, which were based on the respondents to the detailed questionnaire, may therefore have slightly underestimated the true risk estimates for those who worked in cosmetology. The differences in the odds ratios, however, were small and may have been due to chance.

4.13. Assessment of exposure misclassification

For respondents to the detailed questionnaire, the reliability of work-related information could be assessed by comparing the data provided in the screening and detailed questionnaire. Both questionnaires inquired about the type of work performed during pregnancy. For those in cosmetology, information on the number of hours worked per week, the number of customers, hair dyes, and permanents was obtained in both questionnaires. On the average, there were 3.8 months between the completion of the screening and detailed questionnaire. According to the detailed questionnaire, 641 respondents worked in cosmetology during the first trimester of pregnancy (Table 21). Of these, 602 had provided work information in the screening questionnaire. Ninety-six percent of those who provided this information indicated work in cosmetology during pregnancy. For respondents who attended cosmetology school during the first trimester according to the detailed questionnaire, 80% provided the same information in the screening questionnaire. For respondents working in other professions or as full-time homemakers, the proportions were 87%, and 88%, respectively.

Eighty-seven percent of respondents who reported 35 or more hours of work in the detailed questionnaire, gave the same information in the screening questionnaire. For those with less than 35 hours per week, the agreement between the two questionnaires was 80%. For the weekly number of chemical services, the discrepancies between the screening and detailed questionnaire were somewhat greater. Of those who listed 3 or more hair dyes in the detailed questionnaire, 75% reported the same in the screening questionnaire. Agreement percentages were 76 for less than 3 hair dyes, 78 for less than 10 permanents, and

71 for 10 more permanents.

To assess the potential effect of exposure misclassification, odds ratios were computed for the respondents to the detailed questionnaire based on the information provided in the screening and detailed questionnaire. For 35 or more hours of work in cosmetology, the odds ratio was slightly higher for exposure information derived from the detailed questionnaire (OR=1.1) compared to the screening questionnaire (OR=0.9) (Table 22). For the high exposure levels of chemical services, odds ratios were slightly higher for the exposure data from the screening questionnaire, compared to the exposure data from the detailed questionnaire. The reverse was found for cosmetologists with 60 or more customers per week.

4.14. Assessment of recall bias

For the main analysis, which included women who worked 35 or more hours per week in cosmetology or other professions, the length of the recall period was similar for single live births and spontaneous abortions. Conceptions between 1983 and 1985 accounted for 38% of spontaneous abortions and 42% of single live births. To assess the effect of potential recall bias on the risk estimates, odds ratios were estimated for the two time periods of 1983-85 and 1986-88.

For cosmetologists with 35 or more hours of work per week, the odds ratio was only slightly higher for 1986-88 (OR=1.4) than for 1983-85 (OR=1.3) (Table 23). For cosmetologists with more than 40 hours or less than 35 hours of work, cosmetology school students, and homemakers the difference between the odds ratios for the two time periods was somewhat larger, although the risk estimates were not consistently higher for the more recent period. Similarly, for the measures of chemical exposure among cosmetologists with 35 or more hours of work, the odds ratios for the high exposure levels varied somewhat for the two time periods, but no consistent patterns were observed (Table 24). In both time periods, however, elevated odds ratios were found for the high exposure levels, whereas the low exposure levels were not associated with spontaneous abortions.

V. DISCUSSION

This study provides the first epidemiologic evidence that work in cosmetology during the first trimester of pregnancy may increase the risk of spontaneous abortion. Compared to women who worked 35 or more hours in other professions, a 30% increased risk of spontaneous abortion was found among women who worked 35 or more hours in cosmetology. For cosmetologists with high levels of chemical exposure, measured by the weekly number of customers, hair dyes, bleaches, permanents, and the total number of chemical services, the unadjusted odds ratios ranged from 1.6 to 2.0. Positive associations were also found for the use of formaldehyde, and work in salons where manicuring or nail sculpturing were performed, with odds ratios ranging from 1.5 to 2.0. Among cosmetologists with 35 or more hours of work and 45 or more customers per week, the unadjusted odds ratios ranged from 1.7 to 3.1 for the various exposure measures. Dose response gradients were found for the weekly number of customers and chemical services. Among licensed cosmetologists who attended cosmetology school during the first trimester of pregnancy, the odds ratio was 2.5, although based on a small number of spontaneous abortions (N=17).

No associations with spontaneous abortion were found among cosmetologists with 35 or more hours of work per week and low chemical exposure and among cosmetologists who worked less than 35 hours per week. Personal use of hair dyes and permanents during the first trimester of pregnancy did not increase the risk of spontaneous abortion.

Adjustment for potentially confounding factors did not appreciably alter the risk estimates among women working 35 or more hours per week in cosmetology, with the adjusted odds ratios ranging from 1.5 to 1.9 for the different measures of chemical exposure.

In interpreting these results the possibility of both systematic and random error needs to be addressed.

5.1. Case and control ascertainment

Both spontaneous abortions (cases) and single live births (controls) were ascertained by self-report through a self-administered mail questionnaire. Spontaneous abortions could not easily be validated against medical records, which raises the concern about underreporting and overreporting of spontaneous abortions.

In the cross-sectional survey, the rate of spontaneous abortion of less than 20 weeks gestation was 7.8% among the most recent pregnancies occurring over the five-year period from 1983 to 1988. In prospective studies which followed women who tried to

conceive, 12-14% of pregnancies ended in a clinically recognized spontaneous abortion (Miller et al., 1980; Edmonds et al., 1982; Whittaker et al., 1983; Wilcox et al., 1988). Estimates from retrospective and cross-sectional studies have been summarized by Kline et al., (1989) and ranged from 11-20%. In a Montreal survey of hospitalized spontaneous abortions of less than 28 weeks gestational age, the rate was 7.4% (McDonald et al., 1986).

These estimates of the rate of spontaneous abortion were generally based on populations without restriction on age, gravidity, or socio-economic background. Differences in these potential risk factors may partly explain the somewhat lower rate of spontaneous abortion found in the present study, which restricted the study population to licensed cosmetologists less than 36 years of age, most of whom were white, high school graduates, and employed at the time of study recruitment. Women over the age of 36 who are at a greater risk of spontaneous abortion, as are women of low socio-economic status (Kline et al., 1989). The proportion of spontaneous abortions per 100 single live births and spontaneous abortions was 8.5% in this study. Compared to the New York study of spontaneous abortions, this proportion is similar to the proportion calculated for private patients aged 18-35 (7.6%) who were predominantly white, but lower than the proportion for public patients (12.5%) who were mostly black and Hispanic (Stein et al., 1980).

Underreporting of spontaneous abortions has been demonstrated in a number of Scandinavian studies. Between 8% and 26% of spontaneous abortions listed in hospital discharge and polyclinic records were not reported by the respondents to mailed questionnaires (Lindbohm and Hemminki, 1988; Axelsson, 1990). In a prospective study of college women, 25% of spontaneous abortions were not reported (Wilcox and Horney, 1984). Early spontaneous abortions are less likely to be reported than later losses (Wilcox and Horney, 1984; Lindbohm and Hemminki, 1988). For spontaneous abortions before 7 weeks gestation only 54% were reported in the study by Wilcox and Horney (1984). In the present study, the distribution of spontaneous abortions by gestational age was similar to the distribution reported by Wilcox and Horney (1984) which is reassuring. In both studies, 22% of spontaneous abortions were less than 7 weeks gestational age.

Several Scandinavian studies have provided evidence for differential underreporting of spontaneous abortions. In a Swedish study of anesthetic gases, 32% of spontaneous abortions among unexposed women which were listed in the hospital records were not reported in the questionnaire, whereas all spontaneous abortions among the exposed were reported (Axelsson and Rylander, 1982). Among laboratory workers, exposure to solvents was more frequently reported for spontaneous abortions which could not be verified with hospital records (Axelsson and Rylander, 1984b). Similarly, a lower proportion of self-reported spontaneous abortions were identified in the hospital registry among Danish women exposed to laboratory or dental work (Heidam and Olsen, 1985). By contrast, in a Swedish community study of women living

near petrochemical plants, the underreporting did not vary by exposure status (Axelsson, 1990). In the present study it was not possible to assess whether the reporting varied by exposure status. Nondifferential underreporting, however, would bias the risk estimates towards the null (Rothman, 1986).

Another explanation for the relatively low rate of self-reported spontaneous abortions may be that cosmetologists with a spontaneous abortion were less likely to respond to the screening questionnaire than cosmetologists with a single live birth. In a Swedish questionnaire study, spontaneous abortions were only slightly more common among respondents (10.5%) compared to nonrespondents (9.4%) (Axelsson, 1990). In the present study, the rate of spontaneous abortion was similar among a small group of nonrespondents screened by telephone compared to mail respondents. Furthermore, response to the detailed questionnaire varied only slightly for cosmetologists with a spontaneous abortion (70%) or single live birth (74%), which is reassuring.

Given the characteristics of the study population, it is unlikely that the spontaneous abortions of recognized pregnancies were greatly underreported in this study. Given the lack of registry data for comparison, however, the magnitude of underreporting and the extent of differrential underreporting could not be assessed in this study.

The second concern in studies of self-reported spontaneous abortions regards overreporting. In two Finnish studies 20% of spontaneous abortions reported by nurses (Selevan et al., 1985) and 17% reported by industrial workers (Lindbohm and Hemminki, 1988) could not be confirmed by hospital discharge and polyclinic records, although for 8% of spontaneous abortions in the latter study this was due to missing identification numbers. In two Swedish questionnaire studies, 12% of spontaneous abortions reported by laboratory personnel (Axelsson and Rylander, 1984b), and 13% reported by women living near petrochemical plants (Axelsson, 1990) could not be confirmed in the hospital records. Among spontaneous abortions for which a positive pregnancy test or confirmation of the pregnancy loss by a doctor was reported, only 3% could not be confirmed through hospital records (Axelsson, 1990).

For inclusion in the case-control analysis, the reporting of either a positive pregnancy test, symptoms of pregnancy loss, or medical attention after the loss were required. Among the 191 self-reported current and previous spontaneous abortions with a completed detailed questionnaire, three losses did not meet these criteria and were therefore excluded from the analysis. The inclusion of false positives in this study is unlikely. However, the results are based on spontaneous abortions of recognized pregnancies, most of whom had some medical attention, and may therefore not be generalizable to early spontaneous abortions of unrecognized pregnancies.

5.2. Reference group

Case and control mothers who worked in cosmetology during the first trimester of pregnancy were compared to two internal reference groups, comprising unexposed licensed cosmetologists who worked in other professions and those who worked as full-time homemakers. The use of an internal reference group offers the distinct advantage that women with exposed and unexposed pregnancies are likely to be similar with regard to social, economic, and psychologic factors which may be difficult to measure, and thus difficult to control for in the analysis. Furthermore, the use of an internal comparison group in this study had the advantage that both women who were in (work in cosmetology or other professions) and out (homemakers) of the work force were included in the screening population, thus minimizing the potential for selection bias (Selevan, 1981). In order to minimize potential differences between full-time, part-time, and non-working women (Lemasters and Pinney, 1989; Savitz et al., 1990), licensed cosmetologists working 35 or more hours per week in cosmetology were compared to unexposed licensed cosmetologists working 35 or more hours in other professions.

5.3. Selection bias

Spontaneous abortions and single live births were identified through a cross-sectional survey of cosmetologists with an active license in April 1988. Cosmetologists who did not renew their license in October 1986 for the three-year licensing period from 1986 to 1989 were therefore not included in the screening for eligible pregnancies. This raises the concern about potential selection bias, since women with a single live births are more likely to leave the work force compared to women with an adverse pregnancy outcome (Selevan, 1981; Axelsson, 1984a). However, licensed cosmetologists who stop working in cosmetology, for example following a live birth, are likely to continue renewing their license in order to re-enter the profession at a later time, without having to re-take the licensing examinations. Among the respondents to the screening questionnaire, fewer than half (46%) of the licensed cosmetologists worked in cosmetology during the previous 6 months. Thirty-eight percent worked in other professions, and 16% as full-time homemakers. It is therefore unlikely that the licensed cosmetologists who were included in the screening overrepresent those with adverse pregnancy outcomes compared to licensed cosmetologists who were not included in the screening.

