The risk of infertility among hairdressers. Five-year follow-up of female hairdressers in a Danish national registry

K.S. Hougaard1,3, H. Hannerz1, J.P. Bonde2, H. Fevile1 and H. Burr1

1National Institute of Occupational Health, Copenhagen and 2Department of Occupational Medicine, Aarhus University Hospital, Denmark
3To whom correspondence should be addressed at: National Institute of Occupational Health, Lersø Parkallé 105, DK-2100 Copenhagen, Denmark. E-mail: ksh@ami.dk

BACKGROUND: One in seven married couples is involuntarily infertile. Several chemical exposures in the work environment have been hypothesized to affect female reproduction, and some are present in products used in hairdressing and related trades. Recent Swedish findings indicate that employment in hairdressing poses a risk for female reproductive function. This study examined the possible association between work as a hairdresser and subsequent hospital contact due to female infertility. METHODS: A cohort of all women in Denmark aged 20–44 years on 1 January 1998 (baseline) and registered as economically active hairdressers, according to national registers, was formed to calculate age-standardized risk ratios (RRs) for hospital contacts due to female infertility during a 5-year follow-up period. Hairdressers were compared to a standard population, that is, all economically active women in Denmark aged 20–44 years at baseline, and to women working as shop assistants. RESULTS: Sixty-eight cases of hospital contact due to female infertility were observed among the female hairdressers. On the basis of the standard population, the expected number was 73.27, which gives an observed RR of 0.928 (95% CI: 0.72–1.18). Hairdressers and shop assistants exhibited similar rates of hospital contact due to female infertility (1.01; 95% CI: 0.77–1.29). CONCLUSION: The findings are not corroborating the hypothesis that hairdressers are at increased risk of infertility, but small risks in the entire group or high risks in small subgroups may not be detected by the study.

Key words: fecundability/fertility/hairdressers/occupational hospitalization register

Introduction

One in seven married couples is involuntarily infertile, and herein, female factors play a significant role. Male factors account for about a quarter of cases of infertility, but it has been estimated that more than 50% of infertility cases are explained solely by female factors (Hull et al., 1985; Snick et al., 1997; Evers, 2002). Problems in gametogenesis, transport of the oocyte, hormonal preparation of the uterine lining, implantation and viability of the conceptus all produce difficulty in achieving a recognized pregnancy, but an estimated 30% of infertility cases are unexplained (Evers, 2002). Environmental factors have been proposed to have the potential to alter female reproductive tissues and thus affect the ability of couples to conceive and maintain a healthy pregnancy, by interfering with the hormonal regulation of the reproductive process, by affecting the reproductive organs or by increasing the incidence of early fetal loss and lengthening the period it takes to obtain a recognizable pregnancy (Hruska et al., 2000).

Several chemical exposures in the work environment have been hypothesized to affect female reproductive function (Rachootin and Olsen, 1983; Lindbohm and Taskinen, 2000). Some of these are present in products used in hairdressing and related trades, for example, potential endocrine disrupters, organic solvents and dyestuffs (International Agency for Research on Cancer, 1993; Kersemaekers et al., 1995; Kersemaekers et al., 1998; Van Tongeren et al., 2002). Furthermore, the effects of exposure to mixtures of many chemicals are largely unknown (Carpenter et al., 2002), and several chemical components have not been tested for reproductive hazards (e.g. International Agency for Research on Cancer, 1993). As hairdressers constitute a major occupational group of female workers at childbearing age, it is important to investigate reproductive ability in women working in hairdressing.

Few epidemiological studies have focused on reproductive disorders among hairdressers. One study compared the prevalence of menstrual disorders among hairdressers with the prevalence in a reference population of shop assistants. Statistically significant associations were found for irregular cycles, oligomenorrhea, unusual cycle length, long-lasting blood loss and prolonged pains (Blatter and Zielhuis, 1993). A recent Swedish study investigated reproductive ability in female hairdressers. Women with a degree from Swedish hairdresser schools were compared with women from the general population. Information on reproductive function was obtained retrospectively,
through self-administered questionnaires. The fecundability ratio was obtained based on time to pregnancy, and hairdressers were observed to be approximately 10% less successful in conceiving each month compared to the referents [fecundability ratio 0.91; 95% confidence interval (CI): 0.83–0.99] (Axmon et al., 2006). Hence, there is some indication that employment in hairdressing poses a risk for female reproductive function. The limited availability of data calls for further investigation.

