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Pregnancy outcomes among female dental personnel – a registry-based retrospective cohort study

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Objectives The aim of this study was to investigate whether women who have worked as dental personnel in Norway, a group with possible previous exposure to mercury vapor, have had an excess risk of having children with congenital malformations or other adverse pregnancy outcomes compared to the general population.

Methods A cohort of female dental personnel was identified from the archives of the public dental healthcare and the national trade unions in Norway. Data on births and pregnancy outcomes during 1967–2006 were obtained from the Medical Birth Registry of Norway (MBRN). The final cohort of dental personnel consisted of 4482 dental assistants and 1011 dentists. All other women registered in the MBRN were assigned to the control group, in total 1 124 758. Excess risks of several adverse pregnancy outcomes for dental personnel compared to the general population were estimated. Analyses were conducted for the whole time period as well as stratified by 10-year periods.

Results Female dental personnel had no observed increased occurrence of congenital malformations (including malformations of the central nervous system, dysplasia of the hip, clubfoot, malformations of the heart and great vessels), low birth weight, preterm birth, small for gestational age, changed gender ratio, multiple birth, stillbirth, or prenatal death.

Conclusion On a group level, we did not observe any excess risks of congenital malformations or other adverse pregnancy outcomes among female dental personnel in Norway during 1967–2006 compared to the general population.

Key terms birth defect; congenital malformation; dental work; dentist; mercury; metallic mercury; Norway.

Metallic mercury vapor at high doses has well-known neurotoxic effects with symptoms including tremors, fatigue, memory impairment, depression as well as changes in behavior and personality (1). Amalgam-containing metallic mercury has been used for teeth restoration for several decades, entailing varying degrees of mercury exposure among dental personnel. Whether such occupational exposure has caused deleterious health effects has repeatedly been subject to public debate in the Scandinavian countries, including Nor-

way. Some previous studies have shown that dental personnel have had an increased prevalence of cognitive and neuropsychological symptoms (2–5). In 2005, the Norwegian Ministry of Labor and Social Inclusion initiated a study to investigate cognitive symptoms among Norwegian dental personnel. This study found that dental assistants in Norway had a slight increase in the occurrence of cognitive symptoms (6).

In addition to cognitive symptoms, the issue of possible reproductive effects of occupational exposure to

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metallic mercury has been raised. The literature on occupational mercury exposure and pregnancy outcomes is sparse and contains somewhat inconsistent results. Some studies have found an increased rate of miscarriages among women with occupational mercury exposure (7–8), but most studies have found neither such an association (9–15) nor any excess risk of prenatal mortality (11–13). An increased occurrence of congenital malformations in association with mercury exposure has been reported by several researchers (7, 11–12) while others have not found any such associations (8–9, 13, 16).

In 2008, the Norwegian Ministry of Labor and Social Inclusion initiated a follow-up study regarding pregnancy outcomes among dental personnel previously exposed to metallic mercury. In Norway, the degree of exposure to mercury among dental personnel has varied considerably over the last 50 years (17–18). Until the 1980s, a special form of copper amalgam (consisting of 70% mercury and 30% copper) was commonly used for restoring deciduous teeth. Solid tablets of copper amalgam were heated to above melting point of the alloy, leading to a high concentration of mercury vapor in the air. In 1973, the levels of mercury vapor were measured in 15 dental clinics, and the reported mean level was 0.043 mg/m³ with measurements ranging from 0.00–0.40 mg/m³ (19). Dental silver amalgam has been widely used, with different preparation methods causing variable levels of exposure throughout the years (17). Due to the introduction of prefabricated capsules, the exposure has been negligible since about 1990 (18) and, from 2008 onwards, the use of dental amalgam has been prohibited in Norway. Correspondingly, measurements of mercury levels in urine among Norwegian dental personnel as part of a voluntary monitoring showed a reduction of about 90% from the 1960s to the 1990s. In the 1960s, 62% of the samples were over the biological limit value of 200 nmol/l compared to none in the 1990s (18). Thus, the main concern has been that women working in dental healthcare prior to 1990 have been exposed to levels of mercury that may have caused reproductive toxicity.