The validity of the study results may be limited by the less than optimal response to the screening (74%) and detailed questionnaire (74%). Given the lack of information on the nonrespondents to the screening questionnaire, the direction of potential bias due to nonresponse cannot be determined. Nondifferential nonresponse, however, would bias the risk

estimates towards the null (Rothman, 1986).

To minimize differential response rates, the study was introduced as a general health study among cosmetologists, without any mention of adverse reproductive outcomes. Besides the pregnancy-related information, the screening questionnaire inquired about health problems experienced during the previous 6 months. The response to the screening questionnaire varied only slightly by current work status, which is reassuring.

To assess the magnitude and direction of potential bias due to nonresponse to the detailed questionnaire, unadjusted odds ratios for the respondents to the screening questionnaire were compared to those for the respondents to the detailed questionnaire. This analysis, however, was limited to current spontaneous abortions and single live births and the unexposed group included all women working in other professions, regardless of the number of hours worked per week. For the respondents to the screening questionnaire the odds ratio was 1.2, compared to 0.9 for the respondents to the detailed questionnaire. This finding suggests that differential response to the detailed questionnaire may have slightly biased the risk estimates towards the null for those who worked 35 or more hours in cosmetology.

5.4. Exposure assessment and misclassification

Work status during the first trimester was determined on the basis of a work history covering the previous six years and work-related questions regarding the index pregnancy. Exposure to chemicals, the hypothesized occupational hazard, was not directly measured, but assessed through surrogate measures, such as the self-reported number of hours worked in cosmetology, the number of customers per week, the weekly number of hair bleaches, dyes, and permanents, and the use of formaldehyde. Measures of background exposure included salon characteristics such as the number of cosmetologists and the performance of manicuring and nail sculpturing in the salon. This is an improvement over previous occupational surveys which estimated the risk of spontaneous abortion among cosmetologists on the basis of the job title alone (Kline et al., 1982; McDonald et al., 1986). Given the large proportion of cosmetologists who work part-time, and given the large variation in the number and type of services provided, the job title alone is a poor surrogate measure of chemical exposure in this industry, and would therefore tend to dilute any association with adverse health outcomes.

The exposure data in this study relied on self-report and could not be validated against any employment records. Exposure misclassification and recall bias are therefore of concern. For respondents with a current spontaneous abortion or a single live birth, the reliability for some of the self-reported exposure data could be assessed by comparing the data provided in the

screening and detailed questionnaire. Considering the detailed questionnaire as the "gold standard", the highest agreement between the two data sources was found for the reporting of work in cosmetology (96%) during the first trimester of pregnancy. Slightly lower agreement was found for work as a full-time homemaker (88%), work in other professions (85%), and students of cosmetology school (80%).

These discrepancies between the screening and detailed questionnaire with regard to the kind of work performed during pregnancy may be explained in two ways. The screening questionnaire did not specifically ask about work during the first trimester but work during pregnancy. The detailed questionnaire, on the other hand, asked more detailed questions about work during pregnancy which allowed the determination of the work status during each trimester of pregnancy. Respondents who worked in another profession but quit their job in early pregnancy could have listed their work as homemaking in the screening questionnaire, since this work activity accounted for the majority of time during pregnancy. Similarly, respondents who attended cosmetology school early in pregnancy and then worked as a licensed cosmetologist may have listed cosmetology as their work during pregnancy in the screening questionnaire. For some respondents, however, discrepancies between the two questionnaires could not be resolved and appeared to be due to erroneous reporting in either questionnaire.

Among the respondents who worked in cosmetology during the first trimester, 87% of those who reported 35 or more hours of work per week indicated the same in the screening questionnaire. For other items such as the weekly number of customers, hair dyes and permanents, the agreement between the two data sources was lower, ranging from 71-77%. The agreement between the two questionnaires varied somewhat by pregnancy outcome, although the variation did not seem to be systematic.

For exposure-related information the agreement between the screening and detailed questionnaire was remarkably high, considering that cosmetologists tend to work a very flexible schedule, with the numbers of hours, customers, and services varying from week to week. Discrepancies in the self-report of these work characteristics are likely to be explained by the difficulty in recalling the average number of customers and chemical services covering a recall period of as much as 6 years. Missing data on these exposure measures and frequency ranges suggest difficulty in recall. The coding of the mid-point when frequency ranges were provided may have also introduced some exposure misclassification. However, since this coding rule was applied for both cases and controls, such exposure misclassification is likely to be nondifferential.

To assess the direction and magnitude of potential bias due to exposure misclassification, separate odds ratios were computed based on the information provided in the detailed and screening questionnaire. Odds ratios based on information provided in the

screening questionnaire tended to be slightly higher than the odds ratios based on information provided in the detailed questionnaire. This finding suggests that the risk estimates from the case-control analysis may have underestimated the true risk.

Exposure misclassification is likely to occur, given that the recall period was as much as six years for respondents with a pregnancy in 1983. In studies of adverse pregnancy outcomes in particular, there is general concern that case mothers may be more likely to recall and report exposures then controls mothers. A recent study, however, did not provide evidence of biased reporting of exposures by mothers with adverse outcomes (Mackenzie and Lippman, 1989). In the present study, the recall period was similar for single live births and spontaneous abortions. For the main exposure categories, the odds ratios associated with the longer recall period (1983-1985) were similar to those for the shorter recall period (1986-88), although this analysis was limited by small numbers. Given these findings and the fact that occupational exposures have not been publicized as reproductive hazards, it is unlikely that the associations found in this study are due to selective recall.

5.5. Confounding bias

Relatively few risk factors for spontaneous abortions have been identified (Kline et al., 1989). The most commonly suspected risk factors include a history of spontaneous abortion, high gravidity, advanced maternal age, low socio-economic status, and maternal cigarette smoking and alcohol consumption during pregnancy. In this study, associations of spontaneous abortions with these risk factors are consistent with previous reports (Kline et al., 1989). Given the restriction of the study population to licensed cosmetologists aged 22-36, spontaneous abortions and single live births were similar with regard to mother's age at conception, mother's education and family income. Spontaneous abortions were most strongly associated with a history of pregnancy loss (OR=4.7) and gravidity of three or more (OR=1.8). Mother's alcohol consumption at least once a week (OR=1.7) and mother's smoking of 20 or more cigarettes per week (OR=1.6) were also more commonly reported for spontaneous abortions than single live births, although the proportion of single live births in these risk categories was relatively small for both smoking (6.7%) and alcohol (2.2%). These findings are reassuring and suggest that the recall of pregnancy-related information, including exposures at the workplace, was unlikely to be biased.

Individual and multiple adjustment for these potentially confounding factors did not appreciably alter the risk estimates associated with occupational exposure to cosmetology. The excess of spontaneous abortions among cosmetologists with highest levels of chemical exposures could not be attributed to differences in

known maternal risk factors between mothers working in cosmetology and those working in other professions during pregnancy. It is therefore unlikely that confounding accounts for the increased risks found in this study, although there always remains the possibility that unknown risk factors may explain the observed excess of spontaneous abortions. Such potential risk factors, however, would have to be very strong in order to account for the observed associations.

5.6. Study power

Although nearly 8,400 licensed cosmetologists were screened for eligible pregnancies, completed detailed questionnaires were available for only 188 spontaneous abortions and about five times as many single live births. The main analysis, which included women who worked 35 or more hours in cosmetology or other professions during the first trimester of pregnancy, was based on only 96 spontaneous abortions. Analyses for subgroups with high chemical exposure are therefore limited by small sample size. Risk estimates were bounded by relatively wide confidence intervals and did not always exclude the null value. However, this does not preclude the presence of a real cause-effect relation.

5.7. Interpretation of results

As reviewed above, deficiencies in the study design and data analysis, including selection bias, information bias, and confounding, are unlikely to have produced the results of the present study, although bias can never be completely ruled out. In the interpretation of the observed associations between spontaneous abortions and occupational exposure to cosmetology during the first trimester of pregnancy, the criteria by Hill (1965) are discussed. The associations found for cosmetologists working 35 or more hours per week were moderate, with odds ratios ranging from 1.5 to 2.0 for the different measures of chemical exposure. For presumably more exposed cosmetologists with 45 or more customers per week, the odds ratios ranged from 1.7 to 3.1. Based on analyses excluding previous spontaneous abortions, there was some evidence that response bias and exposure misclassification may have slightly underestimated the true strength of association. Adjustment for confounding did not appreciably alter the risk estimates.

The results are internally consistent in several ways. Given a work environment with multiple chemical exposures, several measures of chemical exposure were examined. Increased risks were observed for every exposure measure considered. No associations with spontaneous abortion were present among part-time

cosmetologists with presumably less chemical exposure and among full-time cosmetologists who reported low levels of chemical exposure. Among full-time cosmetologists, the risk of spontaneous abortion increased with the number of chemical services performed. These dose response gradients were consistently found for every exposure measure, including the weekly numbers of hours, customers, bleaches, dyes, and permanents, and the total number of chemical services. It is unlikely that bias explains the observed dose response gradient for every exposure measure considered in this study.

Consistency of the results with prior epidemiologic studies cannot be fully evaluated, as there are only limited data available to which the results of the present study can be compared. There are two occupational surveys which included pregnancies of cosmetologists (Kline et al., 1982; McDonald et al., 1986), both of which found no increased risk of spontaneous abortion. These findings are consistent with the present study in which an odds ratio of 1.1 was found for women who worked in cosmetology compared to women who worked in other professions, regardless of the number of hours worked per week. This overall lack of association, however, is misleading as there is considerable variation in the levels of chemical exposures among women working part-time or full-time in cosmetology. The use of the job title is a poor surrogate measure for chemical exposure in this industry. As an improvement over the two prior surveys, chemical exposure in this study was characterized using various measures of direct and background exposure. A single study, however, is rarely definitive, and replication of these findings is clearly needed.

In a work environment with mixed and multiple chemical exposures it is difficult, if not impossible, to isolate the specific agents responsible for an excess of spontaneous abortion. Occupational exposure to chemicals during pregnancy has been associated with an increased risk of spontaneous abortion in several industries (Kline, 1986; Rosenberg et al., 1987). Solvents in particular have been implicated (Lindbohm et al., 1990), which supports the plausibility of the present results.

In the present study, similar elevations in the odds ratios were found for chemical services, such as 3 or more dyes (adj. OR=1.5), or 10 or more permanents (adj. OR=1.7). For cosmetologists with high exposure to both dyes and permanents, the adjusted odds ratio was 1.8. Cosmetologists rarely perform a single service, although they may be specialized in a certain area of hairdressing. In the present study, 67% of cosmetologists with high exposure to permanents (10 or more per week) also had high exposure to hair dyes (3 or more per week). Given such high correlation between the services performed, it is difficult to distinguish between the separate effects of each service. Furthermore, each service involves the use of a wide variety of commercial products consisting of complex mixtures of chemical substances. This study, however, was not designed to identify potentially harmful chemicals contained in bleaches, dyes,

permanent solutions, and other products used in cosmetology.

A 60% increased risk of spontaneous abortion was found among cosmetologists who reported sanitizing of implements with formaldehyde, a suspected carcinogen (Śwenberg et al. 1980). An increased risk of spontaneous abortion has been reported among nurses exposed to formaldehyde used for sterilization (Stucker et al., 1990). No increased risk, however, was noted among Finnish nurses (Hemminki et al., 1982). Since other means to sanitize equipment are available in cosmetology, substitution of formaldehyde with safer products should be required.

The risk of spontaneous abortion varied only slightly with background exposure variables, such as the number of cosmetologists working in the salon or the presence of manicuring in the salon. Among all measures of chemical exposures considered in this study, the highest risk estimate (OR=2.0) was found for full-time cosmetologists who worked in salons in which nail sculpturing was performed.