The purpose of this study was to investigate the risk of reduced ability to conceive among female hairdressers. One problem in studying trade-related effects on health is the identification of sufficient numbers of individuals working in the concerned occupation (Weinberg and Wilcox, 1998). In this regard, the Danish Occupational Hospital Register offers a unique opportunity. The register is based on national figures comprising all employees and all hospital contacts during the study period. This means that the number of hospital contacts often is sufficiently large to study a specific health effect in a selected trade (Hannerz et al., 2002). In this study, the diagnosis of infertility was used as a proxy for reduced fecundity, as it implies failure to achieve pregnancy after at least 12 months of unprotected intercourse in the majority of couples (Sundhedsstyrelsen, 1997).

Materials and methods

Data source

This study used information in the Danish Occupational Hospitalisation Register (OHR), a database obtained through a record linkage between three national registers—the Central Person Register, the Hospital Register and the Employment Classification Module. Currently, the OHR includes every person who has been economically active and an inhabitant of Denmark at some time between 1981 and 2002.

The Danish Hospital Register has existed since 1977 and contains data from all public hospitals in Denmark (more than 99% of all admissions). For the time period 1977–1994, the register included only inpatients, but from 1995, it also covers the conclusion of outpatient courses and emergency ward visits (Soll-Johanning et al., 2004). The diagnoses are, since 1994, coded according to International Classification of Diseases and Health Related Problems version 10 (ICD-10) (WHO, 1992).

The Central Person Register contains information on gender, addresses and dates of birth, death and migrations for every person who is or has been an inhabitant of Denmark sometime between 1968 and present time. Age and gender are part of the personal identification number, which is recorded practically without errors.

Every adult person in Denmark is, since 1975, classified annually according to industry, occupation and socioeconomic status in the Employment Classification Module (ECM) (Soll-Johanning et al., 2004). The industries in the ECM are coded in accordance with the Danish Industrial Classification of All Economic Activities 1993 (Statistics Denmark, 1995), which is a national version of the European Industrial Classification of All Economic Activities. The occupations are coded in accordance with Statistics Denmark’s Standard Classification of Occupations (DISCO-88) (Statistics Denmark, 1996), which is a national version of the International Standard Classification of Occupations (ISCO-88).

The subjects

The inclusion criteria for the subjects were that they should be female inhabitants of Denmark in the age interval 20–44 years at baseline (1 January 1998) and registered as economically active, with bath assistant, hairdresser, barber, beautician and masseur (occupational code 5141) and hairdressing saloons (industrial code 930210) as their main occupation and industry during the 1997 registration in the ECM. Risk was evaluated relative to two populations. First, we compared hairdressers with the population of all economically active women in Denmark aged 20–44 years at baseline. Second, hairdressers were compared with 33 775 economically active shop assistants (occupational code 5220) according to their main occupation during the 1997 registration in the ECM, also aged 20–44 years at baseline. Shop assistants were selected as specific reference group, due to similarities in educational and socioeconomic background (Blatter and Zielhuis, 1993; Kersemaekers et al., 1997; Zhu et al., 2006). We wanted the follow-up period to be as recent as possible, as exposures may have been reduced during the last decades in the hairdresser profession (Nielsen, 1993; Kersemaekers et al., 1995; Hollund and Møen, 1998). Therefore, the follow-up period was initiated in 1998. In 2002, the follow-up period was concluded, as the OHR at present does not contain data after 2002. In total, we found 4113 women matching that description. The upper cut-off point of 45 years was chosen because it is illegal to artificially fertilize women above that age in Denmark (Sundhedsstyrelsen, 1997). Every woman was followed throughout the 5-year period regardless of occupational status. At the conclusion of the follow-up period (1 January 2003), 73.3% of the women still worked within hairdressing and 13.4% worked in another industry, and for the remaining 13.3%, the industrial code was not available. In the initial year of the follow up, 1998, this number was 4.3%. Unavailable industrial codes occur when a person leaves the labour market, because of, for example, occupational leave, pregnancy or education. In total, 87% of the person-years (PY) belonged to active hairdressers.

