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Occupational Chemical Exposures Among Cosmetologists:

Risk of Reproductive Disorders

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Abstract

More research is needed to understand possible occupational reproductive risks for cosmetologists, specifically hairdressers and nail technicians, two occupations that often share workspace and exposure to hair dyes and nail polish. Cosmetologists are predominantly females of reproductive age; thus, they may be at higher risk for the effects of exposure to reproductive toxins. The purpose of this article is to inform nurses and public health professionals about occupational exposures for cosmetologists and discuss interventions to reduce the risks of reproductive disorders among susceptible worker populations.

Cosmetology is a predominantly female occupation; more than half a million women in the United States are employed as cosmetologists (Bureau of Labor Statistics, 1991), using their skills to apply beauty treatments. Cosmetologists typically provide pedicures, manicures, facials, and other beauty treatments (Halliday-Bell, Gissler, & Jaakkola, 2009).

Cosmetology has many specialties, including hairdressers and nail technicians. More than one million individuals are licensed as cosmetologists in the United States, the majority being women (Gallicchio, Miller, Greene, Zacur, & Flaws, 2010), and several million individuals practice as hairdressers and barbers worldwide (World Health Organization, International Agency for Research on Cancer [IARC], 1993). The number of registered manicurists has increased by 345% in the United States, to more than 393,000, since 1991 (Roelofs, Azaroff, Holcroft, Nguyen, & Doan, 2008), and the 10-year employment growth projection for nail technicians is 28% (Reutman et al., 2009). Hairdressers and nail technicians are predominantly female, and many are of reproductive age (Halliday-Bell et al., 2009). As these workers often start their careers before the age of 20, it is assumed that

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many begin working before considering family planning (Baste, Moen, Riise, Hollund, & Øyen, 2008). This assumption raises concerns because these women of reproductive age are at higher risk for the effects of exposure to potential reproductive toxins.

Hairdressers use a wide range of products, including shampoos, hair dyes, hair sprays, straighteners, and bleaches. Hair dyes represent the largest segment of chemical products in the hair market today. As such, they are the main source of chemical exposure among hairdressers (Ronda, Hollund, & Moen, 2009). The process of dyeing human hair can be traced back at least 4,000 years. Evidence from Egyptian tombs indicates the use of henna for dyeing hair, nails, and skin (World Health Organization, 1993). These products may play a positive role in improving quality of life, due to the human desire to improve appearance; individuals' frequent contact with these products requires the ingredients be safe (Nohynek, Fautz, Benech-Kieffer, & Toutain, 2004). Approximately 35% to 40% of women living in the United States use hair dyes, applied personally or by a hairdresser (McCall, Olshan, & Daniels, 2005).

Among nail technicians, nail polish is the product most often used and the main potential source of chemical exposure for them. Common nail polish ingredients include toluene, plasticizers (i.e., dibutyl phthalate), and formaldehyde (U.S. Food and Drug Administration [FDA], 2013). Toluene is a widely used industrial solvent. Toluene inhalation ("sniffing" of paint reducer or paint thinner) during pregnancy has led to neonatal effects, including intrauterine growth retardation, premature delivery, congenital malformations, and postnatal developmental retardation (Donald, Hooper, & Hopenhayn-Rich, 1991). Dibutyl phthalate, which keeps polish from becoming brittle and chipping, has been linked to reproductive issues in humans if the mother is exposed while pregnant and has been banned for use by the European Union (Pak, McCauley, & Pinto-Martin, 2011). Nail technicians handle fewer chemicals than hairdressers, but they frequently share a workspace with hairdressers and sometimes perform some of the same tasks. The shared space and dual roles increase occupational exposures for both groups (Halliday-Bell et al., 2009).

More than 9,000 chemicals are found in cosmetic products (Halliday-Bell et al., 2009). Hair dyes are classified as permanent, semi-permanent, and temporary, each having its own chemical formulation (McCall et al., 2005). For nail polish, a typical nail treatment in a salon takes 1 hour or more and includes application of a base coat of nail polish, two coats of the colored nail polish, and then a top coat (World Health Organization, 1993). Both occupations require long shifts during which hairdressers and nail technicians offer a variety of services.

Hairdressing has been reported to be associated with a variety of health issues, including dermatitis, cancer, and respiratory problems (Ronda, Garcia, Sánchez-Paya, & Moen, 2009). In a meta-analysis of 42 studies, a statistically significant increased risk for bladder cancer was found among hairdressers, specifically those who had held the job for more than 10 years (Harling, Schablon, Schedlbauer, Dulon, & Nienhaus, 2010). Alternatively, a review conducted by Nohynek et al. (2004) concluded that evidence suggests that occupational exposure to hair dyes poses no carcinogenic or other human health risk. However, this review focused on acute toxicity and health effects of hair dyes, not on the potential long-

term reproductive effects of exposure. The evidence related to the harmful effects of hair dyes and nail polish on reproductive health is limited.

