© International Epidemiological Association 2000 Printed in Great Britain International Journal of Epidemiology 2000;**29**:100–106

Induced abortion and low birthweight in the following pregnancy

Weijin Zhou,[a,b] Henrik Toft Sørensen[a,c] and Jørn Olsen[a]

Background To examine whether induced abortion increases the risk of low birthweight in subsequent singleton live births.

Methods Cohort study using the Danish Medical Birth Registry (MBR), the Hospital Discharge Registry (HDR), and the Induced Abortion Registry (IAR). All women who had their first pregnancy during 1980–1982 were identified in the MBR, the HDR, and the IAR. We included all 15 727 women whose pregnancy was terminated by a first trimester induced abortion in the induced abortion cohort and 46 026 women whose pregnancy was not terminated by an induced abortion were selected for the control cohort. All subsequent pregnancies until 1994 were identified by register record linkage.

Results Low birthweight (<2500 g) in singleton term live births occurred more frequently in women with one, two, three or more previous induced abortions, compared with women without any previous induced abortion of similar gravidity, 2.2% versus 1.5%, 2.4% versus 1.7%, and 1.8% versus 1.6%, respectively. Adjusting for maternal age and residence at time of pregnancy, interpregnancy interval, gender of newborn, number of previous spontaneous abortions and number of previous low birthweight infants (control cohort only), the odds ratios (OR) of low birthweight in singleton term live births in women with one, two or more previous first trimester induced abortions were 1.9 (95% CI : 1.6, 2.3), and 1.9 (95% CI : 1.3, 2.7), respectively, compared with the control cohort of similar gravidity. High risks were mainly seen in women with an interpregnancy interval of more than 6 months.

Conclusions The findings suggest a positive association between one or more first trimester induced abortions and the risk of low birthweight in subsequent singleton term live births when the interpregnancy interval is longer than 6 months. This result was unexpected and confounding cannot be ruled out.

Keywords Induced abortion, low birthweight, interpregnancy interval, follow-up study, register linkage

Accepted 22 July 1999

In most countries, even in countries where pregnancy termination is illegal, many induced abortions are performed. In Denmark, where the procedure is legal, almost all pregnancy terminations are performed by medically qualified doctors in the first trimester by means of an invasive procedure. Induced abortion is mainly used in case of contraceptive failure, but a small fraction is performed for social or medical reasons. Inducing an abortion carries a small risk of uterine perforation, haemorrhage, post-abortion syndrome, laceration of the cervix,[1–4] or subsequent infections.[1,2,4–10]

Since the procedure is frequent we need to estimate its risks since even a small increase in long-term complications will have major public health importance. Risk estimates are also needed for decision-making when new induced abortion procedures are compared with standard methods.

In this study we will primarily focus upon low birthweight (LBW), i.e. <2500 g. It is an important measure since it is closely correlated with increased perinatal mortality[11] and because the quality of birthweight data is high. Intrauterine fetal growth retardation is also associated with the long-term risk of coronary heart disease, stroke, diabetes and impaired cognitive function. Organ 'programming' has been suggested as responsible for this increased susceptibility, but the mechanisms

[a] The Danish Epidemiology Science Centre, Aarhus University, Vennelyst Boulevard 6, DK-8000 Aarhus C, Denmark.

[b] Shanghai Institute of Planned Parenthood Research, 2140 Xie Tu Road, Shanghai 200032, PR China.

[c] Department of Medicine V, Aarhus University Hospital, DK-8000 Aarhus C, Denmark.

are unknown.[12–15] Fetal growth depends upon appropriate placental functioning,[16] and it is possible that pregnancy termination interferes with placental development, perhaps related to trauma or infection.

There are many determinants of fetal growth,[17–30] and previous induced abortion is among these as concluded by some studies,[25,31] but not all.[26,32–35] Some of the negative studies, however, did not have the power to detect a small or moderate increase in LBW risk. Whether induced abortion is a risk factor for LBW is still a controversial issue and most studies have been subject to recall and selection bias.