End-point

With the exception of N97.4 (female infertility associated with male factors), a person was defined as a case if she obtained the ICD-10 code N97 (female infertility) as principal diagnosis during at least one hospital contact during the follow up. In other words, the following sub-diagnoses were included in the case definition: N97.0 female infertility associated with anovulation; N97.1 female infertility of tubal origin; N97.2 female infertility of uterine origin; N97.3 female infertility of cervical origin; N97.8 female infertility of other origin; N97.9 female infertility, unspecified. In Denmark, unprotected intercourse for at least 12 months is required to qualify for a referral from the general practitioner to the hospital system for further investigation of involuntary infertility (Sundhedsstyrelsen, 1997).

Power calculations

Before we decided whether or not to carry out the study, we performed a series of power calculations to estimate the power (the probability that the null hypothesis would be rejected) as a function of the true risk ratio (RR) between the study population and the standard population. The significance level was set to 0.05, and it was assumed that the number of cases would follow a Poisson distribution. We used all female employees aged 20–44 years in the total population of Denmark as standard population. The expected number of cases in the study population was estimated in accordance with age-specific rates in the standard population. To calculate the power we used the following equation

\[
\beta(RR) = \Phi \left( \sqrt{\lambda (RR-1) - \frac{z(1-\alpha)}{2}} \right)
\]

where \(\beta\) is the power function, \(RR\) is the risk ratio, \(\Phi\) is the standard normal distribution function, \(\lambda\) is the expected number of cases in the
study population under the hypothesis that \( RR \) equals one, \( z \) is the inverse function of \( \Phi \) and \( \alpha \) is the level of significance. The equation is based on large sample theory and the properties of the Poisson distribution (Bickel and Doksum, 1977). Hence, the power of the study was more than 80% to identify a RR for hospital contact due to infertility >1.3, Table I [Increased risk of not conceiving within 12 months and reduced fecundability is not directly comparable. If the fecundability (technical term for the monthly chance of pregnancy) is decreased with \( \% \), then (based on the Poisson distribution) the probability of failing to conceive within \( t \) months is increased with

\[
y(t, \nu) = 100\left( e^{\nu/100} - 1 \right)\%
\]

where \( \nu \) is the expected time to pregnancy (measured in months) among women trying to become pregnant in the control population. The decrease in fecundability rate in percent (\( x \)) can differ quite a lot from the increase in percent of the probability of failing to conceive within a given period of time (\( y \)). For example, if the expected time to pregnancy is 3 months [based on a median time to pregnancy of 2 months, as in (Axmon et al., 2006)], then a 10% decrease in fecundability ratio approximately increases the risk of failing to conceive within 12 months with 50% compared to the standard population].

**Follow up and statistical analysis**

The study subjects were followed up for their first hospital contact with female infertility as the principal diagnosis in the time period 1 January 1998–31 December 2002. The follow up ended on the date of the diagnosis, date of death, date of emigration or at the end of study, whichever came first. PY at risk were calculated for each individual as the number of days they were followed divided by 365.25. Indirect age standardization (5-year age groups) was used to estimate the RR for hospital contact due to infertility between the study and the standard population, respectively, between hairdressers and shop assistants. RR was calculated as the ratio between the total number of observed cases and the total number of expected cases under the hypothesis that the age-specific infertility rates in the study population were the same as those in the standard population or among shop assistants. The expected number of cases in a given age group was calculated by multiplying the total number of PY at risk during the follow-up period in that particular 5-year-age group with the infertility rates of that age group in the reference populations. The total number of expected cases was obtained as the sum of the expected numbers in each age group. Assuming a Poisson distribution for the observed number of cases was obtained as the sum of the expected numbers in each age group in the reference populations. The total number of expected cases among women employed as shop assistants yielded a RR of 1.01 (95% CI: 0.77–1.29). The majority of infertility cases appear lumped under code N97.8 ‘Female fertility of other origin’ (28%) or N97.9 ‘Female fertility, unspecified’ (58%), Table II. It was therefore not possible to evaluate if the number of cases could hide highly specific types of infertility inherent to hairdressing.