Artificial fingernails, also called sculptured or acrylic nails, are prepared by mixing polymeric powder such as polymethyl methacrylate with liquid methyl methacrylate (MMA) or other methacrylate ester monomers (Hecht, 1988). Other chemicals used in nail care include organic solvents, such as toluene, isopropyl alcohol, ethyl and butyl acetates, acetone and other ketones which are contained in nail polish, polish remover, acrylic primer, and enamel undercoat and topcoat. Health effects associated with exposure to MMA include dermatitis, respiratory problems, and symptoms of the central nervous system, including headaches, nausea, loss of appetite, memory loss, and sleep disturbance (Froines and Garabrant, 1986). Eye, skin and respiratory tract irritation have also been reported for some of the organic solvents used in manicuring (Hiipakka and Samimi, 1987).

Air-borne vapors in nail salons were measured in two studies (Froines and Garabrant, 1986; Hiipakka and Samimi, 1987). The 8-hour time-weighted average exposures to different methacrylates and organic solvents were below the OSHA permissible exposure limits (PEL), although the peak values for MMA exceeded the PEL and the short-term exposure limits. The time-weighted average exposures to methacrylates correlated highly with the number of customers and the actual duration of using these chemicals. Background exposures in the nail salon and exposure to solvents contained in nail polish and polish remover were found to be low and contributed little to the overall exposure (Froines and Garabrant, 1986).

The finding of the small contribution of background exposure to total exposure is of interest, since the performance of nail sculpturing in the present study referred to background exposure rather than the performance of this service by the cosmetologist. If nail sculpturing indeed increases the risk of spontaneous abortion, a larger effect would be expected among manicurists who

perform this service themselves.

A significantly elevated odds ratio of 2.5 (95% CI=1.3-4.8) was found among cosmetologists who attended cosmetology school during the first trimester of pregnancy, although the number of spontaneous abortions was small (N=17). In 1983, an apparent excess of spontaneous abortion among students of a North Carolina cosmetology school came to the attention of the North Carolina Health Department (G. Smith, personal communication). Over a 26-month period from 1981 to 1983, 6 of 12 pregnancies (50%) among students resulted in a spontaneous abortion. During the 12-month period from 1982 to 1983, 5 of 8 pregnancies (63%) ended in a spontaneous abortion. Given the small number of spontaneous abortions included in the present study and in the earlier report, the results remain inconclusive and need to be replicated.

VI. CONCLUSIONS

This is the first epidemiologic study which examined the risk of spontaneous abortion among cosmetologists, using more refined exposure data than the job title alone. The results suggest moderately increased risks of spontaneous abortion among cosmetologists who worked full-time and who performed a large number of chemical services. The use of formaldehyde and working in salons where manicuring and nail sculpturing was performed were also associated with an increased risk of spontaneous abortion. Given that chemical exposures in other industries, particularly occupational exposure to solvents, have previously been associated with an increased risk of spontaneous abortion, further reproductive studies in this industry are warranted. Findings from a single study are rarely definitive and need to be replicated in order to rule out the possibility of bias being the cause of the observed relationships.

Several findings of this study suggest directions for future research. The findings of a two-fold increased risk of spontaneous abortion associated with background exposure to nail sculpturing deserves further investigation. Given that manicurists have a separate license, a more heavily exposed population could easily be identified, and a large-scale investigation of spontaneous abortion and other adverse reproductive outcomes in the nail industry would be feasible. In California alone there were nearly 37,000 licensed manicurists in 1989. Limiting a reproductive study to manicurists who work in nail salons would have the advantage of restricting the exposures to a smaller number of chemicals, compared to those used by hairdressers.

The more than two-fold increased risk of spontaneous abortion among cosmetology school students needs further research. A larger study population is needed to assess whether the observed associations were due to small numbers, and thus to chance. The registration of cosmetology schools with the state cosmetology boards would facilitate the identification of the study populations for a large school-based study.

The increased risk of spontaneous abortion associated with the use of formaldehyde needs to be investigated in other professions with occupational exposure to formaldehyde used to sterilize equipment.

Improved exposure measurements are clearly needed in order to minimize exposure misclassification. Environmental sampling as performed in two studies of nail salons (Froines and Garabrant, 1986; Hiipakka and Samimi, 1987) and measurement of biological markers of chemical exposure would contribute to the improved characterization of chemical exposure in this industry.

This study was unable to link the excess of spontaneous abortion to a single service or specific cosmetic products. Improved methods in the collection of self-reported exposure

data, coupled with environmental sampling, may make it possible to distinguish between the effects of various services.

Cosmetology school students and licensed cosmetologists and manicurists should be aware of the potential health hazards of working with chemical substances. Continuing education programs and cosmetology school curricula should emphasize the importance of ventilation, the use of personal protective equipment, and substitution of products containing less harmful chemicals. Training should be provided in the reading and interpretation of product labels and material safety data sheets, basic toxicology, potential health effects, and engineering controls. Thirty hours of training in chemicals and cosmetics do not seem sufficient to adequately cover these issues. Efforts are needed to improve the safety of the workplace for the more than half a million women and men who work in cosmetology and thus to contribute to a better understanding of the inherent risks.

Table 1: Response to screening questionnaire

Screening questionnaires sent	8,356	100.0%
Responses to mailed questionnaires	6,070	72.6%
Completed questionnaires	5,945	71.1%
Refusals	93	1.1%
Male respondents	24	0.3%
Deceased	8	0.1%
Responses to phone contact *	172	2.1%
Interviewed	148	1.8%
Refusals	24	0.3%
Responses to address tracing **	86	1.0%
Completed questionnaires	85	1.0%
Refusals	1	
Non-deliverables	740	8.9%
No response	1,288	15.4%

* Strategy used for Wave 1 and 4 only
** Strategy used for Wave 1 only

Table 2: Outcome of most recent pregnancies

Respondents to screening questionnaire	6,178	
Never pregnant	2,183	
Ever pregnant	3,995	
Most recent pregnancy 1983-88	1,866	
Single live birth	1,557	83.4%
Without previous spontaneous abortion* or stillbirth** (1983-88)	1,429	
With previous spontaneous abortion (1983-88)	116	
Spontaneous abortion	145	7.8%
Stillbirth	14	0.8%
Twin live births	29	1.6%
Previous spontaneous abortion (1983-88)	5	
Fetal loss of twins	6	0.3%
Ectopic pregnancy	30	1.6%
Molar pregnancy	1	0.1%
Induced abortion	84	4.5%
Previous spontaneous abortion (1983-88)	1	

* Spontaneous abortion: less than 20 weeks gestation
** Stillbirth: 20 or more weeks gestation

Table 3: Response to detailed questionnaire by demographic characteristics and current work status

	Completed screening questionnaire (N=1,696)	Completed detailed questionnaire (1,249)	
Race			
White	1,396	1,087	78%
Black	217	112	52%
Other	37	25	68%
Unknown	46	25	54%
Education			
<12 years	81	53	65%
12+ years	1,586	1,196	75%
Unknown	29	0	
Age			
22-24 years	337	249	74%
25-29 years	734	539	73%
30-36 years	606	461	76%
Unknown	19	0	
Current work			
Cosmetology	894	650	73%
Other profession	356	259	73%
Homemaker	387	307	79%
Unknown	59	33	56%

Table 4: Response to detailed questionnaire by pregnancy outcome

Single live births	1,429	100.0%
Completed questionnaire	1,057	74.0%
Completed for wrong pregnancy	7	0.5%
Refusals	31	2.2%
Non-deliverable address	7	0.5%
No response	326	22.8%
Current spontaneous abortions	145	100.0%
Completed questionnaire	102	70.3%
Completed for wrong pregnancy	2	1.4%
Refusals	5	3.5%
No response	36	24.8%
Previous spontaneous abortions	122	100.0%
Completed questionnaires	89	73.0%
Completed for wrong pregnancy	1	0.8%
Incomplete information	1	0.8%
Refusals	4	3.3%
No response	27	22.1%

Table 5: Response to detailed questionnaire by work status *

Work in cosmetology	925	100.0%
Completed questionnaire	690	74.6%
Single live birth	586	75.9%
Current spntaneous abortion	56	66.7%
Previous spontaneous abortion	48	69.6%
Student in cosmetology school	85	100.0%
Completed questionnaire	65	76.5%
Single live birth	48	75.0%
Current spontaneous abortion	9	90.0%
Previous spontaneous abortion	8	72.7%
Work in other profession	373	100.0%
Completed questionnaire	266	71.3%
Single live birth	228	71.3%
Current spontaneous abortion	23	71.8%
Previous spontaneous abortion	15	71.4%
Work in full-time homemaking	302	100.0%
Completed questionnaire	228	75.5%
Single live birth	196	74.5%
Current spontaneous abortion	14	73.7%
Previous spontaneous abortion	18	90.0%

* Based on 1,685 pregnancies; work status was not reported for 11 pregnancies.

Table 6: Characteristics of current and previous spontaneous abortions

	Current spontaneous abortion (N=100)		Previous spontaneous abortion (N=88)		All spontaneous abortions (N=188)	
Gestational age						
< 7 weeks	20	20%	22	25%	42	22%
7-8 weeks	20	20%	19	22%	39	21%
9-10 weeks	21	21%	13	15%	34	18%
11-12 weeks	18	18%	19	22%	37	20%
13-14 weeks	14	14%	6	6%	20	11%
15-19 weeks	7	7%	9	10%	16	8%
Mean gestational age (weeks)	9.9		9.6		9.8	
No medical attention following spontaneous abortion	3	3%	3	3%	6	3%
Hospitalization	41	41%	38	43%	79	42%
D & C	62	62%	58	66%	120	64%
Bleeding	71	71%	66	75%	137	73%
Absolutely sure about spontaneous abortion	91	91%	82	93%	173	92%
Aware of pregnancy	86	86%	80	91%	166	88%
Planned pregnancy	34	34%	56	64%	90	48%
No pregnancy test	8	8%	1	1%	9	5%
Home pregnancy test only	7	7%	6	7%	13	7%
Symptoms of pregnancy						
Nausea	26	26%	26	30%	52	28%
Vomiting	15	15%	19	22%	34	18%
Ultrasound	50	50%	39	44%	89	47%

Table 7: Characteristics of current and previous spontaneous abortions by work status

	Cosmetology		Other profession		Homemaker		Cosmet. school student	
	(N=103)		(N=37)		(N=31)		(N=17)	
Gestational age								
< 7 weeks	20	19%	10	27%	8	26%	4	23%
7-10 weeks	44	43%	16	43%	10	32%	3	18%
11-12 weeks	21	20%	6	16%	7	23%	3	18%
13-19 weeks	18	18%	5	14%	6	19%	7	41%
Mean gestational age (weeks)	9.8		9.1		9.8		10.9	
No medical attention following spontaneous abortion	1	1%	1	2%	1	3%	3	18%
Hospitalization	44	43%	19	51%	12	39%	4	24%
D & C	65	63%	27	73%	20	65%	8	47%
Bleeding	73	71%	27	73%	23	77%	14	82%
Absolutely sure about spontaneous abortion	97	94%	36	97%	27	87%	13	76%
Aware of pregnancy	90	88%	34	92%	27	87%	15	88%
Planned pregnancy	49	48%	17	46%	17	55%	7	41%
No pregnancy test	4	4%	3	8%	1	3%	1	6%
Home pregnancy test only	4	4%	4	11%	3	10%	2	12%
Symptoms of pregnancy								
Nausea	33	33%	11	31%	4	13%	4	24%
Vomiting	22	22%	7	20%	3	10%	2	13%
Ultrasound	47	47%	18	51%	16	52%	8	50%

