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Maternal occupation as a nail technician or hairdresser during pregnancy and birth defects, National Birth Defects Prevention Study, 1997–2011

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Abstract

Objective: Nail technicians and hairdressers may be exposed to chemicals with potential reproductive effects. While studies have examined birth defects in children of hairdressers, nail technicians have not been evaluated. We investigated associations between selected birth defects and maternal occupation as a nail technician or hairdresser versus a non-cosmetology occupation during pregnancy.

Methods: We analyzed population-based case-control data from the multisite National Birth Defects Prevention Study, 1997–2011. Cases were fetuses or infants with major structural birth defects; controls were liveborn infants without major birth defects. Expert raters classified self-reported maternal jobs as either nail technician, combination nail technician-hairdressing, hairdressing, other cosmetology, or non-cosmetology work. We used logistic regression to calculate adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for associations between occupation during pregnancy and birth defects, controlling for age, smoking, education, and race/ethnicity.

Results: Sixty-one mothers worked as nail technicians, 196 as hairdressers, 39 as combination nail technician-hairdressers, and 42,810 as non-cosmetologists. The strongest associations among nail technicians included seven congenital heart defect (CHD) groups (ORs ranging from 2.7

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to 3.5) and neural tube defects (OR=2.6, CI: 0.8–8.4). Birth defects most strongly associated with hairdressing included anotia/microtia (OR=2.1; CI: 0.6–6.9) and cleft lip with cleft palate (OR=2.0; CI: 1.1–3.7). All oral cleft groups were associated with combination nail technician-hairdresser work (ORs ranging from 4.2 to 5.3).

Conclusions: Small samples resulted in wide confidence intervals. Still, results suggest associations between maternal nail technician work during pregnancy and CHDs and between hairdressing work and oral clefts.

INTRODUCTION

Nail salon workers (i.e., nail technicians) have sought attention to and research concerning the health and safety of their work. Their concerns led to a 2015 *New York Times* article on the unsafe working conditions in nail salons,[1] which was followed by a Governor-led initiative to address such issues in New York. There has since been increasing public interest in the health and safety of nail technicians.

There are over 400,000 active nail technician licenses in the U.S., according to a recent trade publication estimate.[2] Because this estimate does not include non-licensed professionals or nail professionals practicing under different licenses, the actual number of nail technicians is likely much larger. Much of the nail technician workforce includes female and foreign-born/minority workers; and many are of reproductive age.[2]

Nail technician duties include manicures/pedicures, application/removal of acrylic nails, application of gels and gel polishes, nail reconstruction, airbrushing, and more.[2] These activities expose nail technicians to nail polish and other nail care products that often contain toluene, formaldehyde, acetone, acetonitrile, ethyl and methyl methacrylate, phthalates, and other substances.[3-10] Evidence suggests that some of these chemicals are carcinogenic and may lead to adverse reproductive outcomes.[8 11]

Exposure studies of nail salons have not evaluated associations between measured chemical exposures and specific diagnoses. Other studies have more generally documented acute symptoms as well as respiratory, neurological, and musculoskeletal effects among nail technicians, however, research on reproductive outcomes is limited.[12-14] Analyses of birth defects in relevant occupations have focused on hairdressers or cosmetologists/beauticians in general without examining nail technicians as an individual group.[15-25] While findings have been inconsistent, a few studies have suggested that offspring of hairdressers have an increased risk for birth defects.[17 19-21 25] Roughly 1 in 2 nail technicians report working in settings that offer hair care services,[2] which often involve products such as shampoos, hair dyes, hair sprays, straighteners, and bleaches, some of which may also be associated with adverse reproductive outcomes.[8 11 15 26 27] A 2019 literature review concluded that there are not enough studies of reproductive outcomes among nail and hair salon workers and recommended further research.[8]

The current study sought to evaluate birth defects related to nail technician and hairdressing work, with a novel focus on nail technicians as an individual occupational group in light of an absence of previous research and workspaces commonly shared with hairdressers.