**Results**

In total, we observed 68 cases of hospital contact for female infertility among the hairdressers. The expected number was 73.27, which gives us an observed RR of 0.928 (95% CI: 0.72–1.18). When controlling for county, the RR became 0.911 (95% CI: 0.71–1.16), and control for social group left a RR of 0.901 (95% CI: 0.70–1.14). Comparison of hairdressers to women employed as shop assistants yielded a RR of 1.01 (95% CI: 0.77–1.29). The majority of infertility cases appear lumped under code N97.8 ‘Female fertility of other origin’ (28%) or N97.9 ‘Female fertility, unspecified’ (58%), Table II. It was therefore not possible to evaluate if the number of cases could hide highly specific types of infertility inherent to hairdressing.

**Discussion**

During work, hairdressers are exposed to a variety of conditions, which may affect fertility, for example, chemicals and standing for prolonged periods of time. The present study investigated whether female hairdressers sought treatment for infertility to a larger degree than shop assistants or the working population in general. No differences were observed.

A possible source of bias in the present study relates to care-seeking behaviour. If there is social selection in seeking medical care for reduced fecundity among women in Denmark and, specifically, if this selection leads to reduced contact to the health system of the socioeconomic groups to which hairdressers belong, then the lack of effect of hairdressing on infertility may not be a true finding. One study (Olsen et al., 1996), based on a representative sample of 1028 women, estimated the proportion of Danish women with reduced fecundity that sought medical care. Approximately half of the women with failure to achieve pregnancy after 1 year of unprotected intercourse sought medical care, a finding that has been confirmed in other Danish studies (Rachootin and Olsen, 1981; Schmidt et al., 1995). No association between education and the propensity to seek medical care was observed in an early Danish study of predictors for seeking infertility treatment in a representative sample of 709 women (Rachootin and Olsen, 1981), whereas school education of more than 9 years was a significant denominator in a sample of 2861 women from the County of Copenhagen in Denmark (Schmidt et al., 1995). Also, women residing in rural compared with urban areas tended to seek medical care more often for secondary reduced fecundity (failure to achieve a second child within a 2-year period of cohabitation without the use of contraception) (Rachootin and Olsen, 1981). In our study, adjusting for social group (according to the socioeconomic classification employed by Statistics Denmark) left the conclusion unaltered as did comparison with a socially more equal group, that is, shop assistants, thereby arguing against socioeconomic factors confounding our findings. A second potential source of bias is the possible differences in the treatments offered in the various geographic regions. In Denmark, all hospitals (with a few exceptions) are owned by the counties, and the criteria for offering various treatment might therefore vary between counties (Soll-Johanning et al., 2004). Hospitalization for infertility appears to be a treatment offer that could vary substantially between counties; however,

<table>
<thead>
<tr>
<th>Risk ratio</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>0.050</td>
</tr>
<tr>
<td>1.10</td>
<td>0.213</td>
</tr>
<tr>
<td>1.20</td>
<td>0.522</td>
</tr>
<tr>
<td>1.30</td>
<td>0.817</td>
</tr>
<tr>
<td>1.40</td>
<td>0.960</td>
</tr>
<tr>
<td>1.50</td>
<td>0.995</td>
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</table>
the number of hairdressers per capita presumably is stable across geographic regions, and adjustment for county did not change the risk estimate.

Every woman was followed throughout the 5-year period regardless of, for example, change of job. At the end of the study, 73.3% of the women still worked within hairdressing, whereas the remaining women had changed occupation or the occupational code was missing. This may have diluted the risk estimate. However, as a total of 87% of the PY in the follow-up period belonged to active hairdressers, this dilution seems negligible.