Table 8: Work patterns during the first trimester of pregnancy

Work in cosmetology			689	55.3%
<20 hours	46	6.7%		
20-34 hours	213	30.9%		
35-40 hours	326	47.3%		
41+ hours	104	15.1%		
Cosmetology school student			65	5.2%
Work in another profession			265	21.3%
<20 hours	9	3.5%		
20-34 hours	33	12.8%		
35-40 hours	181	70.4%		
41+ hours	34	13.2%		
Fulltime homemaker			227	18.2%

Table 9: Characteristics of work in cosmetology

SALON CHARACTERISTICS

Number of cosmetologists

1	98	15%
2-5	335	51%
6-9	141	25%
10+	82	9%

Presence of	Manicuring		Nail sculpturing	
Yes	243	38%	161	25%
No	398	62%	477	75%

WEARING OF PROTECTIVE GLOVES

	Hair dyes		Bleaches		Permanents	
Always	413	64%	377	61%	94	16%
Most the time	134	21%	108	17%	39	7%
Seldom	38	6%	45	7%	49	8%
Never	62	10%	92	15%	403	69%

SANITIZING OF IMPLEMENTS

Barbicide	624	91%
Formaldehyde	412	60%
Soap & hot water	403	59%
Alcohol	104	15%
Lysol	53	8%
Chlorine	20	3%

Table 10: Risk of spontaneous abortion by work status

	SPA	SLB	OR	(95% CI)
OTHER PROFESSIONS				
35+ hours *	27	188	1.0	
<35 hours	8	34	1.6	(0.7-3.9)
COSMETOLOGY				
<35 hours	34	227	1.0	(0.6-1.8)
35+ hours	69	359	1.3	(0.8-2.2)
35-40 hours	46	278	1.2	(0.7-1.9)
41+ hours	23	81	2.0	(1.1-3.6)
COSMETOLOGY SCHOOL	17	48	2.5	(1.3-4.8)
HOMEMAKER	31	196	1.1	(0.6-1.9)

* Referent category

Table 11: Risk of spontaneous abortion:
35+ hours per week in cosmetology

	SPA	SLB	OR	(95% CI)
OTHER PROFESSIONS 35+ HOURS	27	188	1.0	
COSMETOLOGY 35+ HOURS	69	359	1.3	(0.8-2.2)
<30 customers	11	69	1.1	(0.5-2.4)
30-44 customers	22	130	1.2	(0.6-2.2)
45-59 customers	17	89	1.3	(0.7-2.6)
60+ customers	14	60	1.6	(0.8-3.3)
0 bleaches	18	117	1.1	(0.6-2.0)
1-2 bleaches	35	175	1.4	(0.8-2.4)
3+ bleaches	14	50	2.0	(1.0-4.0)
0-2 dyes	28	177	1.1	(0.6-1.9)
3-5 dyes	29	119	1.7	(1.0-3.0)
6+ dyes	10	50	1.4	(0.6-3.1)
0-4 permanents	18	116	1.1	(0.6-2.1)
5-9 permanents	23	127	1.3	(0.7-2.3)
10-14 permanents	19	76	1.7	(0.9-3.3)
15+ permanents	7	29	1.7	(0.7-4.2)
<3 dyes, <10 perms	21	141	1.0	(0.6-1.9)
<3 dyes, 10+ perms	7	36	1.4	(0.5-3.3)
3+ dyes, <10 perms	20	101	1.4	(0.7-2.6)
3+ dyes, 10+ perms	19	68	1.9	(1.0-3.7)
<11 chemical services **	29	179	1.1	(0.6-2.0)
11-15 chemical services	20	88	1.6	(0.8-3.0)
16+ chemical services	16	70	1.6	(0.8-3.1)
No formaldehyde	16	133	0.8	(0.4-1.6)
Formaldehyde	51	219	1.6	(1.0-2.7)
<6 cosmetologists	43	218	1.4	(0.8-2.3)
6+ cosmetologists	24	122	1.4	(0.8-2.5)
No manicuring in salon	37	201	1.3	(0.8-2.2)
Manicuring in salon	28	132	1.5	(0.8-2.6)
No nail sculpturing	40	242	1.2	(0.7-1.9)
Nail sculpturing	25	89	2.0	(1.1-3.5)

* Referent category
** Number of bleaches, dyes, and permanents

Table 12: Risk of spontaneous abortion by work status: Restriction to first pregnancies

	SPA	SLB	OR	(95% CI)
OTHER PROFESSIONS				
35+ HOURS *	13	97	1.0	
COSMETOLOGY				
< 35 hours	11	94	0.9	(0.4-2.0)
35+ hours	35	198	1.3	(0.7-2.6)
35-40 hours	22	151	1.1	(0.5-2.3)
41+ hours	13	47	2.1	(0.9-4.8)
COSMETOLOGY SCHOOL	6	26	1.7	(0.6-4.9)
HOMEMAKER	2	39	0.4	(0.1-1.7)

* Referent category

Table 13: Risk of spontaneous abortion:
35+ hours per week in cosmetology -
Restriction to first pregnancies

	SPA	SLB	OR	(95% CI)
OTHER PROFESSIONS 35+ HOURS	13	97	1.0	
COSMETOLOGY 35+ HOURS	35	198	1.3	(0.7-2.6)
<45 customers	19	114	1.2	(0.6-2.6)
45+ customers	12	79	1.1	(0.5-2.6)
0-2 bleaches	28	157	1.2	(0.6-2.4)
3+ bleaches	6	31	1.3	(0.5-3.7)
0-2 dyes	13	103	0.9	(0.4-1.9)
3+ dyes	21	87	1.7	(0.8-3.4)
0-9 permanents	20	125	1.1	(0.5-2.3)
10+ permanents	14	66	1.5	(0.7-3.2)
<3 dyes, <10 perms	8	78	0.7	(0.3-1.7)
<3 dyes, 10+ perms	5	25	1.4	(0.5-4.1)
3+ dyes, <10 perms	12	47	1.8	(0.8-4.0)
3+ dyes, 10+ perms	9	40	1.6	(0.6-3.8)
<11 chemical services **	15	97	1.1	(0.5-2.3)
11+ chemical services	19	90	1.5	(0.7-3.0)
No formaldehyde	5	74	0.5	(0.2-1.5)
Formaldehyde	30	120	1.9	(0.9-3.7)
<6 cosmetologists	21	120	1.2	(0.6-2.4)
6+ cosmetologists	13	68	1.3	(0.6-2.9)
No manicuring in salon	20	111	1.3	(0.6-2.5)
Manicuring in salon	14	71	1.4	(0.6-3.0)
No nail sculpturing	23	132	1.2	(0.6-2.4)
Nail sculpturing	11	48	1.6	(0.7-3.7)

* Referent category
** Number of bleaches, dyes, and permanents

Table 14: Risk of spontaneous abortion: 35+ hours per week in cosmetology and 45+ customers per week

	SPA	SLB	OR	(95% CI)
OTHER PROFESSIONS 35+ HOURS COSMETOLOGY	27	188	1.0	
35+ HOURS & 45+ CUSTOMERS	31	149	1.4	(0.8-2.5)
0-2 bleaches	20	119	1.2	(0.6-2.2)
3+ bleaches	11	30	2.6	(1.2-5.6)
0-2 dyes	9	62	1.0	(0.5-2.3)
3+ dyes	22	86	1.8	(1.0-3.3)
0-9 permanents	13	86	1.1	(0.5-2.1)
10+ permanents	18	63	2.0	(1.0-3.8)
<3 dyes, <10 perms	4	42	0.8	(0.3-2.3)
3+ dyes, 10+ perms	14	42	2.3	(1.1-4.7)
<11 chemical services **	9	55	1.1	(0.5-2.6)
11-15 chemical services	11	52	1.5	(0.7-3.2)
16+ chemical services	14	42	2.3	(1.1-4.7)
No formaldehyde	6	46	0.9	(0.4-2.3)
Formaldehyde	24	99	1.7	(0.9-3.1)
<6 cosmetologists	18	88	1.4	(0.7-2.7)
6+ cosmetologists	13	53	1.6	(0.8-3.2)
No manicuring in salon	15	93	1.1	(0.6-2.2)
Manicuring in salon	15	53	2.0	(1.0-3.9)
No nail sculpturing	16	115	1.0	(0.5-1.9)
Nail sculpturing	14	31	3.1	(1.5-6.5)

* Referent category
** Number of bleaches, dyes and permanents

Table 15: Risk of spontaneous abortion:
<35 hours per week in cosmetology

	SPA	SLB	OR	(95% CI)
OTHER PROFESSIONS 35+ HOURS	27	188	1.0	
COSMETOLOGY <35 HOURS	34	227	1.0	(0.6-1.8)
<30 customers	20	142	1.0	(0.5-1.8)
30+ customers	13	78	1.2	(0.6-2.4)
0 bleach	13	100	0.9	(0.4-1.8)
1 bleach	15	84	1.2	(0.6-2.5)
2+ bleaches	4	33	0.8	(0.3-2.6)
0-2 dyes	23	165	1.0	(0.5-1.8)
3+ dyes	10	58	1.2	(0.5-2.6)
0-4 permanents	18	121	1.0	(0.5-2.0)
5+ permanents	15	102	1.0	(0.5-2.0)
<6 chemical services **	14	88	1.1	(0.6-2.2)
6-10 chemical services	11	89	0.9	(0.4-1.8)
11-15 chemical services	4	24	1.2	(0.4-3.6)
16+ chemical services	3	16	1.3	(0.4-4.8)
No formaldehyde	10	103	0.7	(0.3-1.4)
Formaldehyde	23	119	1.3	(0.7-2.5)
<6 cosmetologists	23	149	1.1	(0.6-2.0)
6+ cosmetologists	11	64	1.2	(0.6-2.6)
No manicuring in salon	22	138	1.1	(0.6-2.0)
Manicuring in salon	12	71	1.2	(0.6-2.5)
No nail sculpturing	28	167	1.2	(0.7-2.1)
Nail sculpturing	6	41	1.0	(0.4-2.6)

* Referent category
** Number of bleaches, dyes and permanents

Table 16: Characteristics of spontaneous abortions and single live births

	Spontaneous abortions		Single live births		OR (95% CI)
MOTHER'S RACE					
White	169	92.4%	915	88.2%	1.0
Black	11	6.0%	101	9.7%	0.6 (0.3-1.1)
Other	3	1.6%	22	2.1%	0.7 (0.3-2.5)
MOTHER'S EDUCATION					
HS graduate	173	92.5%	973	92.0%	1.0
< HS grad.	7	3.7%	32	3.0%	1.2 (0.5-2.8)
College grad.	7	3.7%	53	5.0%	0.7 (0.3-1.7)
FAMILY INCOME					
$20,000-$29,999	64	36.4%	334	34.0%	1.0
< $20,000	55	31.3%	356	36.3%	0.8 (0.5-1.2)
$30,000-$39,999	35	19.9%	184	18.7%	1.0 (0.6-1.6)
$40,000+	22	12.5%	108	11.0%	1.1 (0.6-1.8)
FAMILY HISTORY OF SPONTANEOUS ABORTION					
No	103	60.2%	684	68.1%	1.0
Yes	68	39.8%	321	31.9%	1.4 (1.0-2.0)
MOTHER'S AGE AT CONCEPTION					
20-24 years	68	36.2%	425	40.2%	1.0
< 20	13	6.9%	36	3.4%	2.3 (1.2-4.4)
25-29	74	39.4%	411	38.9%	1.1 (0.8-1.6)
30-36	33	17.6%	186	17.6%	1.1 (0.7-1.7)
YEAR OF CONCEPTION					
1986-88	96	51.1%	564	53.5%	1.0
1983-85	92	48.9%	490	46.5%	1.1 (0.8-1.5)