Specifically, we investigated associations between a spectrum of birth defects and maternal occupation as a nail technician or hairdresser versus a non-cosmetology occupation during pregnancy.

METHODS

Study design

Data were analyzed from the National Birth Defects Prevention Study (NBDPS), a large multi-center, population-based case-control study of birth defects. The NBDPS design and methods have been described thoroughly elsewhere.[28 29] Briefly, cases were recruited from birth defects surveillance sites in 10 states (Arkansas, California, Georgia, Iowa, Massachusetts, New Jersey, New York, North Carolina, Texas, and Utah) to ascertain infants and fetuses with major structural, non-chromosomal birth defects. All study sites ascertained cases among live births, and some also included cases among stillbirths (fetal deaths at ≥20 gestational weeks) and terminations of pregnancy (any gestational age). Clinical geneticists classified cases as being isolated (no other major birth defects) or having multiple major birth defects (two or more major defects occurring in different organ systems). Pediatric cardiology experts used medical record abstracts of echocardiography, cardiac catheterization, surgery, or autopsy results to classify congenital heart defect (CHD) cases as simple (one single CHD or a well-defined constellation of defects recognized as one entity), associated (common, uncomplicated combinations of CHD), or complex (three or more distinct defects). Control families were recruited from a random sample of live births without major structural defects in the same study regions and were identified from hospital delivery logs or vital records. Cases and controls recruited for NBDPS included deliveries on or after October 1, 1997, and with estimated dates of delivery on or before December 31, 2011. Institutional review board approval was obtained from each study site and the Centers for Disease Control and Prevention (protocol #2087).

Mothers of case and control infants completed a computer-assisted telephone interview between 6 weeks and 2 years after the estimated date of delivery. The interviews, conducted in both English and Spanish, included questions about lifestyle and behavioral exposures during pregnancy, reproductive history, and a narrative description of each job held in the three months prior to the estimated date of conception through the end of pregnancy. The current exposure assessment and analysis included all case and control mothers who participated in NBDPS and reported working at any point during this period.

Exposure assessment

The narrative job description provided from the NBDPS interview consisted of answers to five questions: where the mother worked, what the company made or did, the mother's job title, her typical job duties, and any equipment or chemicals she handled. Mothers were also asked to report the month and year that they started and stopped each job, and how many hours per day and days per week they typically worked at the job. Experienced coders assigned 2007 North American Industry Classification System (NAICS) and 2010 Standard Occupational Classification (SOC) codes to all reported jobs in NBDPS. The primary goal of NBDPS was not to evaluate specific occupational risk factors for birth

defects. However, because information on the above-mentioned occupational characteristics was obtained and/or coded, retrospective assignment of specific occupations or occupational exposures can be (and have been) conducted.

For the current analysis, two expert raters (an industrial hygienist with experience in exposure assessments in salons and an occupational epidemiologist with experience in retrospective exposure assessment) completed a retrospective exposure assignment for reported maternal jobs to identify relevant cosmetology work (i.e., cosmetology status). Cosmetology status was determined using NAICS/SOC codes and keyword searches in the narrative job descriptions. Jobs were classified as cosmetology work if they fell within NAICS category 8121 and sub-categories (personal care services), SOC category 39-5000 and sub-categories (personal appearance workers), or if the full-text narrative job description included one or more keywords related to nail or hair salon work or materials. The keywords were developed by public health scientists with relevant experience and included both English and Spanish keywords. Any jobs not flagged during this process were categorized as non-cosmetology work.