Job title was used as a proxy for exposure, but hairdressing occupation may not be synonymous to exposure to adverse chemicals or work conditions. This has some implications: (1) It cannot be excluded that women in the reference population may be exposed to conditions and chemicals that interfere with the reproductive process, thereby introducing confounders, which we were not able to control for. Smoking among women is a well-documented risk factor for delayed conception and reduced fertility (Bolumar et al., 1996). The risk estimates could not be adjusted for smoking, because relevant data were not available, but the prevalence of current smokers among Danish hairdressers appears not to deviate from, for example, female shop assistants in Denmark (Zhu et al., 2006). This is supported by recent Swedish data (Axmon et al., 2006). Several other risk factors and potential confounders as urogenital infections, abdominal surgery, metabolic diseases and hormonal disturbances could not be controlled for, but differential exposure prevalence across exposure groups are not expected. (2) It remains a question, whether exposure to chemicals in hairdressing salons in fact is of sufficient magnitude as to affect the reproductive health of employees working there. For example, there are some indications that exposures may have been reduced during the last decades, for example, due to ban of some hazardous chemicals and increased attention to working conditions as ventilation (Nielsen, 1993; Kersemaekers et al., 1995; Hollund and Moen, 1998). Furthermore, some women registered as hairdressers may never have worked with the potentially reproductive toxic chemicals, leading to differential misclassification, and hairdressers trying to conceive may change their exposures, or even their job, particularly in the presence of concern that such exposures may affect fertility. (3) Allergic as well as musculoskeletal disorders are among the health reasons making hairdressers leave their profession (Leino et al., 1999). In Denmark, the physical/chemical work environment is quoted as the fourth most common reason for leaving the hairdressing profession, after unpleasant working hours, low salary and loss of interest (Handelshøjskolens efteruddannelsescenter, 2000). As an overlap between work conditions, that increase the risk of leaving hairdressing and those associated with reproductive ill-health, cannot be excluded, this introduces a potential underestimation of the harm of hairdressers’ work conditions on reproductive health.

A recent Swedish study observed a 10% lower fecundability ratio in women having graduated from Swedish hairdresser schools compared to women from the general population. Median time to pregnancy was 2 months in both groups. When women who conceived during the first month of trying to attain pregnancy were excluded from the analysis, this effect was no longer significant [fecundability ratio 0.96, 95% CI: 0.87–1.07; note that as this ratio measures positive events (wanted pregnancies), a value of <1 indicates a prolonged time to pregnancy, and thereby reduced fecundability]. The authors suggest that birth control bias may partly account for the decreased conception ratio (Weinberg and Wilcox, 1998; Axmon et al., 2006), but excluding women who got pregnant the first month of trying also reduced the population by more than 30%, thus reducing statistical power. A Dutch study reported numerically increased odds ratios for time to pregnancy above 12 months for hairdressers compared to shop assistants (1986–88: 1.5, 95% CI: 0.8–2.8; 1991–93: 1.2; 95% CI: 0.8–1.6) (Kersemaekers et al., 1997). In the present study, the RR for hospital contact due to infertility was similar in hairdressers and the reference populations. If the Swedish study is representative, based on the Poisson distribution, the observed 10% reduction in fecundability together with the median time to pregnancy of 2 months approximately corresponds to a 50% increase in the risk of failing to conceive within 12 months.

In conclusion, the present study did not observe increased tendency for hospital contact due to infertility in female hairdressers compared to women in the general (working) population or shop assistants. The study does therefore not support the hypothesis that exposures in the hairdresser trade affect the capability to obtain a pregnancy. However, studies of infertility hospitalization rates may be less likely to detect minor or transient effects on fecundity than direct measures of couple fecundability, as the time or number of cycles it takes a couple to conceive (Bonde et al., in press).

Table II. Distribution of diagnoses among cases in the reference population and in hairdressers

<table>
<thead>
<tr>
<th>ICD-10 code</th>
<th>Diagnosis*</th>
<th>Standard population</th>
<th>Hairdressers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>N97.0</td>
<td>Female infertility associated with anovulation</td>
<td>501</td>
<td>3.96</td>
</tr>
<tr>
<td>N97.1</td>
<td>Female infertility of tubal origin</td>
<td>1277</td>
<td>10.09</td>
</tr>
<tr>
<td>N97.2</td>
<td>Female infertility of uterine origin</td>
<td>58</td>
<td>0.46</td>
</tr>
<tr>
<td>N97.3</td>
<td>Female infertility of cervical origin</td>
<td>9</td>
<td>0.07</td>
</tr>
<tr>
<td>N97.8</td>
<td>Female infertility of other origin</td>
<td>3496</td>
<td>27.62</td>
</tr>
<tr>
<td>N97.9</td>
<td>Female infertility, unspecified</td>
<td>7316</td>
<td>57.80</td>
</tr>
<tr>
<td>Sum</td>
<td>12657</td>
<td>100.00</td>
<td>68</td>
</tr>
</tbody>
</table>

*Diagnosis at the last hospital contact during the follow-up period.
References


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