The aim of this study was to examine the association between induced abortion and the risk of a LBW infant in the subsequent pregnancy using a large study cohort with complete follow-up and with accurate data on induced abortion. We also wanted to consider the time lapsed from the induced abortion to the new conception (the interpregnancy interval). We expected the risk to be highest when the interpregnancy interval was short because traumas and infections will heal with time.

Methods, Subjects and Data

We used a historical cohort study design. All data were identified using national registries in Denmark; the Medical Birth Registry (MBR) operational since 1973, the Hospital Discharge Registry (HDR), which was established in 1977, and the Induced Abortion Registry (IAR), which has held computerized forms on all induced abortions in the country since 1973. All pregnant women were identified by means of the civil registration number given to all citizens in 1968. It is a unique 10-digit code used for all administrative purposes, and it was applied to link all pregnancy events in the registries used. Denmark has a population of 1.1 million women aged 15–44 years; the majority of which are Caucasian.[36] In 1995 there were 70 089 births, and the perinatal mortality was 0.75%;[37] 17 720 pregnancies were legally terminated by doctors, more than 96% in the first trimester of pregnancy.[36] First trimester induced abortion became legal in 1973, and the law made induced abortions performed by non-medically qualified people extremely uncommon.[38]

We identified all who were registered as primigravidae (index pregnancy event) in the MBR and the HDR as well as in the IAR from 1980 to 1982. We identified all women with no prior registered pregnancies in the MBR, the HDR or the IAR up to 1980.

From this group we identified two cohorts: (a) *The abortion cohort*: All women whose pregnancies were terminated by a first trimester induced abortion (15 727 women). Induced abortions in the IAR and the HDR were identified as ICD-8 (640.00–642.99). We did not include abortions performed for medical reasons or abortions induced after the first trimester. (b) *The control cohort*: All primigravidae who had a spontaneous termination of their pregnancies; 41 076 women who experienced stillbirth or live birth and 4950 women who had spontaneous abortions. Spontaneous abortions in the HDR were identified as ICD-8 (643.00–645.99).

All subsequent pregnancies were then identified by register record linkage in both cohorts up to 1994 by means of the MBR, the IAR, and the HDR. All live births and still births are registered in the MBR, all spontaneous abortions leading to hospitalization in the HDR (more than 80% of recognized abortions),[39] and induced abortions in the IAR and the HDR.

Furthermore, we defined subcohorts in the abortion cohort of one, two, three or more induced abortions in a row before the woman had her first informative pregnancy (not terminated by induced abortion). In the control cohort, the informative pregnancy was all consecutive subsequent pregnancies which were not terminated by induced abortion. We focused only on the outcomes of the first informative pregnancy following the first trimester induced abortion. Only singletons were included in the analysis.

The LBW of term singleton live births (gestational age 37–41 completed weeks) were mainly compared in the two cohorts considering gravidity. Analyses were stratified on interpregnancy intervals in order to study risk as a function of time lapsed since the induced abortion.

Maternal residence at the time of the last pregnancy was grouped into Copenhagen, cities with more than 100 000 inhabitants (Aarhus, Aalborg, Odense), and other regions.

We used logistic regression analyses (multiple regression analyses) in order to adjust for potential confounders such as, maternal age and residence at time of the informative pregnancy, number of previous LBW newborns, number of previous spontaneous abortions, and gender of newborn. Statistical analyses were performed using SPSS FOR WINDOWS (6.1.3 version).

Results

Table 1 shows descriptive data for both cohorts. The primigravidae in the abortion cohort were younger and lived more often in Copenhagen or in the three largest cities (Aarhus, Aalborg, Odense) than primigravidae in the control cohort. In the control cohort about 5% of the live births were LBW, and 11% of the primigravidae had a hospitalized spontaneous abortion. In the follow-up period the control cohort gave rise to a total of 103 064 pregnancies of which 12 780 ended with an induced abortion followed by 18 915 pregnancies. After excluding these 31 695 pregnancies, there were 71 369 informative pregnancies left for study. In the abortion cohort 2755 women had 3432 repeated induced abortions, and the cohort had altogether 15 727 informative pregnancies during the 12-year follow-up period.