After reviewing the narrative job descriptions, raters then assigned each maternal job indicated as relevant to cosmetology to one of five discrete exposure groups: (1) nail technician work, (2) combination nail technician-hairdressing work, (3) hairdressing work, (4) other cosmetology work (e.g., esthetician, makeup artist, massage therapist, etc.), (5) non-cosmetology work. Additionally, using job descriptions, raters classified cosmetology jobs according to their potential for indirect nail product exposures. Jobs in categories 3 (hairdressing work), 4 (other cosmetology work), and 5 (non-cosmetology work) were rated as involving potential indirect nail product exposure where the maternal job was in an environment where nail work was being performed or nail products were being used, for example, if the mother worked in a salon where nail work was done, but not as a nail technician. All jobs that involved nail technician work (categories 1 and 2) were classified as having potential for indirect (and direct) nail product exposure by default. Where initial classifications differed, the raters conferred to resolve the differences and agreed upon a single classification. The raters were blinded to the case or control status of mothers during exposure group assignment.

The exposure status of mothers was determined based on the classification of jobs worked during early pregnancy (i.e., one month before conception through the third month of pregnancy). This period encompasses egg maturation, fertilization, implantation, and embryo-fetal development (including organogenesis), which are considered most vulnerable to teratogens. Mothers were classified into a cosmetology exposure group if they worked at least one job rated as cosmetology-related during early pregnancy.

Outcomes

Individual birth defect phenotypes were analyzed separately if they contained at least three exposed isolated case mothers (simple, isolated cases for CHDs). Specific birth defect phenotypes that did not meet this sample size criterion were grouped into a larger anatomical group where possible. Only simple isolated cases of birth defects were assessed in order to investigate specific exposure effects for homogeneous outcome categories.[30 31]

Statistical analysis

The non-cosmetologist group was the referent for analyses of both hairdresser and nail technician exposure groups. As such, mothers who worked only in other cosmetology jobs unrelated to nail technician or hairdressing work (e.g., esthetician, makeup artist, massage therapists, etc.) (n=142) and those who worked only non-cosmetology jobs with indirect nail product exposures (cosmetology-adjacent, e.g., retail beauty locations, manufacture of beauty products, salon/spa workers providing no direct care services, direct sales of beauty products, etc.) (n=5) were excluded from analyses to prevent misclassification of cosmetology work exposures and to keep the referent group for nail technician and hairdresser analyses consistent. Additionally, mothers were excluded from analyses if they worked as hairdressers (i.e., category 3 jobs only) with indirect nail product exposures (n=17) to isolate the potential effects of the chemical exposures in nail technician work versus hairdressing; worked cosmetology jobs only outside of the early pregnancy period (and none during early pregnancy) (n=15) to limit exposure timing to the most vulnerable period of pregnancy; or worked jobs in multiple cosmetology job categories (n=<3). Results were not reported where n<3 for confidentiality purposes.

We first assessed the demographic characteristics of mothers working as nail technicians, hairdressers, and non-cosmetologists. Frequencies with percentages or means with standard deviations were calculated for study site (state); mother's smoking status in early pregnancy (any vs. none); age at delivery (in continuous years and ≥35 vs. <35 years); body mass index (BMI) at conception (i.e., pre-pregnancy) (underweight [<18.5 kg/m^2] normal weight [18.5–<24 kg/m^2], overweight [25–<30 kg/m^2], or obese [>30 kg/m^2]); education level at delivery (no high school degree, high school degree, some college, or college degree or higher); and race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, Asian/Pacific Islander, or other).

We used logistic regression to calculate crude odds ratios (ORs) and 95% confidence intervals (CIs) for associations between occupation during early pregnancy and birth defect type for nail technicians and hairdressers without indirect nail product exposures in comparison to non-cosmetologists. We then used multivariable logistic regression to calculate adjusted ORs and 95% CIs. Based on different distributions of covariates by occupation and literature support for *a priori* retention in multivariable models,[32-34] we adjusted for mother's smoking status, age at delivery (in continuous years), education level, and race/ethnicity in adjusted analyses. We considered other potential confounders for the multivariable model, such as study site, but because of the small sample size we limited the number of covariates included in the model to preserve model stability. Mothers with missing covariate information were excluded from multivariable models (<5% of any exposure group for all covariates).