	Spontaneous abortions		Single live births		OR (95% CI)
PREVIOUS PREGNANCY LOSS					
0	136	72.3%	979	92.5%	1.0
1	39	20.7%	67	6.3%	4.2 (2.8-6.3)
2+	13	6.9%	12	1.1%	7.8 (4.0-15)
PREVIOUS INDUCED ABORTION					
No	175	93.1%	999	94.4%	1.0
Yes	13	6.9%	59	5.6%	1.3 (0.7-2.3)
GRAVIDITY					
1	71	37.8%	471	44.5%	1.0
2	63	33.5%	390	36.9%	1.1 (0.7-1.5)
3+	54	28.7%	197	18.6%	1.8 (1.2-2.7)
PLANNED PREGNANCY					
No	98	52.1%	453	42.9%	1.0
Yes	90	47.9%	604	57.1%	0.7 (0.5-0.9)
PREGNANCY TEST					
5-8 weeks	82	47.4%	568	54.7%	1.0
1-4	80	46.2%	332	32.0%	1.7 (1.2-2.3)
9+	10	5.8%	138	13.3%	0.5 (0.3-1.0)
FIRST PRENATAL VISIT					
5-8 weeks	91	59.5%	521	50.1%	1.0
1-4	38	24.8%	174	16.7%	1.3 (0.8-1.9)
9+	20	13.1%	346	33.2%	0.3 (0.2-0.5)
BLEEDING *					
No	60	32.6%	920	87.3%	1.0
Yes	124	67.4%	134	12.7%	14.2 (10-19)
NAUSEA *					
No	134	74.0%	572	55.5%	1.0
Yes	47	26.0%	458	44.5%	0.4 (0.3-0.6)

	Spontaneous abortions		Single live births		OR (95% CI)
VOMITING *					
No	148	81.3%	668	64.2%	1.0
Yes	34	18.7%	372	35.8%	0.4 (0.3-0.6)
ALCOHOL BEFORE CONCEPTION					
Never	91	48.4%	508	48.8%	1.0
< 1 per week	72	38.3%	419	40.0%	1.0 (0.7-1.3)
1+ per week	25	13.3%	121	11.5%	1.2 (0.8-1.7)
ALCOHOL 1ST TRIMESTER					
Never	160	87.4%	907	86.7%	1.0
< 1 per week	16	8.7%	116	11.1%	0.8 (0.5-1.4)
1+ per week	7	3.8%	23	2.2%	1.7 (0.7-4.0)
CIGARETTE BEFORE CONCEPTION					
0	108	60.0%	666	64.3%	1.0
1-19 per day	41	22.8%	200	19.3%	1.3 (0.9-1.9)
20+	31	17.2%	169	16.3%	1.1 (0.7-1.7)
CIGARETTE 1ST TRIMESTER					
0	135	72.2%	795	75.7%	1.0
1-19 per day	33	17.7%	185	17.6%	1.1 (0.7-1.6)
20+	19	10.2%	70	6.7%	1.6 (0.9-2.7)
MOTHER'S HAIR DYEING *					
No	156	84.3%	879	84.0%	1.0
Yes	29	15.7%	167	16.0%	1.0 (0.6-1.5)
MOTHER'S HAIR PERMANENTS *					
No	137	74.1%	759	72.4%	1.0
Yes	48	26.0%	290	27.7%	0.9 (0.6-1.3)

* Exposures during the first trimester of pregnancy

Table 17: Assessment of confounding: Stratified analyses

	Unadjusted OR *	Range of adj. OR **
COSMETOLOGY 35+ HOURS	1.3 (0.8-2.2)	1.3 - 1.4
<45 customers	1.2 (0.7-2.0)	1.0 - 1.2
45+ customers	1.4 (0.8-2.5)	1.3 - 1.5
0-2 bleaches	1.3 (0.8-2.1)	1.2 - 1.4
3+ bleaches	2.0 (1.0-4.0)	1.5 - 2.2
0-2 dyes	1.1 (0.6-1.9)	1.1 - 1.2
3+ dyes	1.6 (0.9-2.7)	1.5 - 1.7
0-9 permanents	1.2 (0.7-2.0)	1.1 - 1.3
10+ permanents	1.7 (1.0-3.1)	1.5 - 1.9
<3 dyes & <10 permanents	1.0 (0.6-1.9)	1.0 - 1.1
3+ dyes or 10+ permanents	1.4 (0.8-2.4)	1.3 - 1.5
3+ dyes & 10+ permanents	1.9 (1.0-3.7)	1.7 - 2.1
<11 chemical services **	1.1 (0.6-2.0)	1.1 - 1.3
11+ chemical services	1.6 (0.9-2.7)	1.4 - 1.7
No formaldehyde	0.8 (0.4-1.6)	0.8 - 0.9
Formaldehyde	1.6 (1.0-2.7)	1.5 - 1.8
<6 cosmetologists	1.4 (0.8-2.3)	1.3 - 1.5
6+ cosmetologists	1.4 (0.8-2.5)	1.2 - 1.5
No manicuring in salon	1.3 (0.8-2.2)	1.2 - 1.3
Manicuring in salon	1.5 (0.8-2.6)	1.4 - 1.6
No nail sculpturing	1.2 (0.7-1.9)	1.1 - 1.2
Nail sculpturing	2.0 (1.1-3.5)	1.8 - 2.0

* Referent category: 35+ hours in other professions

** Individual adjustment for:
previous miscarriage (no, yes), gravidity (1-2, 3+),
age at conception (<20 years, 20+ years),
family income (<20,000, 20,000+),
alcohol (less than once/week, once or more/week),
cigarette smoking (no, yes)

*** Number of bleaches, dyes, and permanents

Table 18: Assessment of effect modification: Stratified analyses

	OR	(95% CI) *
COSMETOLOGY 35+ HOURS	1.3	(0.8-2.2)
Previous spontaneous abortion		
No	1.3	(0.7-2.3)
Yes	1.4	(0.5-4.4)
Adj. OR	1.3	(0.8-2.2)
Gravidity		
1,2	1.3	(0.8-2.3)
3+	1.2	(0.4-3.3)
Adj. OR	1.3	(0.8-2.1)
Age at conception		
20-36 years	1.4	(0.8-2.3)
<20 years	0.9	(0.1-7.5)
Adj. OR	1.3	(0.8-2.2)
Family income		
$20,000+	1.6	(0.9-2.9)
<$20,000	1.1	(0.5-2.7)
Adj. OR	1.4	(0.9-2.4)
Smoking		
Yes	1.0	(0.5-2.3)
No	1.7	(0.9-3.1)
Adj. OR	1.4	(0.9-2.3)
Alcohol		
Once or more per week	0.8	(0.2-2.5)
Less than once per week	1.4	(0.8-2.3)
Adj. OR	1.3	(0.8-2.0)

* Referent category: 35+ hours in other professions

Table 19a: Logistic regression analyses:
Risk of spontaneous abortion by work status

	Full dataset *		Reduced dataset **		
		Unadj. OR		Unadj. OR	Adj. OR ***
	N	OR (95% CI)	N	OR (95% CI)	OR (95% CI)
OTHER PROFESSIONS					
35+ hours ****	215	1.0	195	1.0	
<35 hours	42	1.6 (0.7-3.9)	41	1.8 (0.8-4.4)	1.4 (0.5-4.1)
COSMETOLOGY					
<35 hours	261	1.0 (0.6-1.8)	235	1.0 (0.6-1.8)	1.0 (0.6-1.9)
35+ hours	428	1.3 (0.8-2.2)	395	1.4 (0.9-2.4)	1.3 (0.8-2.3)
35-40 hours	324	1.2 (0.7-1.9)	301	1.2 (0.7-2.1)	1.2 (0.7-2.1)
41+ hours	104	2.0 (1.1-3.6)	94	2.2 (1.1-4.1)	1.9 (0.9-3.7)
COSMETOLOGY SCHOOL	65	2.5 (1.3-4.8)	60	2.7 (1.3-5.5)	2.6 (1.2-6.0)
HOMEMAKER	227	1.1 (0.6-1.9)	208	1.3 (0.7-2.3)	1.1 (0.6-2.0)

* No exclusion of subjects

** Exclusion of subjects with missing data on confounders

*** Adjustment for previous pregnancy loss (no, yes), gravidity (1-2, 3+),
age at conception (<20 years, 20+ years),
family income (<$20,000, $20,000+)
alcohol (less than once per week, once or more per week),
cigarette smoking (no, yes)

**** Referent category: 35+ hours in other professions

Table 19: Logistic regressions analyses:
35+ hours per week in cosmetology *

	Full dataset **		Reduced dataset ***		
		Unadj. OR		Unadj. OR	Adj. OR ****
	N	OR (95% CI)	N	OR (95% CI)	OR (95% CI)
<45 customers	447	1.2 (0.7-2.0)	411	1.2 (0.6-2.1)	1.1 (0.6-2.1)
45-59 customers	321	1.3 (0.7-2.6)	294	1.4 (0.7-2.9)	1.1 (0.5-2.4)
60+ customers	289	1.6 (0.8-3.3)	265	1.7 (0.8-3.6)	1.6 (0.7-3.7)
0-2 bleaches	560	1.3 (0.8-2.1)	518	1.4 (0.8-2.3)	1.2 (0.7-2.6)
3+ bleaches	279	2.0 (1.0-4.0)	254	1.7 (0.8-3.7)	1.5 (0.6-3.1)
0-2 dyes	420	1.1 (0.6-1.9)	386	1.2 (0.6-2.1)	1.1 (0.6-2.0)
3+ dyes	423	1.6 (0.5-3.3)	390	1.6 (0.9-2.9)	1.5 (0.8-2.4)
0-9 perms	499	1.2 (0.7-2.0)	460	1.3 (0.7-2.2)	1.1 (0.6-2.0)
10+ perms	346	1.7 (1.0-3.1)	317	1.7 (0.9-3.2)	1.7 (0.9-3.7)
<3 dyes & <10 perms	377	1.0 (0.6-1.9)	346	1.1 (0.6-2.1)	1.0 (0.5-2.8)
3+ dyes or 10+ perms	380	1.4 (0.8-2.4)	350	1.4 (0.8-2.6)	1.2 (0.6-2.3)
3+ dyes & 10+ perms	302	1.9 (1.0-3.7)	277	1.8 (0.9-3.6)	1.8 (0.8-3.1)
<11 chem. services	423	1.1 (0.6-2.0)	393	1.3 (0.7-2.3)	1.1 (0.6-2.2)
11+ chem. services	409	1.6 (0.9-2.7)	378	1.6 (0.9-2.8)	1.6 (0.8-2.9)
No formaldehyde	364	0.8 (0.4-1.6)	335	0.9 (0.5-1.8)	0.8 (0.4-1.1)
Formaldehyde	485	1.6 (1.0-2.7)	449	1.7 (1.0-3.0)	1.8 (1.0-2.4)
<6 cosmetologists	476	1.4 (0.8-2.3)	441	1.4 (0.8-2.4)	1.4 (0.8-2.2)
6+ cosmetologists	361	1.4 (0.8-2.5)	330	1.5 (0.8-2.7)	1.2 (0.6-2.6)
Manicuring/salon	453	1.3 (0.8-2.2)	415	1.3 (0.7-2.3)	1.2 (0.7-2.4)
No manicuring	375	1.5 (0.8-2.6)	346	1.6 (0.9-2.8)	1.5 (0.8-2.4)
Nail sculpturing	497	1.2 (0.7-1.9)	455	1.2 (0.7-2.1)	1.2 (0.6-2.3)
No nail sculpt.	329	2.0 (1.1-3.5)	304	2.0 (1.1-3.7)	1.9 (1.0-3.9)

* Referent category: 35+ hours in other professions
** No exclusions of subjects
*** Exclusion of subjects with missing data on confounders
**** Adjustment for previous pregnancy loss (no, yes), gravidity (1-2, 3+),
age at conception (<20 years, 20+ years),
family income (<$20,000, $20,000+),
alcohol (less than once per week, once or more per week),
cigarette smoking (no, yes)

Table 20: Assessment of response bias: Odds ratios for respondents to screening and detailed questionnaire *