The aim of this study was to investigate whether female dental personnel in Norway, with previous potential exposure to mercury vapor, have had an increased risk of having children with congenital malformations or other adverse pregnancy outcomes on a group level.

Methods

From dental authorities and public archives, we obtained lists of current and previous employees in the public dental healthcare system from all 19 counties in Norway except one, Rogaland. Employees registered from the

establishment of the archives (all prior to 1967) until the time of data collection (2007/2008) were included and all relevant data from the time of employment and onwards were collected. For 14 of the counties, the lists also included information provided by dentists in private practice. In addition, the three largest national trade unions of dental assistants and dentists provided information about members who had been addressed and had agreed to participate in the study. Approximately 44% (1912) of the trade union members agreed to participate. After collection, the lists were checked and duplications removed. For many of the dental personnel, data were obtained from several sources and were in general consistent (eg, one person ended work in one county the same year as she started work in another county). The data collected on the female dental personnel included name, address, national identification number, occupation, place of work, time period employed or member of the trade union, and graduation year for dentists. The final identified cohort of dental personnel consisted of 7475 female dental assistants and dentists.

The Medical Birth Registry of Norway (MBRN) was established in 1967 and is based on the compulsory notification of all births in Norway after 16 weeks of gestation and after 12 weeks since 2001 (20). The registry includes demographic information about the child and his/her parents, data on complications and interventions during pregnancy and delivery, maternal health before and during pregnancy and the condition of the newborn. From the MBRN, we obtained data on the year of delivery, congenital malformations, neonatal diagnoses, prenatal death, birth weight, gestational age, gender, plurality, maternal age, and parity. Data on the educational level of the mothers was obtained from Statistics Norway.

Record linkage was performed between data from the cohort of dental personnel and data from the MBRN and Statistics Norway, enabled by each mother's unique national identification number. Infants delivered to female dental personnel during 1967–2006 were defined as the exposed group and deliveries to all other females were defined as the unexposed group (control group). The final study population consisted of 1 130 251 mothers, of whom 5493 were dental personnel. The number of female dental personnel was somewhat lower after alignment with the MBRN because some women had no children or had given birth prior to the establishment of the MBRN in 1967.

Owing to differences in working conditions, the cohort of dental personnel was categorized into two occupational groups: dental assistants and dentists. The data on the time periods of employment were incomplete or missing for a considerable number of the dental personnel. Therefore, by use of the available data on periods of time employed, the dental personnel known to be

in employment before each delivery were also identified. The data did not include information on maternity leave or other longer leaves, only on termination of employment. Data from trade unions did not include dates of employment, and therefore the women identified solely from trade unions were not included in the group “dental personnel in employment”.

The pregnancy outcomes studied were chosen based on the available literature regarding occupational exposure to mercury and reproduction and the availability of data. The following categories of congenital malformations were studied: all congenital malformations registered in the MBRN, major congenital malformations (as defined by the MBRN), malformations of the central nervous system (anencephaly, spina bifida, encephalocele, and hydrocephalus), dysplasia of the hip, clubfoot, and malformations of the heart and great vessels. Other adverse pregnancy outcomes investigated included: low birth weight (<2500 grams), preterm delivery (<37 weeks gestational age), small for gestational age [SGA, weight below the 10th percentile for actual gestational age in Norwegian newborns (21)], gender distribution (higher proportion of boys), multiple births, stillbirth (death prior to or during delivery) and prenatal death (stillbirth or death during the first month of life).

