

Adverse birth outcomes and maternal complications in licensed cosmetologists and manicurists in California

Thu Quach · Julie Von Behren · Debbie Goldberg ·
Michael Layefsky · Peggy Reynolds

Received: 1 July 2014 / Accepted: 3 December 2014 / Published online: 14 December 2014
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Abstract

Purpose Due to concerns around occupational chemical exposures, this study sought to examine whether women working as cosmetologists (providing hair and nail care services) and manicurists (providing only nail care services) have an elevated risk for adverse pregnancy outcomes.

Methods In this population-based retrospective study of cosmetologists and manicurists in California, we linked cosmetology licensee and birth registry files to identify births during 1996–2009. We compared outcomes among cosmetologists and manicurists to those of the general female population and to women from other industries. We also conducted restricted analyses for Vietnamese women, who comprise a significant proportion of the workforce.

Results There was little evidence of increased risk for adverse birth outcomes, but we observed an association for small for gestational age (SGA) among Vietnamese manicurists (OR 1.39; 95 % CI 1.08–1.78) and cosmetologists (OR 1.40; 95 % CI 1.08–1.83) when compared to other working women. Some maternal complications were observed, notably an increased risk for gestational diabetes (OR 1.28; 95 % CI 1.10–1.50 for manicurists; OR 1.19; 95 % CI 1.07–1.33 for cosmetologists) compared with the general population, which further elevated when restricted

to Vietnamese workers (OR 1.59; 95 % CI 1.20–2.11 for manicurists; OR 1.49; 95 % CI 1.04–2.11 for cosmetologists). Additionally, we observed an association for placenta previa among manicurists (OR 1.46; 95 % CI 1.08–1.97) and cosmetologists (OR 1.22; 95 % CI 1.02–1.46) compared with the general population.

Conclusions Women in the nail and hair care industry may be potentially at increased risk for some maternal complications, although further research is warranted. Vietnamese workers may also have increased risk for SGA.

Keywords Occupation · Birth outcomes · Cosmetologists · Manicurists · Women's health

Background

The number of beauty salons providing hair and nail care services has increased significantly in recent decades. According to industry estimates, there are currently over 58,000 beauty salons employing nearly 350,000 nail and hair technicians in the USA (Nails Magazine 2006). California has the largest cosmetology industry, mainly due to the rapid growth of the nail care sector in recent decades (Sheriff 2008), with over 114,000 licensed manicurists as of 2007 (Sheriff 2008). A majority of the cosmetology workers are women of child-bearing ages (Nails Magazine 2006). Interestingly, the number of Vietnamese workers in the nail salon sector has also grown significantly, with the proportion of licensed Vietnamese manicurists having increased from 10 % in 1987 to 59 % in 2002 (Federman et al. 2006).

Hair and nail care workers in this industry are exposed daily to toxic and potentially hazardous chemicals in personal care products, including compounds known to be linked to reproductive harm. Chemical ingredients include

T. Quach (✉) · J. Von Behren · D. Goldberg · M. Layefsky ·
P. Reynolds
Cancer Prevention Institute of California, 2001 Center Street,
Suite 700, Berkeley, CA 94704, USA
e-mail: thu.quach@cpic.org

J. Von Behren
e-mail: julie.vonbehren@cpic.org

T. Quach · P. Reynolds
Department of Health Research and Policy, Stanford University
School of Medicine, Stanford, CA, USA

volatile solvents (e.g., formaldehyde, methacrylates, acetone, and toluene), plasticizers (e.g., dibutyl phthalates), and other toxic substances. Many of the compounds that cosmetologists and manicurists routinely handle have been shown to cause reproductive abnormalities in animal studies (Marks et al. 1981; Moorman et al. 2000). A number of chemicals found in beauty products, such as phthalates and parabens, can cause endocrine disruption. Phthalates found in nail polishes, hair sprays and gels are linked to teratological effects, especially of the male reproductive system (Bustamante-Montes et al. 2008; Duty et al. 2005, 2003; Swan 2006, 2008; Swan et al. 2005). Phthalate exposures in women have been linked to disruption of thyroid hormone levels, increased oxidative stress, and inflammation (Ferguson et al. 2012; Huang et al. 2007). Studies have also found a positive association between phthalate exposure levels and adverse reproductive outcomes, such as preterm birth (Ferguson et al. 2014). Phthalates levels in the body have been found to be higher in nail salon workers relative to the general population (Hines et al. 2009), and the use of gloves helps to reduce such exposure (Kwapniewski et al. 2008). Parabens, used as preservatives in cosmetic products like shampoos, are weakly estrogenic in vitro and have been reported to affect reproductive tract development in rats (Kang et al. 2002). Phenylenediamine, used in hair dyes, has been associated with congenital malformation (Marks et al. 1981). Furthermore, previous studies have linked occupational exposure to solvents to adverse reproductive health (e.g., spontaneous abortions and pregnancy-induced hypertension) (Attarchi et al. 2012; Hewitt and Tellier 1998). Solvents like toluene and xylene are used in nail care products, and ethanol and dichloromethane are used in hair sprays. One study noted that exposure to volatile organic compounds, specifically toluene, can induce oxidative stress and various gene expression affecting oxidative stress (Kim et al. 2011).