Lastly, because nail technicians have been particularly underrepresented in research on birth defects, we conducted two exploratory analyses to further characterize potential relationships between the occupation and birth defects. The first included a sensitivity analysis to assess how estimates might change by excluding mothers with short or infrequent nail technician work; the second evaluated associations between occupation and birth defects among mothers classified as combination nail technician-hairdressers. Logistic regression

analyses described above were repeated for 1) only nail technicians working 20 hours per week or more and at least 60 days during early pregnancy (i.e., frequent work) and 2) only mothers who were occupationally classified as combination nail technician-hairdressers during early pregnancy.

RESULTS

Inter-rater reliability

Overall, 48,825 jobs were included in the exposure assessment. A total of 1,473 jobs were flagged for review by NAICS code, SOC code, and/or keywords relating to cosmetology work. Exposure raters agreed on all variables for 1,365 jobs (92.7%), including: whether a job was relevant to cosmetology work (i.e., cosmetology status); cosmetology exposure group classification; and whether there was indirect nail product exposure. Raters disagreed on cosmetology status for 38 jobs, all of which were cosmetology-adjacent occupations (e.g. certain retail or manufacturing jobs). Additionally, there were 70 jobs considered relevant to cosmetology in which there was disagreement on cosmetology exposure group classification and/or indirect nail exposure. Following a consensus conference, both raters reviewed all job descriptions for any job considered relevant to cosmetology by one or both raters, including those with initial agreement, to ensure that decision rules were consistently applied. Subsequently, raters came to consensus on all jobs.

Primary analyses

After analytic exclusions, 43,106 mothers were included in analyses, comprised of 31,541 cases and 11,565 controls. During early pregnancy, 61 mothers worked as nail technicians (51 cases, 10 controls), 196 as hairdressers (149 cases, 47 controls), 39 as combination nail technician-hairdressers (32 cases, 7 controls), and 42,810 as non-cosmetologists (31,309 cases, 11,501 controls). Of mothers who worked as nail technicians, 46 were characterized by frequent work (i.e., at least 20 hours per week and at least 60 days during early pregnancy; 37 cases, 9 controls).

Table 1 displays the distribution of covariates by maternal occupation as a hairdresser, nail technician, or non-cosmetologist. Nail technicians generally smoked less, were more frequently below age 35 at delivery, and more commonly Asian/Pacific Islander than hairdressers and non-cosmetologists. Education level appeared to vary by occupation. The distribution of NBDPS participants did not vary drastically by occupation for most study sites, however, some cells were sparse among nail technicians. BMI at conception did not vary substantially by occupation.

In general, compared to crude estimates, multivariable regression results were similar. Therefore, only adjusted results are displayed in Table 2. Twenty-two birth defect groups were analyzed among hairdressers. The strongest associations were observed for anotia/microtia (defects of the ear) (OR=2.1; CI: 0.6–6.9), cleft lip with cleft palate (OR=2.0; CI: 1.1–3.7), and gastroschisis (defects of the abdominal wall) (OR=1.7, CI: 0.7–3.9). Based on sample size, eight birth defect groups were analyzed among nail technicians. All eight defects appeared to be associated with working as a nail technician during early pregnancy.

These included all CHD groups (any heart defect, conotruncal defects, tetralogy of Fallot, right ventricular outflow tract obstruction, pulmonary valve stenosis, septal defects, and atrial septal defects; ORs ranging from 2.7 to 3.5) and neural tube defects (OR=2.6, CI: 0.8–8.4).

Exploratory analyses

Table 3 shows multivariable results of two exploratory analyses of birth defects among nail technicians with frequent work only (i.e., worked 20 hours per week or more and at least 60 days during early pregnancy) and combination nail technician-hairdressers. Six defect groups qualified for evaluation among nail technicians with frequent work. Again, all CHDs appeared to be associated with a nail technician occupation, with ORs ranging from 2.2 to 3.9.