The most common chemicals mentioned in select studies about hair dye and nail polish were nitrosamines in hair dye, toluene in nail polish, and formaldehyde in both hair dye and nail polish (Table).

NITROSAMINES

The primary ingredient in hair dyes is aromatic amines, which are precursors of nitrosamines (McCall et al., 2005). Nitrosamines require bioactivation and have shown mutagenicity in vitro and carcinogenic properties in vivo (Holly, Bracci, Hong, Mueller, & Preston-Martin, 2002). The actual reproductive risk of nitrosamines is unclear due to limited data (Kersemaekers, Roeleveld, & Zielhuis, 1995).

TOLUENE

The organic solvent toluene, a common ingredient in nail polish and among the most common exposures in the workplace, has been linked to less fetal growth and shorter pregnancy duration (Hannigan & Bowen, 2010). Rapidly absorbed through the lungs, toluene vapors are distributed to highly perfused and fatty tissues. Organic solvents such as toluene have an affinity for lipid-rich tissues and readily cross the placental barrier (Bukowski, 2001). Little is known about the mechanisms of action for toluene; it is unclear how it is absorbed and distributed through the body (Hannigan & Bowen, 2010).

FORMALDEHYDE

Formaldehyde is found in both hair dye and nail polish. Formaldehyde is considered a human carcinogen by the IARC, the U.S. National Toxicology Program (NTP), the U.S. Environmental Protection Agency (EPA), and the Occupational Safety and Health Administration (OSHA). Formaldehyde has been associated with nasal cancers in workers exposed in occupational settings (Agency for Toxic Substances and Disease Registry [ATSDR], 1999; EPA, 2010; NTP, 2010). Formaldehyde has been named a Group 1 carcinogen by the IARC, meaning that “there is sufficient evidence in humans for the carcinogenicity of formaldehyde” (World Health Organization, IARC, 2006). The NTP classified formaldehyde as “reasonably anticipated to be a human carcinogen,” although there is currently a proposal to reclassify formaldehyde as “known to be a human carcinogen” (NTP, 2010). Reproductive and developmental toxicity have been speculated to be associated with formaldehyde for some time, but this has not been confirmed. Although a small number of human studies have suggested that formaldehyde exposure may cause reproductive toxicity, the current understanding of the mechanisms of action is limited. Currently, formaldehyde’s mechanisms of action are proposed to induce reproductive and developmental toxicity via genotoxicity, oxidative stress, disruption of the activity of proteins, enzymes, and hormones important for the maturation of the male reproductive system, apoptosis, and DNA methylation (Duong, Steinmaus, McHale, Vaughan, & Zhang, 2011). These mechanisms are hypothetical and require validation, particularly for reproductive system effects (Duong et al., 2011).

RELEVANT STUDIES OF REPRODUCTIVE HAZARDS

Hairdressers

In a study comparing female hairdressers to female office worker and shop assistant controls ($n = 310$), an increased risk for subfertility and menstrual disorders was found among the hairdressers (Ronda et al., 2009). However, further research is needed to clarify which occupational exposure explains this association.

Another study, involving self-reported reproductive health of women in Norway, found a significant increase in infertility and spontaneous abortions among hairdressers compared to women in other occupations (Baste et al., 2008). John, Savitz, and Shy (1994) reported similar findings, observing associations among spontaneous abortion, the number of hours worked per day, and the number of chemical services performed per week. That study focused on assessing whether working in cosmetology during the first trimester of pregnancy was associated with an increased risk of spontaneous abortion. Part-time work as a cosmetologist was not associated with increased spontaneous abortion risk, and no associations were found for cosmetologists who worked less than 35 hours per week and provided few chemical services (John et al., 1994). However, this study was based on a mail survey. Mail surveys are subject to non-response bias, which occurs if the answers of respondents differ from potential answers of nonrespondents.

One study found that hairdressers and the general population exhibited similar rates of infertility (Hougaard, Hannerz, Bonde, Feveile, & Burr, 2006). This did not support the hypothesis that hairdressers are at increased risk of infertility. However, a potential source of bias in this study related to care-seeking behavior. For instance, for a variety of reasons, some women may have less access to health care or be more likely to avoid seeking care; this bias could have led to an inaccurate finding in this study (Hougaard et al., 2006).