Despite long-standing health concerns, there have been few research studies to examine this issue, especially in the nail care sector. A study in North Carolina found an increased risk of spontaneous abortions among cosmetologists in salons where nail care services were performed (OR 1.9, 95 % CI 1.0–3.7) (John et al. 1994). Women working as hairdressers were found to have increased risk for both infertility and spontaneous abortions in Norwegian cross-sectional study (Baste et al. 2008). A study of hairdressers in the Netherlands found increased risk for low birth weight compared with women working as sales clerks, but the risks appeared to be increased only in the earliest years covered by the study, suggesting that the effects lessened over time (Kersemakers et al. 1997). A recent Danish study of pregnancy outcomes in hairdressers did not find increased risks for preterm birth or small for gestational age, as compared to women working as shopkeepers (Zhu et al. 2006). However,

a recent study in Finland comparing hairdressers and other beauty service workers, including some manicurists, to teachers reported an increased risk for low birth weight, preterm delivery, perinatal growth, small for gestational age, and perinatal death (Halliday-Bell et al. 2009). Similarly, a retrospective study comparing licensed cosmetologists with licensed realtors in New York found increased risk for low birth weight (OR 1.36, 95 % CI 1.09–1.70), with an odds ratio increasing to over a twofold risk when the analysis was restricted to nonwhites (Herdt-Losavio et al. 2009b). This finding is particularly relevant given the sharp rise in minority workers in California, dominated by Vietnamese immigrants in the nail salon industry (Magazine 2006). The New York study also reported increased risks for several adverse maternal health indicators, including postpartum hemorrhage (OR 2.12; 95 % CI 1.26–3.58), hypertension (OR 1.34, 95 % CI 1.01–1.76), and prolonged rupture of membranes (OR 1.52, 95 % CI 1.11–2.09) (Herdt-Losavio et al. 2009a). Notably, both of these studies employed a population-based record-linkage method, comparing licensed cosmetologists with women in other selected occupations in order to be more generalizable to the worker population.

The goal of our study was to determine whether cosmetology workers in general, and nail salon workers in particular, are at greater risk of adverse birth outcomes and maternal pregnancy complications. Importantly, our study was based in California with the largest, most racially diverse cosmetology workforce studied to date. We also conducted restricted analyses for the Vietnamese population, given the growth of these workers in the nail care sector. This racial/ethnic group has been the focus of a number of research studies, given public concerns for their health and safety (Quach et al. 2011, 2008, 2013; Roelofs et al. 2008; Roelofs 2012; White House Initiative on Asians Americans and Pacific Islanders 2011). We also sought to generate hypotheses around impacts of chemical exposures on reproductive health for the large, rapidly growing hair and nail care industry, which is largely comprised of women of child-bearing age.

Methods

Study design and study population

We conducted a statewide population-based retrospective linkage study of licensed cosmetologists and manicurists in California. Cosmetologists provide hair and other beauty services including nail care services, whereas manicurists provide treatment exclusively on the hands and feet to groom fingernails and toenails. All states in the USA require cosmetologists and manicurists to be licensed to provide hair and nail care treatments, and in order to qualify for a license, the individual must graduate from a state-approved

cosmetology program and pass a state exam (US Bureau of Labor Statistics 2012). Licensees must also periodically renew their license. In California, the California Board of Barbering and Cosmetology (CA-BBC) is the licensing agency for cosmetologists and manicurists and has maintained a database containing individual licensee information since 1970.

We used the file for all CA-BBC licensees from 1970 to 2005, which included a total of 260,052 licensed cosmetologists and 159,430 licensed manicurists. Using probabilistic record-linkage, we matched statewide cosmetology licensee and birth registry files to identify births for female cosmologists and manicurists occurring between 1996 and 2009 (a 14-year study period). Because we had the initial date of licensure, we included only individuals who were first licensed prior to giving birth in California in order to ensure temporality of exposure and outcome.