Statistical analysis

The excess risks of adverse pregnancy outcomes for dental personnel compared to the control group were estimated using negative binomial regression models with log link [STATA, version 10 (StataCorp, College Station, TX, USA)]. Poisson regression was used when the standard method could not be performed due to collinearity. When the 95% confidence interval (95% CI) did not include one, the test was considered statistically significant. We adjusted for the following potential confounders as categorical variables: parity (1, 2, ≥3), year of delivery (1967–1976, 1977–1986, 1987–1996, 1997–2006), maternal age (<25, 25 to 34, ≥35) and maternal education level [primary/unknown

(0–9 years), upper secondary (10–12 years), university/university college (≥13 years)]. Relative risks (RR) with 95% CI were estimated with births clustered by mother (using the cluster option in STATA), since births by the same mother are not independent events. For the most frequent congenital malformations (all congenital malformations and major congenital malformations) and the other adverse pregnancy outcomes, we estimated the time trend and tested for interaction between time (year of delivery) and occupation, and in addition performed analyses stratified by 10-year periods (1967–1976, 1977–1986, 1987–1996, and 1997–2006). This was done to investigate whether the risk of adverse outcomes was higher in time periods with assumed high exposure to mercury. Analyses were performed using all dental personnel, as well as sub-analyses using only dental personnel with known employment prior to delivery.

Ethical considerations

The Regional Committee for Medical and Health Research Ethics in Central Norway evaluated and approved this study.

Results

Demographic information on the female dentists, dental assistants and the control group is shown in table 1. On average, the women had two children each. Dentists were older than the other groups at the time of their first delivery. The dental assistants had a lower educational level than the control group. Six percent of the dentists were not registered with higher education, possibly owing to incomplete registration of education completed abroad. A formal education for dental assistants was introduced in Norway in the sixties, but many still worked after that based on their occupational experience, but without formal upper-secondary education.

Table 1. Demographic information of the control group and the dental personnel. [SD=standard deviation.]

	Control group				Dental assistants				Dentists			
	N	Mean	SD	%	N	Mean	SD	%	N	Mean	SD	%
Women	1 124 758				4 482				1 011			
Maternal age at first delivery		26.0	5.2			25.1	4.5			29.3	3.8	
Number of children per woman		2.07				2.09				2.05		
Highest registered education												
Primary and lower secondary/unknown				27.6				24.4				4.8 ^a
Upper secondary				43.1				64.2				1.2 ^a
University/university college				29.3				11.4				94.0

^a The registration of education completed outside Norway is incomplete.

The occurrence of congenital malformations is shown in table 2. Crude and adjusted analyses are shown for all dental personnel as well as for the sub-cohort of dental personnel with known employment before each birth. When adjusting for potential confounders there were no statistically significant differences in the occurrence of congenital malformations between the groups, except for a reduced risk of children with clubfoot in the group of all dental assistants.

Analyses stratified by 10-year periods for all congenital malformations are shown in table 3. There were no significant differences in the risk of adverse outcomes between the groups in any of the time periods. No excess risk was found for any of the time periods in the other malformation categories in the stratified analyses (data not shown).

In addition, in the time trend analysis, a statistically significant increase in the number of registered congenital malformations (all and major) over time was observed ($P<0.001$), which did not differ between occupational groups. This increase was probably attributable to revisions of the birth notification form and an improved registration and diagnosis of congenital malformations.

Table 4 shows the occurrence of other adverse pregnancy outcomes in the groups of dental personnel and the control group. No statistically significant differences between groups of dental personnel and the control group were found.

The occurrence of the outcomes low birth weight, preterm birth and multiple births increased over time while a decrease was observed for the outcomes SGA, stillbirth and prenatal death ($P<0.001$ for all). There was no change in the proportion of male births during the study period.

For the outcomes preterm birth and multiple births, the occupational groups had diverging trends: dental assistants had an increasing risk over time compared to the control group, while the dentists had a decreasing risk. However, in the analyses stratified by 10-year periods, the risks of these outcomes for dental personnel were not significantly different from the control group in any of the time periods (data not shown). Likewise, the offspring of dental personnel did not have excess risks of low birth weight, SGA, being disproportionately of male gender, stillbirth, and prenatal death in any of the time periods (data not shown). However, occasional

Table 2. Congenital malformations in the offspring of dental personnel and the rest of the population (control group) in Norway, 1967 to 2006. [RR=relative risk; 95% CI=95% confidence interval; Adj=adjusted; ref=reference; CNS=central nervous system]