In Table 2 the abortion cohort is subdivided into three cohorts according to the number of induced abortions they had before the first informative pregnancy. By far the most frequently used method of abortion was dilation with vacuum aspiration. About two-thirds of the induced abortions were performed late in the first trimester with a tendency to earlier termination after the first induced abortion. A large proportion of women with three or more induced abortions lived in Copenhagen.

Women with previous induced abortions had a higher risk of LBW compared with women in the control cohort of similar gravidity (Table 3). The odds ratios (OR) of LBW in singleton live births following one, two, three or more induced abortions were 1.5 (95% CI : 1.3, 1.6), 1.5 (95% CI : 1.2, 1.9), and 1.1 (95% CI : 0.7, 1.7), respectively. Since birthweight is strongly associated with gestational age, the analyses were also restricted to term live births. Stratified on gravidity, the OR of LBW in singleton term live births following one, two, three or more first trimester induced abortions were 1.4 (95% CI : 1.2, 1.7), 1.4 (95% CI : 1.0, 2.0), and 1.1 (95% CI : 0.5, 2.5), respectively.

Table 1 Maternal and neonatal characteristics in primigravidae who had a first trimester induced abortion (abortion cohort) or who did not terminate their pregnancy by an induced abortion (control cohort) between 1980 and 1982

	Abortion cohort		Control cohort	
Characteristics	n	%	n	%
Maternal age				
–17 years	3697	23.5	1128	2.4
18–19 years	3941	25.1	4115	9.0
20–24 years	5754	36.8	22 635	49.5
25–29 years	1630	10.4	14 471	31.6
30+ years	665	4.2	3451	7.5
Missing	40	–	226	–
Maternal residence				
Copenhagen	5760	36.6	10 274	22.3
Aarhus, Aalborg, Odense	2208	14.0	5489	11.9
Smaller towns or rural areas	7753	49.4	30 257	65.8
Missing	6	–	6	–
Outcome of index pregnancy				
Induced abortion	15 727	100	0	0
Spontaneous abortion[a]	–	–	4950	10.8
Stillbirth[b]	–	–	264	0.6
Low birthweight <2500 g[c]	–	–	2116	5.2
Preterm delivery <37 weeks[c,d]	–	–	1663	4.1
Term delivery 37–41 weeks[c,d]	–	–	35 364	86.8
Post-term delivery ≥42 weeks[c,d]	–	–	3722	9.1
No. of primigravidae	15 727	100.0	46 026	100.0

[a] Spontaneous abortion (%) = No. of spontaneous abortions/No. of pregnancies.

[b] Stillbirth (%) = No. of stillbirths/No. of stillbirths plus all live births.

[c] Event (%) = No. of events/All live births.

[d] In control cohort, 63 primigravidae had live births and their gestational age was not recorded in the MBR, and was not taken into account in rates of preterm, term and post-term delivery.

The abortion subcohorts more often lived in urban areas and were younger than the women who did not terminate their pregnancy.

Women with an induced abortion had an increased risk of LBW in term live births following the abortion, compared with women in the control cohort of similar gravidity after adjustment for a number of confounders (Table 4). The OR of LBW in singleton term live births for one or more than one induced abortion were 1.9 (95% CI : 1.6, 2.3) and 1.9 (95% CI : 1.3, 2.7), respectively. The increased risk was only seen in women who had an abortion performed by vacuum aspiration. Furthermore, we stratified the analyses on interpregnancy intervals and found one first trimester induced abortion, particularly when using the vacuum aspiration method, to be associated with an increased risk of LBW when the interpregnancy interval exceeded 6 months. Two prior vacuum aspirations were related with an elevated risk of LBW when the interpregnancy interval was longer than 12 months.

In Table 5 results are stratified according to the gestational age of induced abortions (before 9 weeks of gestation or later). Late in first trimester evacuation induced abortions were associated with an increased risk of LBW when the interpregnancy interval exceeded 6 months (OR = 2.1, 95% CI : 1.1, 3.9).