Five birth defect groups qualified for analysis among combination nail technician-hairdressers; four were types of oral clefts (Table 3). Mothers of infants from these oral cleft groups had strong associations with working as combination nail technician-hairdressers versus non-cosmetologists (ORs ranging from 4.2–5.3).

DISCUSSION

We found select birth defects to be associated with maternal occupations of nail technician and hairdresser during pregnancy. Multiple CHD groups were associated with nail technician work, including any heart defect, conotruncal defects, RVOTO, and septal defects. A sensitivity analysis excluding nail technicians with less frequent work reinforced associations with CHDs. Although fewer defects were related to hairdressing, oral clefts were associated with working as a hairdresser, particularly for those with simultaneous nail technician responsibilities (i.e., combination nail technician-hairdressers).

Because past studies have not specifically examined birth defects among nail technicians, our results cannot be directly compared with previous analyses. Quach et al.[13] documented other maternal and reproductive effects in a sample of California manicurists, including small for gestational age, gestational diabetes, and placenta previa. Birth defects have been studied among cosmetologists as a broader occupational class, which might often involve nail technician activities. Kalfa et al.[17] found an association between hypospadias and maternal work as a beautician; however, Herdt-Losavio et al.[15] found no associations for multiple birth defect groups, including heart defects (i.e., any heart defect), among cosmetologists. Of interest, an NBDPS analysis by Desrosiers et al.[35] found paternal occupation as a hairdresser or cosmetologist to be associated with ventricular septal defects. Our sample size inhibited analysis of many non-heart defects among nail technicians.

Epidemiological studies have found inconsistency in associations between birth defects and occupation as a hairdresser.[16-25] However, at least three previous studies support our findings of an association between oral clefts and maternal occupation as a hairdresser, with some variation by phenotypes.[19 20 25] Although data from one previous study is slightly overlapping (1997–2003 NBDPS data),[25] the current study added 8 additional years of data and used a more detailed exposure assessment. The current exposure assessment classified

hairdressers using information from narrative job descriptions in addition to NAICS/SOC codes (rather than using NAICS/SOC codes alone) and excluded those with simultaneous nail technician duties or exposures. Our exploratory analysis provided preliminary evidence that the combination of nail technician and hairdressing activities may even compound the risk for oral clefts. Furthermore, the previous analysis of 1997–2003 NBDPS data found an association between hairdressing and gastroschisis,[25] which is also consistent with our findings.

Exposure studies support that nail technicians are exposed to substances that could have negative reproductive effects.[3 8 9 11] Unsafe working conditions, long working hours, or awkward postures could additionally affect maternal and reproductive health. Similarly, products used by hairdressers, who sometimes share workspaces with nail technicians, may also contain chemicals that are associated with adverse reproductive outcomes.[8 11 15 26 27] Some evidence supports that exposure to endocrine disrupting chemicals among hairdressers and cosmetologists is related to birth defects.[17 23 36] Chemicals in beauty products may affect fetal growth through maternal, placental, and fetal exposure pathways.[37]

Engineering controls, like ventilation, and other workplace practices could help reduce occupational exposures in workplace settings.[5-7 10 12 38 39] Additionally, Quach et al.[40] conducted a randomized-controlled trial to test the efficacy of training aimed at reducing exposures to toxic chemicals in nail products. The training led to greater knowledge regarding safe nail polishes, proper ventilation methods, recommended glove types, and best practices for product handling and storage. Research on reproductive hazards associated with cosmetology work can further inform effective educational programs and workplace interventions.