Outcome and occupation	All						Dental personnel in employment ^a					
	N	per 1000	RR	95% CI	Adj RR ^b	95% CI	N	per 1000	RR	95% CI	Adj RR ^b	95% CI
All malformations												
Control group	75 163	32.4	1.00	ref	1.00	ref	75 163	32.4	1.00	ref	1.00	ref
Dental assistants	258	27.5	0.85	0.75–0.96	0.90	0.76–1.08	114	30.5	0.94	0.78–1.14	0.95	0.74–1.23
Dentists	79	38.1	1.19	0.95–1.49	0.89	0.62–1.28	56	35.6	1.10	0.84–1.45	0.86	0.57–1.28
Major malformations												
Control group	48 954	21.1	1.00	ref	1.00	ref	48 954	21.1	1.00	ref	1.00	ref
Dental assistants	172	18.4	0.87	0.74–1.01	0.88	0.71–1.09	75	20.0	0.95	0.75–1.21	0.92	0.67–1.26
Dentists	48	23.2	1.10	0.83–1.47	0.84	0.54–1.31	35	22.2	1.06	0.75–1.49	0.79	0.48–1.30
Malformations of the CNS												
Control group	3 481	1.5	1.00	ref	1.00	ref	3 481	1.5	1.00	ref	1.00	ref
Dental assistants	12	1.3	0.85	0.46–1.58	0.87	0.47–1.60	6	1.6	1.07	0.43–2.71	1.10 ^c	0.44–2.77 ^c
Dentists	1	0.5	0.32	0.05–2.29	.	..	1	0.6	0.42	0.06–3.01	.	..
Dysplasia of the hip												
Control group	3 780	1.6	1.00	ref	1.00	ref	3 780	1.6	1.00	ref	1.00	ref
Dental assistants	6	0.6	0.39	0.18–0.88	0.47 ^d	0.21–1.05 ^d	2	0.5	0.33	0.08–1.32	0.34 ^d	0.09–1.38 ^d
Dentists	6	2.9	1.78	0.80–3.97	1.02 ^d	0.46–2.27 ^d	5	3.2	1.96	0.81–4.71	1.08 ^d	0.45–2.69 ^d
Clubfoot												
Control group	4 132	1.8	1.00	ref	1.00	ref	4 132	1.8	1.00	ref	1.00	ref
Dental assistants	11	1.2	0.66	0.36–1.19	0.24	0.06–0.94	4	1.1	0.60	0.23–1.61	0.27	0.04–1.92
Dentists	2	1.0	0.54	0.14–2.17	.	..	2	1.3	0.71	0.18–2.86	.	..
Malformations of the heart and great vessels												
Control group	9 971	4.3	1.00	ref	1.00	ref	9 971	4.3	1.00	ref	1.00	ref
Dental assistants	34	3.6	0.84	0.60–1.19	1.24	0.82–1.89	14	3.7	0.87	0.52–1.48	0.96	0.48–1.93
Dentists	11	5.3	1.24	0.69–2.24	0.73	0.27–1.96	9	5.8	1.33	0.69–2.57	0.86	0.32–2.30

^a Known to have been employed as dental personnel prior to delivery.

^b Adjusted for maternal age, educational level, parity and year of birth. Births clustered by mother.

^c Poisson regression.

^d Poisson regression without adjustment for year of birth.

Table 3. All congenital malformations in the offspring of dental personnel and the rest of the population (control group) in Norway, stratified by time periods. [RR=relative risk; Adj=adjusted; 95% CI=95% confidence interval; ref=reference]