After using multiple linear regression analyses to adjust for previous spontaneous abortion and previous preterm delivery (control cohort only), maternal age, residence at the time of the informative pregnancy, gestational age at delivery, gender of newborn, and interpregnancy intervals, we found that induced abortions were associated with a decreased birthweight in subsequent singleton term live births. Compared with women in the control cohort of similar gravidity, one, two, three or more induced abortions were associated with a lower birthweight of –89 g (95% CI : –99 g, –78 g), –111 g (95% CI : –137 g, –85 g), and –99 g (95% CI : –153 g, –44 g), respectively.

Discussion

We found an elevated risk of LBW in term births following an induced abortion mainly with an interpregnancy interval longer than 6 months. Results for term newborns do not indicate that the association is through a shortening of gestation. No 'dose-response' pattern was seen and a low risk following a short interpregnancy interval mitigates to some extent against causation.

Our study is large, without non-responders, has complete follow-up and is carried out within a uniformly organized health care system and almost all induced abortions are reported to the IAR.[40] The main shortcoming is the lack of data on confounders such as social factors and smoking, although we do not expect this type of confounding to be related to the choice of abortion method. Gestational age was recorded by the midwives and based upon ultrasound or the date of the last menstruation. In any case, estimations were made early postpartum and without access to data on the induced abortion.

Our findings of an increased risk is supported by other studies. Lekea-Karanika *et al.* found that mothers who had induced abortions had an increased relative risk (RR) of LBW in subsequent singleton births (RR = 1.8, 95% CI : 1.3, 2.3).[25] Algert *et al.*[26] found an unadjusted RR of small for gestational age in singleton births following induced abortion of 1.2 (95% CI : 1.1, 1.2), but after adjustment for 11 potential confounders the RR was even closer to one. A similar observation was made by Mandelson *et al.*[32]

After reviewing the literature, Hogue concluded that vacuum aspiration induced abortion does not protect against LBW in first-born offspring compared with women who had one previous delivery.[33] Atrash *et al.* suggest that evacuation with dilatation is associated with an increased risk of LBW.[41] In our study, both the vacuum aspiration method and the evacuation method were associated with an increased risk of LBW in singleton term live births. Although, the negative results after a short interpregnancy interval mitigate against causation, the results should be interpreted with caution.

Stratifying on interpregnancy interval may introduce confounding by fecundity and low fecundity has been associated with poor reproductive outcome. The negative findings after a short interval may be due to unequal fecundity between the compared groups, although it is difficult to predict the direction of the difference.

We know that gravity and parity are associated with birthweight[26,28–30,35] but it is unclear whether these associations

Table 2 Maternal age and residence, method and timing of the induced abortion according to the number of induced abortions before an informative pregnancy (abortion cohort only)

	No. of induced abortions							
	1		2		⩾3		Total	
Characteristics	n	%	n	%	n	%	n	%
No. of women	12 972	100.0	2232	100.0	523	100.0	15 727	100.0
Method used in last abortion								
Vacuum aspiration with dilation	11 548	91.7	2057	95.2	457	96.0	14 080	92.3
Evacuation	1005	8.0	100	4.6	20	4.0	1125	7.4
Other methods	37	0.3	4	0.2	0	0.0	41	0.3
Missing	382	–	71	–	28	–	481	–
Timing of last abortion (completed gestational weeks)								
⩽8	4944	38.1	879	39.4	218	41.7	6041	38.4
9–12	8028	61.9	1353	60.6	305	58.3	9686	61.6
Maternal age at last abortion (years)								
<20	6099	47.2	531	23.8	42	8.0	6672	42.5
20–29	6226	48.1	1535	68.8	413	79.0	8174	52.1
30+	607	4.7	166	7.4	68	13.0	841	5.4
Missing	40	–	0	–	0	–	40	–
Residence at time of last abortion								
Copenhagen	4572	35.3	1019	45.7	265	50.6	5856	37.3
Aarhus, Aalborg, Odense	1794	13.8	357	16.0	95	18.2	2246	14.3
Smaller towns or rural areas	6602	50.9	853	38.3	163	31.2	7618	48.4
Missing	4	–	3	–	0	–	7	–

[a] Informative pregnancy: first pregnancy which ended as a birth.