Another study found an increased risk of prolonged “time-to-pregnancy” of more than 12 months for hairdressers (Kersemackers, Roeleveld, & Zielhuis, 1997). An historical cohort study was conducted in the Netherlands examining two time periods, conceptions in 1986 to 1988 and 1991 to 1993, as exposure to reproductive toxic agents in hair salons could have changed during this time. These periods were chosen based on the enactment of bans on the use of dichloromethane and several dye formulations in 1990 in the United States and several European countries. The results demonstrated an increased risk of spontaneous abortions for those hairdressers who conceived in 1986 to 1988. For the hairdressers who conceived in 1991 to 1993, no increased risk of spontaneous abortions was found. The results indicated increased reproductive risk for hairdressers in earlier years that appeared to decrease over time. These results agree with those of John et al. (1994), who found an increased risk of spontaneous abortions among cosmetologists, using pregnancy data from 1983 to 1988; however, they found increased risks only among those who worked more than 35 hours per week.

Kersemackers et al. (1995) evaluated reproductive disorders due to chemical exposure among hairdressers to determine risk and identify the activities and agents most likely to cause such effects. They found inconsistent results from epidemiologic studies and limited

human data on the reproductive risks of chemicals and chemical amounts used in salons, leading to few data-driven conclusions (Kersemaekers et al., 1995). Axmon, Rylander, Lillienberg, Albin, and Hagmar (2006) found prolonged “time-to-pregnancy” among hairdressers. However, this finding could have potentially been confounded by stressful work situations, as chemicals handled by hairdressers were not strongly supported or controlled in the study. Miscarriage risk was not higher for hairdressers compared to referents, and risks were not statistically significantly increased for most hair treatments (Axmon et al., 2006). The study results were consistent with those of a previous study involving hairdressers in which an increased risk for subfertility was found (Kersemaekers et al., 1997).

Hairdressers and Nail Technicians

Several other studies explored occupational risk for infertility associated with cosmetology. By examining associations between cosmetologists and fertility in the general population through a reproductive and occupational history survey and a listing of particular job responsibilities in salons, one study determined that cosmetologists are not at increased risk for infertility compared to women of the same age working in other occupations (Peretz et al., 2009). A review of publications was conducted on the association between occupational exposure in the hairdressing profession and fertility; it was determined that evidence for risks was low but fertility disorders could not be excluded (Peters et al., 2010). In exploring whether cosmetologists are at increased risk of miscarriage and other negative pregnancy outcomes compared to controls who are not cosmetologists, one study found no statistically significant associations between occupation and miscarriage (Gallicchio, Miller, Greene, Zacur, & Flaws, 2009). The researchers determined cosmetologists do not have an increased risk of adverse pregnancy outcomes compared with women of the same age in other occupations. They also found no increased risk of menstrual cycle abnormalities for cosmetologists of reproductive age compared to women of the same age working in other occupations (Gallicchio et al., 2010).

MECHANISMS OF ACTION

The majority of studies showing occupational reproductive effects among hairdressers and nail technicians suggest that chemical exposure is the probable cause of these findings (Ronda et al., 2009). However, the effects of exposures to mixtures of chemicals, such as those found in salons, are largely unknown (Hougaard et al., 2006). The evidence is inconclusive regarding hair dyes and potential human carcinogenicity. Regarding carcinogenicity, the primary concern is chemical absorption through human skin (McCall et al., 2005). However, the level of absorption depends on the extent of dermal contact (Kersemaekers et al., 1995). Hair dyes are found in many forms (i.e., liquids, creams, gels, shampoos, and rinses), and the method of application may affect exposure. As an example, permanent cream dyes are commonly applied with a brush, whereas other dyes are more often worked into the hair by hand. The major route of entry for hair dye chemicals is cutaneous absorption (Kersemaekers et al., 1995).

The main concern with nail polish is inhalation exposure. Working in close proximity to multiple agents exposes nail technicians to potential sensitizers and respiratory irritants

(Reutman et al., 2009). Nail technicians commonly inhale and breathe harmful vapors, dusts, or mists, and can get the product on their skin or in their eyes or can swallow the product if it is accidentally transferred onto food or cigarettes (OSHA, 2013). These exposures can accumulate if the products are used daily or if poor ventilation exists in salons (OSHA, 2013). Chemical exposure over time is a concern. Several other potentially hazardous chemicals can affect workers in nail salons. Acetone (nail polish remover) can cause headaches, dizziness, and eye, skin, and throat irritation. Acetonitrile (fingernail glue remover) can cause nose and throat irritation, breathing problems, nausea, and vomiting. Ethyl methacrylate (artificial nail liquid) can cause asthma, eye, skin, nose, and mouth irritation, and reproductive effects for the fetus if exposure occurs during pregnancy (OSHA, 2013). The Table provides additional details on the chemicals most frequently cited as being associated with reproductive issues in salons.