Despite the potential health and reproductive hazards associated with nail technician work and workplaces, this study is the first to the authors' knowledge to evaluate the relationship between a maternal occupation as a nail technician and a selected spectrum of birth defects. This study also contributed to the limited body of literature on birth defects among hairdressers, particularly oral clefts. However, this analysis had several limitations. Sample sizes were small, which led to large confidence intervals and an inability to analyze many birth defects, primarily non-heart defects among nail technicians. Residual confounding may also be of concern since small sample size inhibited the ability to control for additional covariates or risk factors, such as other lifestyle and health behaviors (e.g., drug use), co-exposures, and paternal characteristics. Nonetheless, strong associations were observed for several CHDs among nail technicians and oral clefts among hairdressers, and estimates were similar after controlling for a few covariates.

Although we restricted our analysis to simple isolated cases of birth defects to reduce the heterogeneity of outcome categories, there are still limitations to grouping birth defects into categories such as "any heart defect" and "oral clefts." The developmental heterogeneity of individual birth defect phenotypes should be considered when interpreting associations with grouped phenotype outcome categories (i.e., grouped phenotypes may share an anatomical location but not necessarily developmental pathways or etiologies). Because occupational studies of birth defects often lack sufficient sample size for analyzing specific phenotypes,

we nevertheless present data for grouped phenotypes for comparison with other studies and hypothesis-generating purposes. The relatively small sample sizes for individual birth defect groups, combined with multiple comparisons, mean that the associations we observed in our study could represent chance findings. Additional work is needed to confirm whether nail technician work is associated with CHDs in particular.

Furthermore, the exposure assessment was conducted retrospectively using self-reported questionnaire information, which could have caused some misclassification. However, the assessment was conducted by experts with diverse experience in occupational epidemiology and industrial hygiene, and the inter-rater reliability was high. Because this study involved a special emphasis on nail technicians, the exposure assessment only included classification of indirect exposure to nail products, and no assessment of indirect exposure to hair products. It is therefore possible that some nail technicians were occupationally exposed to some hair products, particularly if they shared a workspace with hairdressers. This limitation, in addition to a lack of power, inhibited the ability to directly compare nail technicians and hairdressers. Still, the analysis of these two occupational groups in reference to non-cosmetologists showed substantially different findings, suggesting that such misclassification may be of limited concern. Lastly, any potential for misclassification caused by information bias was reduced by some characteristics of the NBDPS design, including the structured questionnaire administration.

Another limitation is the lack of information on specific exposures or workplace practices that could be affecting reproductive outcomes observed in these occupations. But as described above, there are many potential reproductive risk factors within these occupations. Understanding potential adverse reproductive outcomes at the occupation level establishes a need for analyses on specific hazards among these populations.

Lastly, mothers included in this analysis were recruited from 1997–2011. As nail trends evolve, new products, application methods, and technologies are continuously being introduced, and older technologies, such as acrylic dip application methods, are re-introduced into the nail industry.[2] Therefore, exposures might have since changed across nail technician and hairdresser occupations due to changes in style trends, product development, and workplace practices.

Research on birth defects in nail technicians and hairdressers could benefit from larger studies with women employed more recently. Additional understanding of the specific hazards faced by workers in related occupations can inform interventions through a hierarchy of controls approach and contribute to health education aimed at reducing adverse reproductive outcomes in working populations.

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Disclaimer:

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KEY MESSAGES

What is already known about this subject?

- Although nail technicians and hairdressers use products that often contain chemicals with potential reproductive effects, there is a lack of research on birth defects in children of women working in these occupations during pregnancy.

What are the new findings?

- This study provided novel results suggesting an association between maternal occupation as a nail technician during pregnancy and congenital heart defects.
- Cleft lip with cleft palate was associated with working as a hairdresser during pregnancy, which is consistent with some previous studies.
- An exploratory analysis provided preliminary evidence that the combination of nail technician and hairdressing activities may even compound the risk for oral clefts.

How might this impact policy or clinical practice in the foreseeable future?

- Employers, healthcare providers, and nail technicians and hairdressers can work together to raise awareness of potential reproductive hazards encountered in the workplace and reduce exposures as much as possible.
- Additional understanding of the specific and evolving reproductive hazards faced by working nail technicians and hairdressers is needed to inform workplace practices, recommendations, training, and other interventions aimed at reducing adverse outcomes.