	Respondents to screening questionnaire		Respondents to detailed questionnaire	
	SPA**	OR (95% CI)	SPA**	OR (95% CI)
OTHER PROFESSIONS ***	32	1.0	24	1.0
COSMETOLOGY	84	1.0 (0.7-1.6)	56	0.8 (0.5-1.4)
<35 HOURS	19	0.6 (0.3-1.0)	16	0.6 (0.3-1.2)
35+ HOURS	57	1.2 (0.8-2.0)	37	0.9 (0.5-1.6)
COSMETOLOGY STUDENT	11	1.7 (0.8-3.6)	10	2.0 (0.9-4.4)
HOMEMAKER	13	0.4 (0.2-0.8)	10	0.4 (0.2-0.9)
COSMETOLOGY 35+ HOURS				
<60 customers	44	1.2 (0.8-2.0)	28	0.9 (0.5-1.6)
60+ customers	11	1.5 (0.7-3.1)	8	1.1 (0.5-2.6)
0-2 dyes	17	0.8 (0.4-1.5)	10	0.5 (0.2-1.1)
3+ dyes	38	1.7 (1.0-2.8)	27	1.4 (0.8-2.5)
0-9 permanents	20	0.8 (0.4-1.4)	13	0.6 (0.3-1.1)
10+ permanents	35	1.9 (1.2-3.2)	24	1.5 (0.8-2.8)
<3 dyes & <10 perms	7	0.4 (0.2-0.9)	4	0.3 (0.1-0.7)
3+ dyes or 10+ perms	23	1.7 (1.0-3.1)	15	1.2 (0.6-2.4)
3+ dyes & 10+ perms	25	1.8 (1.1-3.2)	18	1.6 (0.8-3.1)

* Based on exposure data in screening questionnaire
** Current spontaneous abortions only
*** Referent category

Table 21: Reliability of self-reported exposure data *

	Information provided in detailed questionnaire	Percent agreement with screening questionnaire	Percent agreement with screening questionnaire	Percent agreement with screening questionnaire
	Current SPA and SLB		Current SPA	SLB
COSMETOLOGY	602	575 (96%)	44 (94%)	531 (96%)
<35 hours	214	172 (80%)	31 (89%)	280 (88%)
35+ hours	358	311 (87%)	6 (67%)	166 (81%)
<60 customers	431	389 (90%)	26 (90%)	363 (90%)
60+ customers	61	32 (52%)	4 (44%)	28 (54%)
0-2 dyes	299	227 (76%)	15 (68%)	212 (77%)
3+ dyes	216	161 (75%)	16 (89%)	145 (73%)
0-9 permanents	394	308 (78%)	18 (62%)	212 (77%)
10+ permanents	120	85 (71%)	9 (90%)	145 (73%)
COSMETOLOGY STUDENT	55	44 (80%)	7 (88%)	37 (79%)
OTHER PROFESSIONS	237	202 (85%)	17 (89%)	201 (85%)
HOMEMAKER	201	177 (88%)	8 (67%)	169 (89%)

* Respondents to detailed questionnaire with exposure data in both the screening and detailed questionnaire; respondents with missing exposure data in either questionnaire were excluded.

Table 22: Effect of exposure misclassification on odds ratios: Respondents to detailed questionnaire

	Exposure based on detailed questionnaire		Exposure based on screening questionnaire	
	SPA*	OR (95% CI)	SPA*	OR (95% CI)
OTHER PROFESSIONS **	23	1.0	24	1.0
COSMETOLOGY				
35+ hours	41	1.1 (0.7-1.9)	37	0.9 (0.5-1.6)
<35 hours	14	0.6 (0.3-1.2)	16	0.6 (0.3-1.2)
COSMETOLOGY 35+ HOURS				
0-2 dyes	18	1.0 (0.5-1.9)	10	0.5 (0.2-1.1)
3+ dyes	23	1.3 (0.7-2.5)	27	1.4 (0.8-2.5)
0-9 permanents	27	1.1 (0.6-2.0)	13	0.6 (0.3-1.1)
10+ permanents	14	1.3 (0.7-2.7)	24	1.5 (0.8-2.8)
<3 dyes & <10 perms	14	1.0 (0.5-2.0)	4	0.3 (0.1-0.7)
3+ dyes or 10+ perms	17	1.2 (0.6-2.4)	15	1.2 (0.6-2.4)
3+ dyes & 10+ perms	10	1.5 (0.7-3.2)	18	1.6 (0.8-3.1)
<60 customers	29	1.0 (0.6-1.8)	28	0.9 (0.5-1.6)
60+ customers	11	1.8 (0.8-3.9)	8	1.1 (0.5-2.6)

* Current spontaneous abortions only
** Referent category

Table 23: Risk of spontaneous abortion: 1983-85 and 1986-88

	1983-1985		1986-1988	
	SPA	OR (95% CI)	SPA	OR (95% CI)
OTHER PROFESSIONS				
35+ HOURS *	10	1.0	17	1.0
COSMETOLOGY				
<35 hours	19	1.4 (0.6-3.2)	15	0.8 (0.4-1.7)
35+ hours	26	1.3 (0.6-2.8)	43	1.4 (0.8-2.6)
35-40 hours	14	0.9 (0.4-2.1)	32	1.3 (0.7-2.5)
41+ hours	12	2.5 (1.0-6.1)	11	1.6 (0.7-3.8)
COSMETOLOGY SCHOOL	10	1.9 (0.8-5.0)	7	5.1 (1.8-14)
HOMEMAKER	20	1.5 (0.7-3.5)	11	0.7 (0.3-1.7)

* Referent category

Table 24: Risk of spontaneous abortion: 35+ hours per week in cosmetology, 1983-85 and 1986-88

	1983-1985		1986-1988	
	SPA	OR (95% CI)	SPA	OR (95% CI)
OTHER PROFESSIONS				
35+ HOURS *	10	1.0	17	1.0
COSMETOLOGY				
35+ HOURS	26	1.3 (0.6-2.8)	43	1.4 (0.8-2.6)
<45 customers	13	1.2 (0.5-2.9)	20	1.1 (0.6-2.3)
45+ customers	9	1.0 (0.4-2.7)	22	1.8 (0.9-3.5)
0-2 bleaches	19	0.9 (0.4-1.8)	34	1.3 (0.7-2.4)
3+ bleaches	5	1.2 (0.4-3.7)	9	2.2 (0.9-5.3)
0-2 dyes	9	0.7 (0.3-1.6)	19	1.2 (0.6-2.5)
3+ dyes	15	1.2 (0.5-2.5)	24	1.7 (0.9-3.2)
0-9 permanents	10	0.5 (0.2-1.2)	31	1.5 (0.8-2.8)
10+ permanents	14	1.9 (0.9-4.2)	12	1.3 (0.6-2.7)
<3 dyes & <10 perms	6	0.6 (0.2-1.5)	15	1.3 (0.6-2.6)
<3 dyes & 10+ perms	3	1.2 (0.3-4.7)	4	1.2 (0.4-3.9)
3+ dyes & <10 perms	4	0.5 (0.2-1.5)	16	1.9 (0.9-4.0)
3+ dyes & 10+ perms	11	2.2 (0.9-5.3)	8	1.3 (0.5-3.2)
<11 chem. services	9	0.9 (0.3-2.2)	22	1.4 (0.7-2.8)
11+ chem. services	15	1.7 (0.7-4.0)	21	1.5 (0.8-3.0)
No formaldehyde	4	0.6 (0.2-2.0)	12	1.0 (0.4-2.1)
Formaldehyde	21	1.6 (0.7-3.5)	30	1.7 (0.9-3.3)
<6 cosmetologists	16	1.2 (0.5-2.7)	27	1.6 (0.8-3.0)
6+ cosmetologists	9	1.5 (0.6-3.9)	15	1.3 (0.6-2.8)
No manicuring/salon	16	1.3 (0.6-3.0)	21	1.3 (0.6-2.6)
Manicuring in salon	9	1.3 (0.5-3.5)	19	1.5 (0.8-3.2)
No nail sculpturing	17	1.1 (0.5-2.6)	23	1.2 (0.6-2.3)
Nail sculpturing	8	2.0 (0.7-5.6)	17	1.9 (0.9-4.0)

* Referent category

REFERENCES

Alderson M. Cancer mortality in male hairdressers. J Epid Comm Health 1980;34:182-85.

Ames BN, Kammen HO, Yamasaki E. Hair dyes are mutagenic: Identification of a variety of mutagenic ingredients. Proc Nat Acad Sci 1975;72:2423-27.

Anonymous. Possible link to chromosomal gaps leads to ban on spray adhesives. JAMA 1973;225:1581-82.

Anthony HM, Thomas GM. Tumors of the urinary bladder: an analysis of the occupations of 1,030 patients in Leeds, England. JNCI 1970;45:879-95.

Axelsson G, Rylander R. Exposure to anaesthetic gases and spontaneous abortion: Response bias in a postal questionnaire study. Int J Epid 1982;11:250-56.

Axelsson G. Selection bias in studies of spontaneous abortion among occupational groups. J Occ Med 1984a;26:525-28.

Axelsson G, Rylander R. Validation of questionnaire reported miscarriage, malformation and birth weight. Int J Epidemiol 1984b;13:94-98.

Axelsson G, Lutz C, Rylander R. Exposure to solvents and outcome of pregnancy in university laboratory employees. Br J Ind Med 1984c;41:305-12.

Axelsson G. Use of questionnaires in a study of spontaneous abortion in a general population. J Epidemiol Commun Health 1990;44:202-04.

Baget L. Understanding MSDS. Nails Magazine 1989 (February): 95-101.

Barlow SM, Sullivan FM. Reproductive hazards of industrial chemicals. London: Academic Press, 1982.

Baxter PJ, McDowall ME. Occupation and cancer in London: An investigation into nasal and bladder cancer using the Cancer Atlas. Br J Ind Med 1986;43:44-49.

Bunin GR, Kramer S, Marrero O, et al. Gestational risk factors for Wilms' tumor: Results of a case-control study. Cancer Res 1987;47:2972-77.

Burnett C, Lanman B, Giovacchini R, et al. Long-term toxicity studies on oxidation hair dyes. Food Cosmet Toxicol 1975;13:353-57.

Burnett CM, Goldenthal EI, Harris SB. Teratology and percutaneous toxicity studies on hair dyes. J Toxicol Env Health 1976;1:1027-40.

Burnett CM, Fuchs CM, Corbett JH. Mutagenicity studies on urine concentrates from female users of dark hair color products. Drug Chem Toxicol 1979;2:283-93.

Burnett CM, Goldenthal EI. Multigeneration reproduction and carcinogenicity studies in Sprague-Dawley rats exposed topically to oxidative hair-coouring formulations containing p-Phynylenediamine and other aromatic amines. Food Chem Toxicol 1988;26:467-74.

California Department of Health Services. California occupational mortality, 1979-81. Sacramento, CA: 1987.

Calnan C. Occupational disorders of hairdressers. In: Zviak C, ed. The science of hair care. New York: Marcel Dekker Inc., 1986.

Cantor KP, Blair A, Everett G, et al. Hair dye use and risk of leukemia and lymphoma. Am J Public Health 1988;78:570-71.

Clemmesen J. Epidemiological studies into the possible carcinogenicity of hair dyes. Mutat Res 1981;87:65-79.

Cole P, Hoover R, Friedell GH. Occupation and cancer of the lower urinary tract. Cancer 1972;29:1250-60.

Dowty SJ, Lasseter JL. The transplacental migration and accumulation in blood of volatile organic constituents. Pediatr Res 1976;10:696-701.

Dubrow R, Wegman DH. Cancer and occupation in Massachusetts: A death certificate study. Am J Ind Med 1984;6:207-30.

Dunham LJ, Rabson AS, Stewart HL, et al. Rates, interviews, and pathology study of cancer of the urinary bladder in New Orleans, Louisiana. JNCI 1968;41:683-709.

Edmonds DK, Lindsay KS, Miller JF, et al. Early embryonic mortality in women. Fertil Steril 1982;38:447-453.