Over 7.5 million births occurred in California during 1996–2009. We identified births to licensed cosmetologists and manicurists during this time period, excluding births that occurred prior to the date of issue of the license. We restricted these analyses to singleton births only (excluded twins, triplets, etc.) and to women at least 18 years of age, resulting in 81,205 identified births among cosmetologists and manicurists. We selected two comparison groups. For the first, we took a random sample of singleton live births to non-cosmetologists from the general population of women at least 18 years of age, frequency-matched 5:1 by year of birth (406,025 live births). For a second comparison group, we identified women in this general population sample who had occupations on the birth records listed as teachers, realtors, sales people, bankers, office workers, and food service workers (53,056 births). The rationale for using this second reference group of working women was to account for the healthy worker effect, where working populations tend to be healthier than the general population and thus can mask small effects from occupational exposures. Given our research interest in occupational exposure to chemicals, we excluded occupations that may have chemical exposures, such as factory and assembly workers, janitors, medical and dental professionals, and farm workers.

To link the CA-BBC licensee file to the birth registry files, we used a generalized automated probabilistic record-linkage program, Automatch (Jaro 1989, 1995; Wajda et al. 1991), to evaluate the likelihood that two records represent the same individual. We used first, last, and middle names, and date of birth from each of the files as identifying variables to determine the likelihood of a match.

Outcome measures

We compared birth outcomes (e.g., birth weight, gestational age, selected birth defects, and infant death) and

maternal health outcomes (e.g., preeclampsia and gestational diabetes) listed from the birth certificate among cosmetologists and manicurists to outcomes in each reference group. The main birth outcomes were low birth weight (<2,500 vs. \geq 2,500 g), preterm delivery (<37 vs. \geq 37 weeks), and infant death (death in the first year of life). We also examined small for gestational age (SGA), defined as babies below the 10th percentile of weight using sex-specific percentiles (Oken et al. 2003). Maternal health outcomes included preeclampsia, gestational diabetes (only available for births in 2006–2009 since prior years did not specify “gestational diabetes” for those who were identified as having diabetes), chronic diabetes, prolonged labor, precipitous labor, premature rupture of membranes, abruption placenta, and placenta previa (available for births in 1996–2005 only).

Analysis

For each of the birth outcomes and maternal health outcomes, we used multivariable logistic regression to calculate odds ratios and 95 % confidence intervals (CI) and adjusted for race/ethnicity, parity/birth order, maternal education, maternal age (<35 vs. \geq 35 years of age), and month prenatal care began. Prenatal care was modeled as three categories: none, unknown and fifth month or later combined, third to fourth month, and first to second month. The analyses were stratified by cosmetologist and manicurist licensee groups. In addition, we also conducted restricted analysis for Vietnamese cosmetologists and manicurists, comparing them with the Vietnamese general population of women as well as to other Vietnamese working women in the selected occupations. All statistical analyses were performed using SAS 9.3 (SAS Institute 2010).

The study protocol was reviewed and approved by the institutional review boards of the Cancer Prevention Institute of California and the California Health and Human Services Agency, Committee for the Protection of Human Subjects.

Results

Table 1 shows the demographic characteristics for cosmetologists and manicurists in comparison with the general female population and to other working women who gave birth in California from 1996 to 2009. Manicurists were predominately Asian, with Vietnamese comprising 62.1 % of the manicurist group, even though they only comprised 1.2 % of the general female population who gave birth during this period. Non-Hispanic White women comprised 46.1 % of the cosmetologist group, 23.2 % of the manicurist group, and 31.2 % of the general female population

Table 1 Maternal characteristics by occupational groups compared with the general population sample, California births 1996–2009

Maternal characteristics	Comparison groups							
	Manicurists		Cosmetologists		Other working groups ^a		General population	
	N (24,832)	%	N (56,373)	%	N (53,056)	%	N (406,025)	%
Race/ethnicity								
Non-Hispanic White	5,765	23.2	26,016	46.1	25,051	47.2	126,665	31.2
Non-Hispanic Black	302	1.2	4,247	7.5	3,231	6.1	24,257	6.0
Hispanic	1,848	7.4	17,718	31.4	17,585	33.1	201,407	49.6
Vietnamese	15,420	62.1	4,039	7.2	712	1.3	5,046	1.2
Other Asian	988	4.0	2,872	5.1	3,314	6.2	22,825	5.6
Other/unknown	509	2.0	1,481	2.6	3,163	6.0	25,825	6.4
Age (years)								
18–24	1,912	7.7	3,921	7.0	11,471	21.6	128,090	31.5
25–34	17,428	70.2	36,412	64.6	31,770	59.9	211,307	52.0
≥35	5,492	22.1	16,040	28.5	9,815	18.5	66,628	16.4
Parity								
First birth	9,769	39.3	18,233	32.3	24,316	45.8	150,025	36.9
Second birth	9,690	39.0	20,403	36.2	17,785	33.5	131,360	32.4
Third birth	3,802	15.3	11,424	20.3	7,389	13.9	71,998	17.7
Fourth or more birth	1,563	6.3	6,252	11.1	3,544	6.7	52,222	12.9
Unknown	8	0.0	61	0.1	22	0.0	420	0.1
Education								
Less than high school	3,703	14.9	4,837	8.6	3,492	6.6	112,430	27.7
High school graduate	10,556	42.5	20,986	37.2	14,472	27.3	113,074	27.8
Some college	6,688	26.9	23,912	42.4	15,003	28.3	81,807	20.1
College graduate	3,236	13.0	5,771	10.2	19,929	37.6	90,109	22.2
Unknown	649	2.6	867	1.5	160	0.3	8,605	2.1
Prenatal care								
Began in first 2 months	17,727	71.4	40,623	72.1	38,760	73.1	263,523	64.9
Began in third/fourth months	5,759	23.2	12,972	23.0	11,491	21.7	102,625	25.3
Began in fifth month or later	1,023	4.1	2,087	3.7	2,246	4.2	31,329	7.7
None	43	0.2	100	0.2	142	0.3	2,471	0.6
Unknown	280	1.1	591	1.0	417	0.8	6,077	1.5