Time period and occupations	All						Dental personnel in employment ^a					
	N	per 1000	RR	95% CI	Adj RR ^b	95% CI	N	per 1000	RR	95% CI	Adj RR ^b	95% CI
1967–1976												
Control group	13 598	21.5	1.00	ref	1.00	ref	13 598	21.5	1.00	ref	1.00	ref
Dental assistants	65	21.5	1.00	0.78–1.28	0.88	0.56–1.39	27	26.8	1.25	0.85–1.84	1.32	0.70–2.47
Dentists	28	17.5	0.81	0.40–1.63	0.79	0.25–2.47	5	16.7	0.77	0.32–1.87	1.07	0.34–3.37
1977–1986												
Control group	15 158	29.6	1.00	ref	1.00	ref	15 158	29.6	1.00	ref	1.00	ref
Dental assistants	70	24.6	0.83	0.65–1.05	0.88	0.64–1.22	28	22.1	0.74	0.51–1.08	0.71	0.42–1.20
Dentists	13	29.6	1.00	0.58–1.73	0.84	0.37–1.90	11	31.2	1.06	0.58–1.92	0.80	0.33–1.93
1987–1996												
Control group	19 787	33.2	1.00	ref	1.00	ref	19 787	33.2	1.00	ref	1.00	ref
Dental assistants	74	31.9	0.96	0.76–1.21	0.89	0.65–1.23	35	37.3	1.13	0.80–1.58	1.06	0.69–1.64
Dentists	20	37.0	1.12	0.72–1.75	0.72	0.34–1.52	12	28.4	0.85	0.48–1.51	0.73	0.32–1.64
1997–2006												
Control group	26 620	45.7	1.00	ref	1.00	ref	26 620	45.7	1.00	ref	1.00	ref
Dental assistants	49	41.7	0.91	0.68–1.21	0.96	0.67–1.38	24	45.5	1.00	0.66–1.50	0.95	0.57–1.59
Dentists	38	59.9	1.33	0.96–1.85	1.06	0.64–1.75	28	56.2	1.25	0.85–1.82	0.92	0.52–1.64

^a Known to have been employed as dental personnel prior to delivery.

^b Adjusted for maternal age, educational level and parity.

significantly lower risks of some of the outcomes were observed for dental personnel in some of the stratified analyses. For instance where dental assistants (all) had a reduced risk of SGA in the time period 1967–1976 (adjusted RR 0.78, 95% CI 0.63–0.95) and dental assistants (in employment) had a reduced risk of low birth weight in the time period 1997–2006 (adjusted RR 0.46, 95% CI 0.23–0.90). However, since the level of significance was not adjusted for multiple testing, these results must be interpreted with care.

We also performed analyses with the dental personnel stratified into groups based on the number of years in employment prior to delivery, which did not influence the results.

Discussion

In the present study, we did not observe any excess risks of congenital malformations or other adverse pregnancy outcomes for female dental personnel on a group level in Norway during 1967–2006.

The population-based cohort design of this study represents a strength due to the considerable number of deliveries (>11 000 among female dental personnel and 2 328 000 in the control group). As the majority of the cohort of dental personnel was identified from public archives and registries, the risk of selection bias is considered to be low. The women identified from the trade unions, however, were included after agreeing to participate. This might have caused some selection bias, as there has been considerable media attention in Norway

over the past few years regarding exposure to mercury and its possible adverse health effects in dental personnel. It is not unlikely that dental personnel who have had health problems or experienced adverse pregnancy outcomes could have been more willing to participate. This could potentially have caused stronger estimates of excess risks in dental personnel. However, we did not observe any such excess risk. In addition, only 10% of the cohort of dental personnel was identified from the trade unions.

Working as dental personnel in the period before delivery was used as an indicator of occupational exposure, but data on time periods of employment were missing or incomplete for many of the dental personnel (table 2). We cannot rule out that the missing data could have affected the findings. However, analyses performed using the sub-cohort with known employment prior to delivery provided similar results as when using the whole cohort. A dose–response relationship could not be demonstrated either, as stratification based on the number of years of employment prior to delivery did not influence the results.

As the outcomes are registry based, any information bias is likely to be negligible. A certain misclassification of dental personnel as controls was probably present as not all women who had worked as dental personnel were identified as such. However, this is not likely to be related to any of the outcomes and would therefore represent a non-differential misclassification. Likewise, all data on outcomes and potential confounders were collected from the public registries MBRN and Statistics Norway. Even if earlier studies have indicated that the registration of congenital malformations in MBRN may

Table 4. Adverse pregnancy outcomes among dental personnel and the rest of the population (control group) in Norway, 1967–2006. [RR=relative risk; Adj=adjusted; 95% CI=95% confidence interval; ref=reference; SGA=small for gestational age.]