Table 1.

Distribution of covariates among hairdressers, nail technicians, and non-cosmetologists, National Birth Defects Prevention Study, 1997–2011

	Hairdressers (n=196)[1]		Nail technicians (n=61)		Non-cosmetologists (n=42,810)	
Covariate	*n (%)* [2,3]		*n (%)* [2,3]		*n (%)* [2,3]	
Study site						
Arkansas	28	(14.3)	NR		5649	(13.2)
California	8	(4.1)	8	(13.1)	5141	(12.0)
Georgia	30	(15.3)	8	(13.1)	4760	(11.1)
Iowa	13	(6.6)	5	(8.2)	4197	(9.8)
Massachusetts	41	(20.9)	10	(16.4)	5258	(12.3)
New Jersey	15	(7.7)	9	(14.8)	2184	(5.1)
New York	16	(8.2)	4	(6.6)	3092	(7.2)
North Carolina	18	(9.2)	NR		3356	(7.8)
Texas	13	(6.6)	6	(9.8)	4740	(11.1)
Utah	14	(7.1)	9	(14.8)	4433	(10.4)
Smoking status in early pregnancy						
No	150	(76.5)	54	(88.5)	34118	(80.4)
Any	46	(23.5)	7	(11.5)	8310	(19.6)
Age at delivery						
Years (mean, SD)	29.1	(5.6)	28.9	(4.6)	27.7	(6.2)
<35 years	159	(81.1)	56	(91.8)	36445	(85.1)
≥35 years	37	(18.9)	5	(8.2)	6365	(14.9)
Pre-pregnancy body mass index						
Underweight	5	(2.6)	5	(8.2)	2223	(5.4)
Normal weight	98	(50.8)	32	(52.5)	21119	(51.6)
Overweight	52	(26.9)	16	(26.2)	9356	(22.9)
Obesity	38	(19.7)	8	(13.1)	8195	(20.0)
Education level at delivery						
No high school degree	12	(6.1)	3	(4.9)	7364	(17.4)
High school degree	51	(26.0)	16	(26.2)	10679	(25.2)
Some college	123	(62.8)	31	(50.8)	11378	(26.9)
College degree or higher	10	(5.1)	11	(18.0)	12897	(30.5)
Maternal race/ethnicity						
Non-Hispanic White	133	(67.9)	38	(62.3)	25061	(58.6)
Non-Hispanic Black	28	(14.3)	NR		4414	(10.3)
Hispanic	26	(13.3)	8	(13.1)	10454	(24.4)
Asian/Pacific Islander	4	(2.0)	11	(18.0)	1210	(2.8)
Other	5	(2.6)	NR		1664	(3.9)

[1] Excluding hairdressers with indirect nail product exposure

[2] Estimates shown as n (%) except where indicated otherwise (i.e., age in years)

[3]Frequencies may not add up to sample totals where there are missing values (<5% missing for all variables in each exposure category)

NR: Not reportable based on n<3

Table 2.

Adjusted associations[1] between birth defects and maternal occupation as a nail technician or hairdresser in comparison to non-cosmetologist during pregnancy, National Birth Defects Prevention Study, 1997–2011