POLICY AND IMPLICATIONS

Cosmetic safety falls under the jurisdiction of the FDA, and personal care products are regulated under the Food, Drug, and Cosmetic Act (Nohynek et al., 2004). Concerning the safety of all personal care product ingredients, the cornerstone of U.S. cosmetic regulations includes the principles that a personal care product must not cause damage to human health and manufacturers are responsible for the safety of any product on the market (Antignac, Nohynek, Re, Clouzeau, & Toutain, 2011). In 1976, the Cosmetic Ingredient Review (CIR) was established by the Personal Care Products Council, formerly the Cosmetic, Toiletry, and Fragrance Association. The CIR allows the industry to represent itself and self-regulate through an Expert Panel that reviews relevant data on cosmetic ingredients and determines, under current conditions of use, whether cosmetics are safe (Antignac et al., 2011). However, the Environmental Working Group, a non-profit research organization, investigated and found that the CIR only reviewed 11% of the more than 10,000 cosmetic ingredients listed with the FDA, calling into question the adequacy of self-regulation in protecting occupational and consumer safety (Roelofs et al., 2008).

Worker health and safety in nail salons is covered by the Occupational Safety and Health Act. However, due to their small size and the belief that salons do not have significant health hazards, few have been inspected. In 2005, just 18 nail salons were inspected by the OSHA (Roelofs et al., 2008). In the United States, a total of 375,000 nail technicians work in salons. The lack of oversight in salons is expected because companies qualify for partial exemption if they employ no more than 10 employees.

Toxicological considerations play an increasingly significant role in product formulation; however, reproductive risks are typically not taken into account (Kersemakers et al., 1995). For example, many of these studies focus on acute end points of health, not long-term cumulative effects of chronic exposure. In the past, several types of aromatic amines, which were recognized as causing urothelial cancers, were ingredients in hair dyes. Because human urothelial cancers chemically induced by aromatic amines usually have a latency period of 30 or 40 years, it is unknown whether hairdressers who began working after 1980, when these known carcinogenic compounds were banned from hair dye, will have an increased risk of bladder cancer (Harling et al., 2010). This ban did demonstrate that changes have

been made in this industry to protect the health of workers and that product manufacturers were able to meet the new regulation. As an example of a policy affecting the occupational health of salon workers, specific regulations were enacted in 1978 and several aromatic amines in hair dyes were banned in the European Union, which values the precautionary approach to environmental health.

The introduction of the Safe Cosmetics Act of 2011 was an attempt to update the Food, Drug and Cosmetic Act of 1938 (U.S. Government Printing Office, 2011). Under the current law, the FDA cannot require cosmetic companies to conduct safety assessments. If enacted, the law would have included such provisions as phasing-out ingredients linked to cancer and developmental harm and eliminating labeling loopholes by mandating full ingredient disclosure on labels. This law would also have included full disclosure of salon products (The Campaign for Safe Cosmetics, n.d.). The Safe Cosmetics Act of 2011 was not enacted.

Employers should read the material safety data sheet (MSDS) for each product used in the salon that may contain hazardous chemicals at 1% or more (or 0.1% or more for chemicals that may cause cancer) or that may be released into the air above limits set by OSHA or the American Conference of Governmental Industrial Hygienists (ACGIH). The MSDS explains the health risks of the product and lists the precautions necessary for worker protection. Employers must also provide MSDSs in a place near where the product is used so workers can conveniently access the information. Employers are also required to provide information and training to all workers who use the product about the chemical's potential hazards and how to use the product safely. The MSDS provides the following: hazardous ingredients in the product; how users can be exposed to the ingredients; health and safety risks to users when using the product; and precautions for safely using and storing the product, including what to do in emergencies (OSHA, n.d.a).

FUTURE DIRECTIONS AND IMPLICATIONS FOR OCCUPATIONAL HEALTH NURSES

Although the majority of studies showing adverse reproductive effects suggest that the cause could be occupational chemical exposure, more research is needed to determine which particular occupational exposures may explain the association. Because hairdressers and nail technicians can be exposed to a mixture of different chemicals, it is challenging to detect possible reproductive hazards through epidemiological studies (Baste et al., 2008). To protect hairdressers and nail technicians from potential reproductive disorders, occupational health nurses could conduct a safety assessment of finished products, taking into consideration the toxicology profile of the ingredients, their chemical structure, and both human external and systemic exposures (Antignac et al., 2011).