Outcome and occupation	All						Dental personnel in employment ^a					
	N	per 100	RR	95% CI	Adj RR ^b	95% CI	N	per 100	RR	95% CI	Adj RR ^b	95% CI
Low birth weight												
Control group	120 975	5.2	1.00	ref	1.00	ref	120 975	5.2	1.00	ref	1.00	ref
Dental assistants	484	5.2	0.99	0.89–1.10	0.96	0.82–1.12	217	5.8	1.12	0.96–1.32	0.98	0.77–1.24
Dentists	89	4.3	0.82	0.64–1.04	0.92	0.64–1.30	64	4.1	0.77	0.58–1.03	0.90	0.61–1.33
Preterm birth												
Control group	148 474	6.8	1.00	ref	1.00	ref	148 474	6.8	1.00	ref	1.00	ref
Dental assistants	555	6.2	0.92	0.83–1.01	0.89	0.77–1.03	239	6.7	0.99	0.85–1.15	0.89	0.72–1.09
Dentists	91	4.6	0.66	0.52–0.84	0.70	0.49–1.00	70	4.6	0.67	0.52–0.87	0.67	0.47–1.00
SGA												
Control group	252 371	10.9	1.00	ref	1.00	ref	252 371	10.9	1.00	ref	1.00	ref
Dental assistants	994	10.6	0.97	0.90–1.05	0.90	0.81–1.01	400	10.7	0.99	0.87–1.11	0.94	0.79–1.12
Dentists	193	9.3	0.84	0.72–0.99	0.92	0.70–1.19	130	8.3	0.74	0.61–0.90	0.83	0.62–1.12
Gender (proportion of boys)												
Control group	1 192 805	51.4	1.00	ref	1.00	ref	1 192 805	51.4	1.00	ref	1.00	ref
Dental assistants	4 776	51.0	0.98	0.94–1.02	0.99	0.94–1.05	1 884	50.6	0.97	0.91–1.03	0.96	0.88–1.05
Dentists	1 076	52.0	1.02	0.94–1.12	0.95	0.84–1.08	822	52.3	1.04	0.94–1.15	0.93	0.81–1.07
Multiple births												
Control group	60 169	2.6	1.00	ref	1.00	ref	60 169	2.6	1.00	ref	1.00	ref
Dental assistants	192	2.0	0.79	0.64–0.97	0.80	0.60–1.06	91	2.4	0.94	0.70–1.27	0.66	0.42–1.04
Dentists	52	2.5	0.97	0.65–1.44	1.04	0.64–1.71	40	2.5	0.98	0.62–1.55	1.00	0.57–1.73
Stillbirth												
Control group	24 888	1.1	1.00	ref	1.00	ref	24 888	1.1	1.00	ref	1.00	ref
Dental assistants	101	1.1	1.01	0.82–1.24	1.16	0.88–1.53	40	1.1	1.00	0.72–1.38	1.04	0.69–1.57
Dentists	18	0.9	0.81	0.48–1.37	1.04	0.53–2.05	15	1.0	0.89	0.49–1.61	1.11	0.54–2.28
Prenatal death												
Control group	36 832	1.6	1.00	ref	1.00	ref	36 832	1.6	1.00	ref	1.00	ref
Dental assistants	148	1.6	1.00	0.84–1.18	1.06	0.83–1.34	56	1.5	0.95	0.72–1.24	0.95	0.66–1.35
Dentists	28	1.4	0.85	0.55–1.32	1.13	0.66–1.93	25	1.6	1.00	0.62–1.61	1.26	0.73–2.20

^a Known to have been employed as dental personnel prior to delivery.^b Adjusted for maternal age, educational level and parity. Births clustered by mother.

be somewhat incomplete (22), mainly because many malformations are discovered some time after birth, this incomplete registration is not likely to be related to maternal occupation.

There were potential confounders for which we were unable to control, such as smoking during pregnancy, which is known to be related to low birth weight and preterm birth (23). Smoking habits are strongly correlated to education (24), but we cannot rule out the possibility of residual confounding.