Edmonds LD, Anderson CE, Flynt JW, et al. Congenital central nervous system malformations and vinyl chloride monomer exposure: A community study. Teratology 1978;17:137-42.

Eskenazi B, Bracken MB, Holford TR, et al. Exposure to organic solvents and hypertensive disorders of pregnancy. Am J Industr Med 1988;14:177-88.

Flamm WG. Hair dyes: Laboratory evidence. In IARC: Interpretation of negative epidemiological evidence for carcinogenicity. IARC Scientific Publication, No. 65. Lyon, IARC, 1985.

Froines JR, Garabrant DH. Quantitative evaluation of manicurists exposure to methyl, ethyl and isobutyl methacrylate during production of synthetic fingernails. Appl Ind Hyg 1986;1:70-74.

Garfinkel J, Selvin S, Brown SM. Possible increased risk of lung cancer among beauticians. JNCI 1977;58:141-43.

Giles AL, Chung CW. Dermal carcinogenicity study by mouse-skin painting with 2,4-toluenediamine alone or in representative hair dye formulations. J Toxic Env Health 1976;1:433-440.

Glashan RW, Cartwright RA. Occupational bladder cancer and cigarette smoking in West Yorkshire. Br J Urol 1981;53:602-04.

Gong BT, Smith DW. Normal chromosome findings in spray adhesives users. JAMA 1974;227:1259-60.

Goulet L, Theriault G. Stillbirth and chemical exposure of pregnant workers. (Abstract) Am J Epidemiol 1989;130:835.

Green A, Willet WC, Colditz GA et al. Use of permanent hair dyes and risk of breast cancer. JNCI 1987;79:253-57.

Guberan E, Raymond L, Sweetnam PM. Increased risk for male bladder cancer among a cohort of male and female hairdressers from Geneva. Int J Epid 1985;14:549-54.

Guidotti S, Wright WE, Peters JM. Multiple myeloma in cosmetologists. Am J Ind Med 1982;3:169-71.

Hanson JW, Oakley GP. Spray adhesives and birth defects. (Letter) JAMA 1976;236:101.

Hansson E, Jansa S, Wande H, et al. Pregnancy outcome for women working in laboratories in some of the pharmaceutical industries in Sweden. Scand J Work Env Health 1980;6:131-34.

Hartge P, Hoover R, Altman R, et al. Use of hair dyes and risk of bladder cancer. Cancer Res 1982;42:4784-87.

Hartz SC, Jacques PF. Occupational health surveillance of reproductive outcomes: A case-control study. Final Report for NIOSH contract No. 210-78-0057. Cincinatti, Ohio, 1978.

Heacock HJ, Rivers JK. Occupational diseases of hairdressers. Can J Public Health 1986;77:109-13.

Hecht A. Artificial fingernails: Apply with caution. FDA Consumer 1988 (February):18-21.

Heidam LZ, Olsen J. Self-reported data on spontaneous abortions compared with data obtained by computer linkage with the hospital register. Scand J Soc Med 1985;13:159-63.

Hemminki K, Fransilla E, Vainio H. Spontaneous abortions among female chemical workers in Finland. Int Arch Occup Envion Health 1980a;45:123-26.

Hemminki K, Niemi M-L, Koskinen K, et al. Spontaneous abortions among women employed in the metal industry in Finland. Int Arch Occup Environ Health 1980b;47:53-60.

Hemminki K, Mutanen P, Saloniemi I, et al. Spontaneous abortions in hospital staff engaged in sterilizing instrument with chemical agents. Br Med J 1982;285:1461-63.

Hemminki K, Vineis P. Extrapolation of the evidence on teratogenicity of chemicals between humans and experimental animals. Chemicals other than drugs. Teratogen, Carcinogen, Mutagen 1985;5:251-318.

Hennekens CH, Speizer FE, Rosner B, et al. Use of permanent hair dyes and cancer among registered nurses. Lancet 1979;1:1390-93.

HESIS. Artificial fingernail products. A Guide to chemical exposures in the nail salon. Hazard Evaluation System and Information Service. California Occupational Health Program. Berkely, CA: 1986

Hill AB. The environment and disease: Association and causation? Proc R Soc Med 1965;58:295-300.

Hiipakka D, Samimi B. Exposure of acrylic fingernail sculptors to organic vapors and methacrylate dusts. Am Ind Hyg Assoc 1987;48:230-37.

Hofer H, Bornatowicz N, Reindle E. Analysis of human chromosomes after repeated hair dyeing. Food Chem Toxicol 1983;21:785-89.

Holmberg B. The toxicology of monomers of the polyvinyl plastic series. In: Jarvisalo J, Pfaffly P, Vainio H, eds. Industrial hazards of plastics and synthetic elastomers: Proceedings of the international symposium on occupational hazards related to plastics and synthetic elastomers. New York: Alan R. Liss, 1984.

Holmberg PC, Nurminen M. Congenital defects of the central nervous system and occupational factors during pregnancy. A case-referent study. Am J Ind Med 1980;1:167-76.

Holmberg PC, Hernberg S, Kurppa K, et al. Oral clefts and organic solvent exposure during pregnancy. Int Arch Occ Env Health 1982;50:371-76.

Hopkins HC. Making cosmetics labeling more than skin deep. FDA Consumer 1975 (May):11-12.

Howe GR, Burch JD, Miller AB, et al. Tobacco use, occupation, coffee, various nutrients and bladder cancer. JNCI 1980;64:701-13.

IARC. IARC monographs on the evaluation of the carcinogenic risk of chemicals to man: Some aromatic amines and related nitro compounds - hair dyes, coloring agents and miscellaneous industrial chemicals. Monograph Vol 16. Lyon: IARC, 1978.

IARC. IARC monographs on the evaluation of carcinogenic risk of chemicals to man: Some monomers, plastics and synthetic elastomers, and acrolein -- N-vinyl-2-pyrrolidone. Monograph Vol 19. Lyon: IARC, 1979.

IARC. IARC monographs on the evaluation of carcinogenic risk of chemicals to man: Some aromatic amines, anthraquinones and nitroso compounds, and inorganic fluorides used in drinking-water and dental preparations. Appendix 1: Epidemiological evidence relating to the possible carcinogenic effects of hair dyes in hairdressers and users of hair dyes. Monograph Vol 27. Lyon: IARC, 1982.

Infante PF, Wagoner JK, McMichael AJ, et al. Genetic risks of vinyl chloride. Lancet 1976a;1:734-35.

Infante PF. Oncogenic and mutagenic risks in communities with polyvinyl chloride production facilities. Ann New York Acad Sci 1976b;27:49-57.

Jacobs MM, Burnett CM, Penicnak JA, et al. Evaluation of the toxicity and carcinogenicity of hair dyes in Swiss mice. Drug Chem Toxicol 1984;7:573-86.

Jain M, Morgan RW, Elinson L. Hair dyes and bladder cancer. Can Med Assoc J 1977;117:1131-32.

John EM, Savitz DA. Effect of a monetary incentive on mail survey response. (Abstract) Am J Epidemiol 1989;130:806.

Kalopissis G. Toxicology of hair dyes. In Zviak C (ed): The science of hair care. New York, Marcel Dekker Inc., 1986.

Kiese M, Rauscher E. The absorption of p-toluenediamine through human skin in hair dyeing. Toxicol Appl Pharmacol 1968;13:325-31.

Kinlen LJ, Harris R, Garrod A et al. Use of hair dyes by patients with breast cancer: A case-control study. Br Med J 1977;2:366-68.

Kinlen L. Hair dyes: Epidemiological evidence. In: Interpretation of negative epidemiological evidence for carcinogenicity. IARC Scientific Publication, No. 65. Lyon, IARC, 1985.

Kirkland DJ, Venitt S. Cytotoxicity of hair colourant constituents: Chromosome damage induced by two nitrophenylenediamines in cultured Chinese hamster cells. Mutat Res 1976;40:47-56.

Kirkland DJ, Lawler SD. Chromosomal damage and hair dyes. Lancet 1978;2:124-27.

Kline J, Stein Z, Hatch M. Surveillance of parental employment and spontaneous abortion. Final report for NIOSH contract No. 210-81-5002. Cincinatti, Ohio: 1982.

Kline J, Stein Z. Spontaneous abortion (Miscarriage). In: Bracken MB, ed. Perinatal Epidemiology. New York: Oxford University Press, 1984.

Kline J, Stein Z. Very early pregnancy. In Dixon RL (ed): Reproductive toxicology. New York, Raven Press, 1985.

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, Inc., 1986.

Kline J, Stein Z, Susser M. Conception to birth. Epidemiology of prenatal development. New York: Oxford University Press, 1989.

Kono S, Tokudome S, Ikeda M, et al. Cancer and other causes of death among female beauticians. JNCI 1983;70:443-46.

Kramer S, Ward E, Meadows AT, et al. Medical and drug risk factors associated with neuroblastoma: A case-control study. JNCI 1987;78:797-804.

Kyyronen P, Taskinen H, Lindbohm M-L, et al. Spontaneous abortions and congenital malformations among women exposed to tetrachloroethylene in dry cleaning. J Epidemiol Commun Health 1989;43:346-51.

Lecos C. Cancer, the law, and methylene chloride. FDA Consumer 1986 (February):15-17.

Lemasters GK, Pinney SM. Employment status as a confound when assessing occupational exposures and spontaneous abortion. J Clin Epidemiol 1989;42:975-81.

Lindbohm M-L, Hemminki K, Kyyronen P. Parental occupational exposure and spontaneous abortions in Finland. Am J Epidemiol 1984;120:370-78.

Lindbohm M-L, Taskinen H, Hemminki K. Reproductive health of working women: Spontaneous abortions and congenital malformations. Public Health Rev 1985a;13:55-87.

Lindbohm M-L, Hemminki K, Kyyronen P. Spontaneous abortions among women employed in the plastics industry. Am J Indust Med 1985b;8:579-86.

Lindbohm M-L, Hemminki K. Nationwide data base on medically diagnosed spontaneous abortions in Finland. Int J Epidemio 1988;17:568-573.

Lindbohm M-L, Taskinen H, Sallmen M, et al. Spontaneous abortions among women exposed to organic solvents. Am J Ind Med 1990;17:449-63.

Lowengart RA, Peters JM, Cicioni C, et al. Childhood leukemia and parents' occupational and home exposures. JNCI 1987;79:39-46.

Lynge E, Thygesen L. Use of surveillance systems for occupational cancer: Data from the Danish national system. 1988;17:493-500.

Mackenzie SG, Lippman A. An investigation of report bias in a case-control study of pregnancy outcome. Am J Epidemiol 1989;129:65-75.

Maibach HI, Leaffer MA, Skinner WA. Percutaneous penetration following use of hair dyes. Arch Dermatol 1975;111:1444-45.

Malker HSR, McLaughlin JK, Silverman DT, et al. Occupational risks for bladder cancer among men in Sweden. Cancer Res 1987;47:6763-66.

Mantel N, Haenszel W. Statistical aspects of the analysis of data from retrospective studies of disease. JNCI 1959;22:719-48.

Markovitz JA, Szklo M, Sensenbrenner LL, et al. Hair dyes and acute nonlymphocytic leukemia. (Abstract) Am J Epidemiol 1985;122:523.

Marshall S, Palmer WS. Dark urine after hair coloring. JAMA 1973;226:1010.

Marzulli FN, Weisburger EK. Cosmetics. In: Sontag JM, ed. Carcinogens in industry and the environment. New York: Marcel Dekker, Inc., 1981.

Matinowski GM, Elliott EA. Bladder cancer epidemiology. Epidemiol Reviews 1981;3:203-29.

McDonald AD, Armstrong B, Cherry NM, et al. Spontaneous abortion and occupation. J Occ Med 1986;12:1232-38.

McDonald AD, McDonald JC, Armstron B, et al. Occupation and pregnancy outcome. Br J Ind Med 1987a;44:521-526.