^a A subset of the general population sample that included teachers, realtors, sales people, bankers, office workers, and food service workers

group. The majority of the cosmetology group (64.6 % of cosmetologists and 70.2 % of manicurists) was between the ages of 25 and 34 years at the time of giving birth, compared with 52.0 % of general female population in this age-group. Nearly three-quarters of the births were a first or second birth in all three groups. With respect to education, 57.4 % of the manicurist group and 45.8 % of the cosmetologist group had a high school education or less compared with 55.5 % in the general female population and 33.9 % in working women from other industries. Interestingly, over 70 % of the cosmetologist and manicurist groups started their prenatal care in the first or second month, relative to 64.9 % in the general female population.

Table 2 shows the distribution of birth and maternal outcomes by the different groups. For infant birth weight,

gestational age, and infant death, the distributions were fairly similar across the different groups.

Adjusted odds ratios (OR) and 95 % CI for the birth outcomes and maternal health outcomes for all manicurists and cosmetologist are presented in Table 3. These ORs are adjusted for maternal age, parity, race/ethnicity, education, and month prenatal care started. For low birth weight (<2,500 g), preterm birth (gestational age <37 weeks), SGA, and infant death the ORs were close to the null for both the cosmetologists and manicurists, when compared to the reference group of other working women. When compared to the general populations, the ORs for low birth weight and SGA for the cosmetologists were below one with confidence intervals that excluded one. For infant death, a very rare outcome, the ORs had

Table 2 Birth outcomes and maternal complications by occupational groups compared with the general population sample of California births, 1996–2009

	Pregnancy outcomes				Comparison groups			
	Manicurists		Cosmetologists		Other working groups ^a		General population	
	N	%	N	%	N	%	N	%
<i>Birth outcomes</i>								
<i>Birth weight</i>								
Low (<2500 g)	1,203	4.8	2,586	4.6	2,481	4.7	19,782	4.9
Normal	22,064	88.9	47,504	84.3	44,367	83.6	344,415	84.8
High (≥4,000 g)	1,565	6.3	6,283	11.1	6,208	11.7	41,828	10.3
<i>Preterm</i>								
Preterm (<37 weeks)	2,012	8.5	4,759	8.9	4,187	8.3	35,255	9.2
Not preterm (≥37 weeks)	21,721	91.5	48,997	91.2	46,514	91.7	349,664	90.8
<i>Small for gestational age (SGA)</i>								
Yes	2,840	12.0	4,470	8.3	4,382	8.6	35,645	9.3
No	20,893	88.0	49,286	91.7	46,319	91.4	349,274	90.7
<i>Infant death^b</i>								
Yes	67	0.3	148	0.3	151	0.3	1,297	0.4
No	22,077	99.7	49,063	99.7	47,048	99.7	355,478	99.6
<i>Maternal complications</i>								
<i>Preeclampsia</i>								
Yes	403	1.6	1,288	2.3	1,371	2.6	8,445	2.1
No	24,429	98.4	55,085	97.7	51,685	97.4	397,580	97.9
<i>Diabetes, unspecified</i>								
Yes	119	0.5	299	0.5	244	0.5	1,470	0.4
No	24,713	99.5	56,074	99.5	52,812	99.5	404,555	99.6
<i>Diabetes, gestational^c</i>								
Yes	518	7.1	487	4.7	156	3.6	2,828	3.2
No	6,790	92.9	9,824	95.3	4,142	96.4	85,267	21.0
<i>Premature rupture of membranes</i>								
Yes	597	2.4	1,259	2.2	1,327	2.5	8,352	2.1
No	24,235	97.6	55,114	97.8	51,729	97.5	397,673	97.9
<i>Abruptio placenta</i>								
Yes	106	0.4	191	0.3	158	0.3	1,212	0.3
No	24,726	99.6	56,182	99.7	52,898	99.7	404,813	99.7
<i>Placenta previa^d</i>								
Yes	84	0.5	158	0.3	143	0.3	792	0.2
No	17,440	99.5	45,904	99.7	48,615	99.7	317,138	99.8
<i>Precipitous labor</i>								
Yes	378	1.5	687	1.2	596	1.1	5,120	1.3
No	24,454	98.5	55,686	98.8	52,460	98.9	400,905	98.7
<i>Prolonged labor</i>								
Yes	162	0.7	406	0.7	437	0.8	2,948	0.7
No	24,670	99.3	55,967	99.3	52,619	99.2	403,077	99.3