Regrettably, our study is limited regarding exposure assessment. The main concern when this study was initiated was exposure to metallic mercury vapor, but with the available data it was not possible to estimate this exposure reliably. We do, however, have reason to assume that both dentists and dental assistants in Norwegian dental healthcare were exposed to metallic mercury to a varying degree at least until 1990 (17). Working as dental personnel in the period before delivery was used as an indicator of occupational exposure. This is clearly not specific for mercury and thus other occupational exposures in dental work are also included (eg, x-rays, chloroform, disinfectants, methyl methacrylate and organic solvents). Thus, this study cannot

relate the occurrence of adverse pregnancy outcome to any specific substances, but rather assess whether the occupational exposure on a whole has had an effect. In addition, with such crude measurements of exposure, we can only make inferences on how employment as dental personnel might have affected reproductive outcomes on a group level, not among individuals.

Even with these uncertainties, mercury is our main concern regarding occupational exposure among dental personnel. Mercury vapor is easily absorbed when inhaled and is readily transported to other organs via the blood stream. In the organs, the metallic mercury is oxidized to form mercuric mercury, and this is thought to be the toxic species. Metallic mercury is mainly neurotoxic even though it is found in several organs, including the kidney, after exposure (25). Metallic mercury can also be transported across the placenta (26) and could thus affect the fetus. In the present study, the analyses stratified by time periods did not show any excess risk of congenital malformations or other adverse pregnancy outcomes among dental personnel, not even during the periods with frequent use of amalgam and especially copper amalgam (ie, 1967–1976 and 1977–1986). This indicates that the exposure to mercury vapor during these time periods did not

cause any measurable excess risk of adverse pregnancy outcomes on a group level, among Norwegian dental personnel. Even so, we cannot exclude the possibility that there have been cases of mercury exposure high enough to cause reproductive effects among some individuals. In addition, as this study is based on data from MBRN, it does not address deliveries prior to 1967, a time period in which amalgam was in common use. Thus, any possible earlier effects, or effects among individuals, would not have been detected in this study.

Our results are in agreement with other registry-based studies. An earlier Norwegian study on neural tube defects in children of dental assistants did not find an increased risk for malformations (16) and a Swedish study did not find a higher-than-expected number of congenital malformations, prenatal deaths, or low birth weight among children of dental personnel (13). Our findings also correspond with two questionnaire-based studies; a British study on female dentists that did not find an increased occurrence of congenital malformations or low birth weight but an increased risk of miscarriages (8) and an American study on dental personnel that did not find an excess risk of congenital malformations or miscarriages (9). Regrettably, we did not have the opportunity to include miscarriages or infertility in our study, as these outcomes are not registered in the MBRN. A recent study on dental assistants from New Zealand showed a non-statistically significant increased risk of miscarriage, congenital malformations and low birth weight (7). An Italian study on lamp factory workers exposed to metallic mercury found an increased occurrence of congenital malformations, especially hip dysplasia, compared to the control group but no increase in miscarriages, prenatal mortality, or low birth weight (11). However, the authors suggested that the increased occurrence of hip dysplasia could be explained by regional differences in its prevalence in Italy. A small American study at a thermometer factory found a non-significant increase in the number of children with malformations in the exposed group, but no differences in the number of miscarriages (12).

Our study did not demonstrate any excess risks of the adverse pregnancy outcomes studied among dental personnel during 1967–2006. In fact, the majority of our risk estimates indicated a reduced occurrence among dental personnel, but, with a few exceptions in some of the stratified analyses, these were not statistically significant. We have, however, not adjusted the significance level owing to multiple testing and therefore the few significant estimates must be cautiously interpreted.

In conclusion, this study did not demonstrate any excess risks of congenital malformations or other selected adverse pregnancy outcomes among female dental personnel during 1967–2006. The results suggest that the previous occupational exposure to mercury in dentistry in Norway has not had a measurable deleteri-

ous effect on pregnancy outcomes among dental personnel on a group level.

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