McDonald AD, Lavoie J, Cote R, et al. Chemical exposures at work in early pregnancy and congenital defect: a case-referent study. Br J Ind Med 1987b;44:527-33.

McDonald AD, McDonald JC, Armstron B, et al. Fetal death and work in pregnancy. Br J Ind Med 1988a;45:148-57.

McDonald AD, McDonald JC, Armstrong B, et al. Congenital defects and work in pregnancy. Br J Ind Med 1988b;45:581-88.

McDonald AD, McDonald JC, Armstron B, et al. Prematurity and work in pregnancy. Br J Ind Med 1988c;45:56-62.

Meirik O, Kallen B, Gauffin U, et al. Major malformations in infants born to women who worked in laboratories while pregnant. Lancet 1979;2:91.

Menck HR, Pike MC, Henderson BE, et al. Lung cancer risk among beauticians and other female workers. JNCI 1977;59:1423-25.

Miettinen OS. Estimability and estimation in case-referent studies. Am J Epidemiol 1976;103:226-35.

Miller JF, Williamson E, Glue J, et al. Fetal loss after implantation. A prospective study. Lancet 1980;2:554-56.

Murphy D. Occupational health hazards. In: Griffith-Kenney J. Contemporary women's health. Menlo Park, CA: Addison-Wesley Publishing Company, 1986.

Najen GR, Louria DB, Seebode JJ. Lifetime occupation, smoking, caffeine, saccharine, hair dyes and bladder carcinogenesis. Int J Epidemiol 1982:11:212-17.

Nasca PC, Lawrence CE, Greenwald P, et al. Relationship of hair dye use, benign breast disease, and breast cancer. JNCI 1980;64:23-28.

Nasca PC, Baptiste MS, Field NA, et al. An epidemiologic case-cotnrol study of breast cancer and exposure to hair dyes. (Abstract) Am J Epidemiol 1990;132(4):790-91.

National Cosmetology Association. Occupational safety and health administration's hazard communication standard. The National Cosmetology Association's salon owner manual. St Louis, MO: 1988.

Neutel CI, Nair RC, Last JM. Are hair dyes associated with bladder cancer? Can Med Assoc J 1978;119:307-08.

National Toxicoloty Program. Technical Report 306, NIH Publication No. 85-2562, 1985.

NIOSH. Potential occupational hazards. Vol III, Industrial processes: Hairdressing and barbering. DHEW Publ. No (NIOSH) 81-148-827, 1980.

North Carolina State Board of Cosmetic Art Examiners. Curriculum and rules for recognized schools and colleges of beauty culture. Raleigh, NC: 1980.

Olsen JH, Jensen SP, Hink M, et al. Occupational formaldehyde exposure and increased nasal cancer risk in man. Int J Cancer 1984;34:639-44.

Osorio AM, Bernstein L, Garabrant DH et al. Investigation of lung cancer among female cosmetologists. J Occ Med 1986;28:291-95.

Ostton DD, Weir J, Thornton P. Hazardous substances in the cosmetology workplace. California Board of Cosmetology, 1988.

Office of Technology Assessment. Reproductive health hazards in the workplace. Washington, DC: US GPO, 1985.

Pastides H, Calabrese EJ, Hosmer DW, et al. Spontaneous abortion and general illness symptoms among semiconductor manufacturers. J Occup Med 1988;30:543-51.

Peters TJ, Adelstein P, Golding J, et al. The effects of work in pregnancy: Short- and long-term associations. In: Chamberlain G, ed. Pregnant women at work. London: Royal Society of Medicine, 1984.

Pearce N, Howard JK. Occupation, social class and male cancer mortality in New Zealand, 1974-78. Int J Epidemiol 1986;15:456-62.

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.

Rosenberg MJ, Feldblum PJ, Marshall EG. Occupational influences on reproduction: A review of recent literature. J Occup Med 1987;29:584-91.

Rothman KJ. Modern Epidemiology. Boston: Little, Brown & Company, 1986.

Saurel-Cubizolles MJ, Kaminski M. Work in pregnancy: Its evolving relationship with perinatal outcome (A review). Soc Sci Med 1986;22:431-42.

SAS Institute Inc. SAS/STAT User's Guide, release 6.03 edition. Cary, NC: SAS Institute Inc., 1988.

Savitz DA, Whelan EA, Rowland AS, et al. Maternal employment and reproductive risk factors. Am J Epidemiol 1990;132:933-45

Searle CE, Harnden DG, Venitt S, et al. Carcinogenicity and mutagenic tests of some hair colourants and constituents. Nature 1975;255:506-07.

Searle CE, Jones EL. Effects of repeated applications of two semi-permanent hair dyes to the skin of A and DBAF mice. Br J Cancer 1977;36:467-78.

Selevan SG. Design considerations in pregnancy outcome studies of occupational populations. Scand J Work Envion Health 1981;7(suppl 4):76-82.

Selevan SG, Lindbohm M-L, Hornung RW, et al. A study of occupational exposure to antineoplastic drugs and fetal loss in nurses. N Engl J Med 1985;313:1173-78.

Shafer N, Shafer RW. Potential of carcinogenic effects of hair dyes. New York State J Med 1976;76:394-96.

Shilling S, Lalich NR. Maternal occupation and incustry and the pregnancy outcome of U.S. married women, 1980. Public Health Rep 1984;99:152-61.

Shore RE, Pasternack BS, Thiessen EU, et al. A case-control study of hair dye use and breast cancer. JNCI 1979;62:277-83

Shulman B. Testimony at the Congressional Hearing (chaired by Ron Wyden) on health and safety problems associated with the use of common cosmetics. July 1988

Silberg SL, Ransom DR, Lyon JA, et al. Relationship between spray adhesives and congenital malformations. South Med J 1979;72:1170-73.

Silverman DT, Hoover RN, Albert S, et al. Occupation and cancer of the lower urinary tract in Detroit. JNCI 1983;70:237-45.

Silverman J, Kline J, Hutzler M, et al. Maternal employment and the chromosomal characteristics of spontaneously aborted conception. J Occup Med 1985;27:427-38.

Skov T, Andersen A, Malker H, et al. Risk for cancer of the urinary bladder among hairdressers in the Nordic Countries. Am J Ind Med 1990;17:217-23.

Spiegelhalder B, Preussmann R. Contamination of toiletries and cosmetic products with volatile and nonvolatile N-nitroso carcinogens. J Cancer Res Clin Oncol 1984;108:160-3.

Spinelli JJ, Gallagher RP, Band PR, et al. Multiple myeloma, leukemia, and cancer of the ovary in cosmetologists and hairdressers. Am J Ind Med 1984;6:97-102.

Stavraky KM, Clarke EA, Donner A. Case-control study of hair dye use by patients with breast cancer and endometrial cancer. JNCI 1979;63:941-45.

Stein Z, Kline J, Susser E, et al. Maternal age and spontaneous abortion. In: Porter IH, Hook EB, eds. Human embryonic and fetal death. New York: Academic Press, 1980.

Stellman JS. Occupational health hazards of women: An overview. Prev Med 1978;7:281-93.

Stenback FG, Rowland JC, Russel LA. Non-carcinogenicity of hair dyes: Lifetime percutaneous applications in mice and rabbits. Food Cosmet Toxicol 1977;15:601-06.

Stucker I, Caillard J-F, Collin R, et al. Risk of spontaneous abortion among nurses handling antineoplastic drugs. Scand J Work Envion Health 1990;16:102-7.

Swenberg JA, Kerns WD, Mitchell RI, et al. Induction of squamous carcinomas of the rat nasal cavity by inhalation exposure to formaldehyde vapor. Cancer Res 1980;40:3398-3402.

Taskinen H, Lindbohm M-L, Hemminki K. Spontaneous abortions among women working in the pharmaceutical industry. Br J Ind Med 1986;43:199-205.

Taskinen H, Anttila A, Lindbohm M-L, et al. Spontaneous abortions and congenital malformations among the wives of men occupationally exposed to organic solvents. Scand J Work Environ Health 1989;15:345-52.

Teta JM, Walrath J, Meigs JW, et al. Cancer incidence among cosmetologists. JNCI 1984;72:1051-57.

Tikkanen J, Heinonen OP. Cardiovascular malformations and organic solvent exposure during pregnancy in Finland. Am J Ind Med 1988;14:1-8.

Turanitz K, Kovac R, Tuschl H, et al. Investigations on the effect of repeated hair dyeing on sister chromatid exchanges. Food Chem Toxicol 1983;21:791-93.

US Bureau of the Census. 1980 Census of population. Washington, DC: US GPO, 1984.

US Department of Labor, Bureau of Labor Statistics. Employment and Earnings. Washington, DC: US GPO, 1983.

Vaughan TL, Daling JR, Starzyk PM. Fetal death and maternal occupation. J Occup Med 1984;26:676-678.

Viadana E, Bross ID, Houten L. Cancer experience of men exposed to inhalation of chemicals or to combustion products. J Occ Med 1976;18:787-92.

Vianna N, Polin A. Incidence of low birth weight among Love Canal residents. Science 1984;226:1217-19.

Vineis P, Magnani C. Occupation and bladder cancer in males: A case-control study. Int J Cancer 1985;35:599-606.

Walrath J. Cancer incidence among cosmetologists. PhD dissertation. New Haven, CT: Yale University, 1977.

Weisburger EK, Russfield AB, Homburger F, et al. Testing of twenty-one environmental aromatic amines or derivatives for long-term toxicity or carcinogenicity. J Env Path Toxicol 1978;2:325-56.

Whittaker PG, Taylor A, Lind T. Unsuspected pregnancy loss in health women. Lancet, 1983;1:1126-27.

Wilcox AJ, Horney LF. Accuracy of spontaneous abortion recall. Am J Epid 1984;120:727-33.

Wilxoc AJ, Weinberg CR, O'Connor JF, et al. Incidence of early loss of pregnancy. New Engl J Med 1988;319:189-94.

Wolfram LJ, Maibach HI. Percutaneous penetration of hair dyes. Arch Dermatol Res 1985;277:235-41.

Wynder EL, Onderdonk J, Mantel N. An epidemiologic investigation of cancer of the bladder. Cancer 1963;16:1388-1407.

Wynder EL, Goodman M. Epidemiology of breast cancer and hair dyes. JNCI 1983;71:481-88.

APPENDIX 1

CHEMICAL SUBSTANCES IN FREQUENTLY USED COSMETIC PRODUCTS

SHAMPOOS	Surfactants:	Fatty alcyl sulfates (i.e., lauryl sulfates, alkyl ether sulfates) Fatty acid alkanolamides
	Additives:	Ethyl alcohol, propylene glycol, alkylolamides, perfumes, dyes
	Preservatives:	Formaldehyde
BLEACH	Hydrogen peroxide, ammonium hydroxide	
HAIR DYES	Aromatic, nitro, and amino compounds 2,4-diaminotoluene, 2,4-diaminoanisole, 4-amino-2-nitrophenol, 2-nitro-para-phenyl-enediamine hydrogen peroxide, lead acetate	
PERMANENT SOLUTIONS	Ammonium or sodium thioglycolate, hydrogen peroxide,	
HAIR SPRAY	Resins:	Polyvinylpyrrolidone (PVP), PVP vinyl acetate copolymer
	Solvents:	Ethanol, methylene chloride,
	Propellants:	Isobutane, butane, propane
	Perfumes	
NAIL POLISH AND POLISH REMOVER	Methyl ethyl ketone, toluene, acetone, xylene, ethyl ether, ethyl acetate, butyl acetate, isopropyl alcohol,	
ARTIFICIAL NAILS	Methacrylates (polymethyl methacrylate, methyl methacrylate, ethyl methacrylate, isobutyl methacrylate, butyl methacrylate, methacrylic acid), ethyl cyanoacrylates, glycol ether, benzoyl peroxide, o-toluidine, methylene chloride, formaldehyde,	
ARTIFICIAL NAIL REMOVER	Acetonitrile, acetone, ethyl ether	