Missing or unknown values excluded

^a A subset of the general population sample that included teachers, realtors, sales people, bankers, office workers, and food service workers

^b Not available for births in 1998 and 2009

^c Available for births 2006–2009 only

^d Available for births in 1996–2005 only

wide confidence intervals that included one, except for cosmetologists compared with the general population (OR 0.80; 95 % CI 0.67–0.96). For maternal health outcomes, the adjusted ORs for preeclampsia were 0.84 (95 % CI 0.75, 0.95) for manicurists compared with the general

population. The results for diabetes (unspecified) and gestational diabetes showed increased odds ratios for both manicurists and cosmetologists when compared to the general female population, but the ORs were somewhat lower when compared to other working women and not

Table 3 Adjusted^a odds ratios and 95 % confidence intervals for birth outcomes and maternal complications by occupational group for all races

Birth outcomes	Compared with other working women ^b		Compared with the general population	
	Manicurists	Cosmetologists	Manicurists	Cosmetologists
Low birth weight (<2,500 g)	1.05 (0.96, 1.16)	0.98 (0.92, 1.04)	0.99 (0.92, 1.08)	0.94 (0.90, 0.99)
Small for gestational age (SGA)	0.98 (0.91, 1.05)	0.96 (0.91, 1.00)	0.95 (0.89, 1.00)	0.92 (0.89, 0.95)
Preterm (gestational age <37 weeks)	1.07 (0.99, 1.15)	1.01 (0.97, 1.06)	0.99 (0.93, 1.05)	0.97 (0.94, 1.00)
Infant death	1.08 (0.74, 1.58)	0.84 (0.65, 1.07)	0.93 (0.68, 1.29)	0.80 (0.67, 0.96)
Maternal complications				
Preeclampsia	0.92 (0.80, 1.05)	1.06 (0.98, 1.15)	0.84 (0.75, 0.95)	0.97 (0.91, 1.03)
Diabetes, unspecified	1.26 (0.96, 1.65)	1.08 (0.90, 1.30)	1.36 (1.08, 1.71)	1.14 (1.00, 1.30)
Diabetes, gestational ^c	1.19 (0.93, 1.51)	1.14 (0.94, 1.39)	1.28 (1.10, 1.50)	1.19 (1.07, 1.33)
Premature rupture of membranes	1.15 (1.01, 1.31)	1.03 (0.95, 1.12)	1.21 (1.09, 1.35)	1.10 (1.03, 1.17)
Abruptio placenta ^d	1.15 (0.83, 1.61)	1.02 (0.81, 1.29)	1.19 (0.91, 1.56)	1.01 (0.86, 1.19)
Placenta previa	1.22 (0.85, 1.77)	1.09 (0.85, 1.39)	1.46 (1.08, 1.97)	1.22 (1.02, 1.46)
Precipitous labor	0.95 (0.80, 1.13)	0.92 (0.81, 1.03)	0.96 (0.83, 1.10)	0.90 (0.83, 0.98)
Prolonged labor	1.09 (0.86, 1.38)	1.13 (0.98, 1.31)	1.03 (0.84, 1.26)	1.07 (0.96, 1.20)

Bold values are statistically significance

^a Adjusted for maternal age (<35 vs. 35+), parity (as in Table 1), race/ethnicity (as in Table 1), education (as in Table 1), and month prenatal care began (in the model as 3 categories: None/unknown and 5th month or later were combined, 3–4th month, ref = 1st or 2nd month)

^b Includes teachers, realtors, sales people, bankers, office workers, and food service workers

^c Available for births 2006–2009 only

^d Available for births in 1996–2005 only

statistically significant. Placenta previa was also significantly increased among manicurists (OR 1.46, 95 % CI 1.08, 1.97) and cosmetologists (OR 1.22, 95 % CI 1.02, 1.46) compared with the general population, but when compared to other working women was not statistically significant. Of note, premature rupture of membranes was also slightly increased among manicurists (OR 1.21; 95 % CI 1.09–1.35) when compared to the general population as well as other working women.