More research and more human data are needed to determine which chemicals present in salons may be responsible for the findings in these studies (Ronda et al., 2009). Because the chemical environment in salons has changed over time, reproductive risks that were present in earlier years may have changed as well (Kersemakers et al., 1995). New molecular epidemiological and longitudinal studies are needed to investigate developmental and reproductive toxicity in females to better understand the effects of formaldehyde (Duong et

al., 2011) and other chemicals present in hair dye and nail polish. Additionally, further study is needed to determine how formaldehyde reaches the reproductive system (Duong et al., 2011). Also, the effectiveness of nontoxic hair dyes should be explored further.

Occupational health nurses and public health professionals should provide relevant health and safety education to workers to minimize their exposure to chemicals present in hair dye and nail polish. By asking workers about the products and chemicals they handle each day, occupational health nurses and other health care providers can inform hairdressers and nail technicians of best practices to reduce exposure from inhalation and skin contact. Providing relevant health and safety information to nail salon workers and hairdressers could reduce hazards in the work environment (Roelofs et al., 2008). For example, occupational health nurses and other health care providers could educate workers on how to reduce occupational exposures to chemicals through proper ventilation, which is perhaps the most significant factor in achieving acceptable air quality in salons (Tsiongia et al., 2010). Installing exhaust fans wherever possible or opening doors and windows could increase air circulation. Typical masks used by nail technicians (i.e., N95 dust masks) are not appropriate for protection from chemical vapors; only certain types of respirators—those with organic carbon chemical cartridges or supplied air—can prevent the inhalation of chemical vapors (e.g., formaldehyde) (Roelofs et al., 2008).

Occupational health nurses and public health professionals can:

- Be aware of susceptible workers, such as cosmetologists, who may be trying to become pregnant and warn them about chemicals that could harm the fetus even though these chemicals may not have an immediate effect on them (Bracy, 2011). The effect of chronic low-dose chemical exposure over a long period is a concern.
- Refer workers to resources including the EPA's Protecting the Health of Nail Salon Workers for a checklist of best shop practices for owners and workers (EPA, 2007) and OSHA's Stay Healthy and Safe While Giving Manicures and Pedicures (OSHA, n.d.b).
- Be sensitive to cultural barriers that may prevent access to critical occupational health and safety information and educate susceptible populations on the availability of safe nail salon training in different languages, such as Vietnamese (OSHA, n.d.a).

Occupational health nurses and public health professionals can also advocate for policy changes to protect worker health and safety. Although providing information to workers is essential, intervention is also needed from salon to policy level. For example, occupational health nurses and public health professionals must advocate for workers with salon licensing boards to ensure that salons have adequate ventilation and that nail product manufacturers reformulate their products to reduce chemical hazards (Roelofs et al., 2008). Several U.S. cosmetics makers (e.g., Revlon, Proctor & Gamble, and Estee Lauder) have reformulated some of their nail products in response to new European restrictions on toxic cosmetic ingredients. These product changes have the potential to reduce exposure to chemicals among salon workers, particularly if similar restrictions are implemented in the United States. Occupational health nurses can advocate for such changes (Roelofs et al., 2008).

CONCLUSION

This article informs occupational health nurses and other health care professionals of the occupational chemical exposures of hairdressers and nail technicians. Cosmetologists may be at higher risk for exposure to potential reproductive toxins. Occupational health nurses and public health professionals are in an ideal position to educate susceptible worker populations to reduce exposures and ultimately improve reproductive health.

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IN SUMMARY

1. Occupational health nurses and public health professionals may provide relevant health and safety education such as proper workplace practices (i.e., proper ventilation, handwashing) to minimize occupational chemical exposures among hairdressers and nail technicians.
2. Occupational health nurses and public health professionals should be cognizant of susceptible cosmetology workers, such as hair dresser and nail technician, who may be at risk for reproductive health problems and warn these workers about chemicals that could influence fertility and harm the fetus.
3. More research is needed to understand possible occupational reproductive risks for hairdressers and nail technicians.

Table

Most Frequently Cited Chemicals

Occupational Exposure	Chemical	Reproductive Outcome	Possible Mechanism of Action
Hair dye	Nitrosamines	Undetermined	Undetermined
Nail polish	Toluene	Spontaneous abortion	Undetermined
Hair dye and nail polish	Formaldehyde	Alterations to female reproductive and endocrine systems	Genotoxicity, oxidative stress, disruption of the activity of proteins, enzymes, and hormones important for the maturation of the male reproductive system, apoptosis, and DNA methylation