	Hairdressers[2]			Nail technicians		
Birth defect	***n***	***OR***	***95% CI***	***n***	***OR***	***95% CI***
Congenital Heart Defects						
Any heart defect	*26*	0.8	(0.5 - 1.2)	*19*	2.7	(1.3 - 5.9)
Conotruncal defects	*5*	0.7	(0.3 - 1.6)	*5*	3.0	(1.0 - 8.8)
Tetralogy of Fallot	*3*	0.7	(0.2 - 2.2)	*3*	3.5	(1.0 - 12.9)
LVOTO	*5*	0.8	(0.3 - 2.0)	*NR*		
RVOTO	*6*	1.0	(0.4 - 2.3)	*4*	3.2	(1.0 - 10.4)
Pulmonary valve stenosis	*6*	1.2	(0.5 - 2.9)	*3*	3.5	(0.9 - 12.9)
Septal defects	*9*	0.8	(0.4 - 1.5)	*7*	3.1	(1.2 - 8.1)
Atrial septal defect	*7*	1.0	(0.4 - 2.2)	*4*	3.0	(0.9 - 9.6)
Non-Heart Defects						
Neural tube defects	*7*	0.9	(0.4 - 2.0)	*4*	2.6	(0.8 - 8.4)
Anencephaly and craniorachischisis	*3*	1.4	(0.4 - 4.5)	*NR*		
Spina bifida	*4*	0.8	(0.3 - 2.4)	*NR*		
Anotia/microtia	*3*	2.1	(0.6 - 6.9)	*NR*		
Oral clefts	*21*	1.2	(0.7 - 2.1)	*NR*		
Cleft palate	*3*	0.5	(0.2 - 1.7)	*NR*		
Cleft lip w/wo cleft palate	*18*	1.7	(1.0 - 2.9)	*NR*		
Cleft lip with cleft palate	*13*	2.0	(1.1 - 3.7)	*NR*		
Cleft lip without cleft palate	*5*	1.2	(0.5 - 3.1)	*NR*		
Hypospadias	*15*	1.4	(0.7 - 2.6)	*NR*		
Limb deficiency	*4*	1.0	(0.4 - 2.9)	*NR*		
Craniosynostosis	*7*	1.2	(0.5 - 2.7)	*NR*		
Diaphragmatic hernia	*3*	1.1	(0.4 - 3.7)	*NR*		
Gastroschisis	*7*	1.7	(0.7 - 3.9)	*NR*		

[1] Controlling for mother's smoking status, age at delivery (in continuous years), education level, and race/ethnicity

[2] Excluding hairdressers with indirect nail product exposure

OR: Odds ratio; CI: Confidence interval; RVOTO: Right ventricular outflow tract obstruction; LVOTO: Left ventricular outflow tract obstruction; w/wo: with or without; NR: Not reportable based on n<3

Table 3.

Results from the exploratory analyses[1] of birth defects associated with maternal occupations as a nail technician with frequent work[2] or combination nail technician-hairdresser in comparison to non-cosmetologist during pregnancy, National Birth Defects Prevention Study, 1997–2011

	Nail technicians with frequent work[2]			Combination nail technician-hairdressers		
Birth defect	***n***	***OR***	***95% CI***	***n***	***OR***	***95% CI***
Congenital Heart Defects						
Any heart defect	*14*	2.2	(1.0 - 5.1)	*4*	0.8	(0.2 - 2.7)
RVOTO	*4*	3.6	(1.1 - 11.8)	*NR*		
Pulmonary valve stenosis	*3*	3.9	(1.0 - 15.0)	*NR*		
Septal defects	*6*	2.9	(1.0 - 8.3)	*NR*		
Atrial septal defect	*3*	2.5	(0.7 - 9.3)	*NR*		
Non-Heart Defects						
Neural tube defects	*4*	2.9	(0.9 - 9.6)	*NR*		
Oral clefts	*NR*			*10*	4.2	(1.5 - 11.5)
Cleft palate	*NR*			*4*	5.2	(1.5 - 18.6)
Cleft lip w/wo cleft palate	*NR*			*6*	3.9	(1.2 - 12.0)
Cleft lip with cleft palate	*NR*			*5*	5.3	(1.6 - 17.3)

[1]Controlling for mother's smoking status, age at delivery (in continuous years), education level, and race/ethnicity

[2]Nail technicians working 20 hours per week or more and at least 60 days during early pregnancy

OR: Odds ratio; CI: Confidence interval; RVOTO: Right ventricular outflow tract obstruction; w/wo: with or without; NR: Not reportable based on n<3