Given the research interest in the rapidly growing Vietnamese workforce, we conducted restricted analyses for the Vietnamese population. Table 4 shows the distribution of adverse birth and maternal outcomes for the Vietnamese women. Restricted analyses for the Vietnamese population (Table 5) showed an increase in risk for SGA babies among both manicurist and cosmetologists when compared to other working women, with an OR of 1.39 (95 % CI 1.08–1.78) for manicurists and 1.40 (95 % CI 1.08–1.83) for cosmetologists. For gestational diabetes, the adjusted OR was much more elevated when restricted to the Vietnamese population, with an OR 1.59 (95 % CI 1.20–2.11) for manicurists and 1.49 (95 % CI 1.04–2.11) for cosmetologists when compared to the general population. Similar to the results for all races, the OR for premature rupture of membranes among Vietnamese was slightly elevated among manicurists (OR 1.26; 95 % CI 1.00–1.57) compared with the general population.

Discussion

We did not observe increased risks for adverse birth outcomes in cosmetologists and manicurists among all races combined. Women working as cosmetologists had slightly reduced risk for low birth weight SGA and infant death compared with the general population. However, we did see increased risk for SGA in Vietnamese manicurists and cosmetologists when compared to other working women. Previous studies have found an association between performing hair care services and/or nail care services and adverse reproductive outcomes, such as low birth weight, SGA, and some major infant malformations (Halliday-Bell et al. 2009; Herdt-Losavio et al. 2009a, b; Rylander et al. 2002). These studies also used record-linkage study designs employing cosmetology licensee files and using general female population or other workers as reference groups. While it is unclear why there would be differences in the results from our large study to those from smaller studies with similar designs, it is worth noting that our study was not able to control for smoking during pregnancy due to lack of available data for most of our study time period, and these two other studies included smoking in their adjusted models. Given the importance of smoking as a major risk factor for adverse birth outcomes, not including it as a covariate in our model may have influenced our results. However, smoking during pregnancy in

Table 4 Birth outcomes and maternal complications by occupational groups compared with the general Population sample of California Births for Vietnamese women only, 1996–2009

	Pregnancy outcomes				Comparison groups			
	Manicurists		Cosmetologists		Other working groups ^a		General population	
	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%
<i>Birth outcomes</i>								
<i>Birth weight</i>								
Low (<2,500 g)	769	5.0	208	5.1	27	3.8	232	5.4
Normal	14,121	91.6	3,674	91.0	651	91.4	3,929	90.7
High (≥4,000 g)	530	3.4	157	3.9	34	4.8	173	4.0
<i>Preterm</i>								
Preterm (<37 weeks)	1,236	8.0	330	8.2	58	8.1	364	8.4
Not preterm (≥37 weeks)	13,550	87.9	3,527	87.3	622	87.4	3,764	86.8
<i>Small for gestational age (SGA)</i>								
Yes	2,114	13.7	541	13.4	74	10.4	607	14.0
No	12,672	82.2	3,316	82.1	606	85.1	3,521	81.2
<i>Infant death^b</i>								
Yes	37	0.2	13	0.3	<5	0.1	16	0.4
No	13,782	89.4	3,563	88.2	647	90.9	3,806	87.8
<i>Maternal complications</i>								
<i>Preeclampsia</i>								
Yes	157	1.0	38	0.9	10	1.4	41	0.9
No	15,263	99.0	4,001	99.1	702	98.6	4,293	99.1
<i>Diabetes, unspecified</i>								
Yes	66	0.4	8	0.2	0	0	11	0.3
No	15,354	99.6	4,031	99.8	712	100.0	4,323	99.7
<i>Diabetes, gestational^c</i>								
Yes	431	2.8	82	2.0	5	0.7	58	1.3
No	4,871	31.6	961	23.8	64	9.0	1,015	23.4
<i>Premature rupture of membranes</i>								
Yes	371	2.4	87	2.2	15	2.1	94	2.2
No	15,049	97.6	3,952	97.8	697	97.9	4,240	97.8
<i>Abruptio placenta</i>								
Yes	66	0.4	23	0.6	<5	0.6	13	0.3
No	15,354	99.6	4,016	99.4	708	99.4	4,321	99.7
<i>Placenta previa^d</i>								
Yes	61	0.4	16	0.4	<5	0.4	12	0.3
No	10,057	65.2	2,980	73.8	640	89.9	3,249	75.0
<i>Precipitous labor</i>								
Yes	267	1.7	55	1.4	10	1.4	66	1.5
No	15,153	98.3	3,984	98.6	702	98.6	4,268	98.5
<i>Prolonged labor</i>								
Yes	99	0.6	21	0.5	<5	0.6	27	0.6
No	15,321	99.4	4,018	99.5	708	99.4	4,307	99.4

Missing or unknown values excluded

^a A subset of the general population sample that included teachers, realtors, sales people, bankers, office workers, and food service workers

^b Not available for births in 1998 and 2009

^c Available for births 2006–2009 only

^d Available for births in 1996–2005 only

California women is very low, especially among Hispanics and Asians (California Department of Public Health 2010). Starting in 2007, questions about smoking were added to the birth certificate. For the women in our study during the time period of 2007–2009, the self-reported prevalence of smoking during pregnancy was only about 2.5 % overall,

and less than 1 % among Vietnamese women. Additionally, the previous record-linkage studies on cosmetologists selected either realtors or teachers as a reference group, and findings of increased risk were mostly limited to when comparing them to these other working sectors. Our study selected women in several different occupations including

Table 5 Adjusted^a odds ratios and 95 % confidence intervals for birth outcomes and maternal complications by occupational group for Vietnamese women only

Births outcomes	Compared with other working women ^b		Compared with the general population	
	Manicurists	Cosmetologists	Manicurists	Cosmetologists
Low birth weight (<2,500 g)	1.29 (0.86, 1.93)	1.34 (0.88, 2.04)	0.97 (0.84, 1.13)	1.01 (0.84, 1.23)
Small for gestational age (SGA)	1.39 (1.08, 1.78)	1.40 (1.08, 1.83)	1.03 (0.93, 1.13)	1.04 (0.91, 1.18)
Preterm (gestational age <37 weeks)	0.89 (0.67, 1.19)	0.90 (0.67, 1.22)	0.91 (0.80, 1.02)	0.92 (0.79, 1.08)
Maternal complications				
Preeclampsia	1.26 (0.62, 2.55)	1.33 (0.62, 2.84)	1.00 (0.71, 1.39)	1.05 (0.68, 1.62)
Diabetes, unspecified	***	***	1.98 (1.03, 3.83)	0.88 (0.35, 2.23)
Diabetes, gestational ^c	1.18 (0.47, 2.97)	1.11 (0.43, 2.86)	1.59 (1.20, 2.11)	1.49 (1.04, 2.11)
Premature rupture of membranes	1.50 (0.88, 2.56)	1.38 (0.78, 2.43)	1.26 (1.00, 1.57)	1.16 (0.86, 1.55)
Abruptio placenta	***	***	1.31 (0.75, 2.27)	1.69 (0.88, 3.24)
Placenta previa	***	***	1.65 (0.89, 3.05)	1.34 (0.63, 2.82)
Precipitous labor	1.10 (0.57, 2.11)	0.83 (0.41, 1.66)	1.11 (0.85, 1.45)	0.83 (0.58, 1.19)
Prolonged labor	***	***	1.10 (0.72, 1.66)	0.99 (0.56, 1.74)

Bold values are statistically significance

***Not calculated (unstable estimate, referent group had <5 events)

^a Adjusted for maternal age (<35 vs. 35+), parity (as in Table 1) education (as in Table 1), and month prenatal care began (in the model as 3 categories: None/unknown and fifth month or later were combined, 3–4th month, ref = 1st or 2nd month)

^b Includes teachers, realtors, sales people, bankers, office workers, and food service workers

^c Available for births 2006–2009 only

^d Available for births in 1996–2005 only

a range of socioeconomic levels as a comparison group of other working women, rather than focusing on one job type (such as realtors) (Halliday-Bell et al. 2009; Herdt-Losavio et al. 2009a, b), which may in part explain the differences in our study's results on adverse birth outcomes.

When we examined maternal health outcomes, we observed a significantly increased risk of diabetes (unspecified), gestational diabetes, premature rupture of the membranes, and placenta previa among manicurists and cosmetologists compared with the general population for all races combined and among the subset of Vietnamese. These findings were similar to those from the New York study, which found increased risks for several maternal health indicators, including postpartum hemorrhage (OR 2.12; 95 % CI 1.26–3.58), hypertension (OR 1.34, 95 % CI 1.01–1.76), and prolonged rupture of membranes (OR 1.52, 95 % CI 1.11–2.09) (Herdt-Losavio et al. 2009a).

The prevalent use of endocrine-disrupting chemicals in this occupation may be consistent with the observed predisposition to maternal complications such as diabetes. Data from the NHANES study showed that women with higher urinary concentrations of phthalate metabolites, including mono-n-butyl phthalate from dibutyl phthalates often used in nail polishes, had increased odds of diabetes (James-Todd et al. 2012). It is hypothesized that phthalates can potentially contribute to metabolic diseases such as obesity and diabetes by interfering with receptors regulating

metabolism. Phthalates can interfere with peroxisome proliferator-activated receptors nuclear receptors, affecting metabolic homeostasis (Casals-Casas et al. 2008; Desvergne et al. 2009). As glucose regulation is affected, it can lead to increased risks of diabetes. In addition, some studies have also shown the association between higher phthalate levels and increased waist circumference and insulin resistance (risk factors for diabetes) in males (Stahlhut et al. 2007). Endocrine-disrupting chemicals can also affect inflammation and oxidative stress, which may be linked to birth outcomes, such as SGA, and pregnancy complications (Cobellis et al. 2003; Ferguson et al. 2012; Huang et al. 2007). By design, this study was not able to determine whether elevated risks for select endpoints were due to occupational chemical exposure. In fact, working in this occupation also requires constant standing or sitting, which may also influence pregnancy outcomes.

Strengths and limitations

To date, this is the largest study of licensed cosmetologists and manicurists, with a total of 81,205 births among this service sector. Our study was much larger in size than the New York study by (Herdt-Losavio et al. 2009a, b), which included approximately 15,000 cosmetologists who gave birth during the study period (1997–2003). While of notable size and racial/ethnic diversity, that study examined

race by comparing a “white” group with an aggregated “nonwhite” group. Our study included greater detail in our racial/ethnic categories (i.e., Non-Hispanic White, Non-Hispanic Black, Hispanic, Vietnamese, Other Asian, and Other/unknown), with all groups having relatively large numbers. Additionally, we conducted analyses separately for cosmetologists and manicurists. This is the first record-linkage study to examine manicurists as a separate group. Given the large proportion of Vietnamese working in nail salons, we also conducted a restricted analysis with this population, with resulting significant findings for SGA and gestational diabetes.

Our concern for a potential healthy worker effect motivated us to use a working reference group in addition to the general population. Previous studies have identified a single occupational group, such as teachers or realtors, as a reference group (Halliday-Bell et al. 2009; Herdt-Losavio et al. 2009a, b). Instead of selecting one sector to represent the working female population, we selected multiple sectors to provide more robust comparisons. Given that our primary research question was to explore the role of occupational chemical exposures among cosmetologists and manicurists in relation to adverse reproductive outcomes, we selected sectors that are less likely to be exposed to solvents, phthalates, parabens, and some of the other chemicals common in the cosmetology industry. Our combined working population reference group included office workers, sales clerks, food service workers, teachers, and realtors. The inclusion of multiple professions in this reference group provided more diversity in terms of socioeconomic status and racial/ethnic composition than if we had chosen only one occupational. In general, our findings of elevated risks were statistically significant when compared to the general population, but when compared to other working women, the results were not statistically significant due to smaller numbers. Interestingly, our results for the Vietnamese population for SGA showed elevations when compared to other working women, but not when compared to the general population. The use of the two comparison groups helped to identify potential elevated risks, which may have otherwise been missed due to the healthy worker effect. While there may be other explanations for these findings, such as women drawn to these small businesses could have underlying health issues not related to their occupation, exploring this is beyond the scope of this study.

Our study used data from existing registry files that were not originally collected for research purposes. While we had the period when the individual was licensed as a manicurist or cosmetologist, we did not have actual exposure information, such as how many hours a woman works, the chemicals she used at her workplace, and whether she used personal protective equipment or had other ways of reducing chemical exposures. We also lacked information

on important risk factors, such as smoking behaviors during pregnancy. Furthermore, outcome data were limited in the level of detail available. One notable example is that the variable “gestational diabetes” was recorded on the infant birth certificates as of 2006 and later. Prior to that year, it was recorded as “diabetes” and did not specify “gestational diabetes.” Thus, we provide results for “diabetes” as well as a restricted analysis for “gestational diabetes” during the years 2006–2009. Similarly, the data were only available on placenta previa for 1996–2005. For infant death, the data were not available for 1998 and 2009. Other outcomes may also be underreported and/or may not always be reliable (Dietz et al. 2007; Northam and Knapp 2006), although this misclassification of outcomes is likely to occur across the “exposure groups” (i.e., the cosmetologists, manicurists, and reference group), leading to bias toward the null. We also acknowledge that we examined many different outcomes, and multiple comparisons can lead to spurious associations. Of important note, the health outcomes that were examined are rare, and small numbers may make the risk estimates less reliable, although we did see some statistically significant risk estimates in our study.

With the rapid growth and the size of the cosmetology sector industry in California, the largest in the nation, our study provides some important insights into reproductive health patterns for this cadre of female workers. This workforce is unique because of the racial/ethnic diversity, including a large number of Vietnamese immigrants. Our findings of increased risks for several maternal health outcomes and adverse birth outcomes like SGA are consistent with similarly designed studies of this workforce and raise questions regarding the potential impact of occupational exposures to cosmetologists or manicurists. These findings may be informative for hypothesis generation to guide future research focused on the link between working as a cosmetologist or manicurist and adverse reproductive outcomes.

Acknowledgments This research was funded by a grant from the National Institute of Environmental Health Sciences (1R03ES020551-01).

Conflict of interest The authors declare that they have no conflict of interest.

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