Table 3 Maternal and neonatal characteristics of the first singleton live birth following the index pregnancy, 1980–1994[a]

	Second pregnancy		Third pregnancy		Fourth or later pregnancies	
Characteristics	Abortion cohort %	Control cohort %	Abortion cohort %	Control cohort %	Abortion cohort %	Control cohort %
No. of live births	11 394	40 758	1921	15 486	460	6116
Maternal age (years)						
<20	6.0	1.3	3.3	0.2	0.9	0.0
20–29	74.6	69.4	70.9	47.4	64.5	33.4
30+	19.4	29.3	25.8	52.4	34.6	66.6
Maternal residence						
Copenhagen	34.3	20.4	43.5	17.0	50.0	17.2
Aarhus, Aalborg, Odense	13.5	10.8	14.2	10.0	17.8	8.8
Smaller towns or rural areas	52.2	68.8	42.3	73.0	32.2	74.0
Interpregnancy interval (months)						
0–6	5.2	6.3	9.3	12.8	12.2	17.6
7–12	6.6	8.7	11.4	11.5	13.9	16.7
13+	88.2	85.0	79.3	75.7	73.9	65.7
Low birthweight <2500 g[b]	5.0	3.5	5.4	3.6	5.3	4.7
Low birthweight of term births[c,d]	2.2	1.5	2.4	1.7	1.8	1.6

[a] Comparing maternal and neonatal characteristics of women whose previous pregnancies were terminated by first trimester induced abortion with women whose previous pregnancies were not terminated by induced abortion of similar gravidity.

[b] Low birthweight (%) = No. of low birthweight/No. of singleton live births.

[c] Birthweight <2500 g with gestational age between 37 and 41 completed weeks.

[d] Low birthweight of term birth (%) = No. of low birthweight/No. of singleton term live births.

Table 4 Odds ratio (OR) of low birthweight in singleton term live births according to the abortion method stratified on interpregnancy intervals (follow-up until 1994)

No. of previous induced abortions and methods	Overall[a] OR (95% CI)	Interpregnancy intervals 0–6 months OR (95% CI)[b]	7–12 months OR (95% CI)[b]	13+ months OR (95% CI)[b]
One induced abortion				
All methods	1.9 (1.6, 2.3)	1.4 (0.6, 3.3)	3.2 (1.7, 6.0)	1.9 (1.5, 2.3)
One vacuum aspiration	2.0 (1.6, 2.4)	1.4 (0.5, 3.4)	3.4 (1.8, 6.3)	1.9 (1.6, 2.3)
One evacuation	1.3 (0.7, 2.3)	1.8 (0.2, 14.6)	2.7 (0.4, 21.0)	1.2 (0.6, 2.3)
Two and more induced abortions				
All methods	1.9 (1.3, 2.7)	1.4 (0.3, 6.3)	1.6 (0.6, 4.5)	2.0 (1.3, 3.0)
Vacuum aspirations	2.0 (1.3, 2.9)	1.8 (0.4, 7.6)	1.9 (0.7, 5.2)	2.0 (1.3, 3.1)
Evacuations	ND	ND	ND	ND

[a] Adjusted for maternal age (6 levels) and residence at time of informative pregnancy (3 levels), interpregnancy intervals (2 levels), gender of newborn (2 levels), number of previous spontaneous abortions and number of previous low birthweight infants (control cohort only).

[b] As above but without interpregnancy intervals.

ND = too few observations.

Table 5 Odds ratio (OR) of low birthweight in singleton term live births according to abortion method, time of last induced abortion and stratified on interpregnancy intervals (follow-up until 1994). Second gravida women only

Characteristics	Overall[a] OR (95% CI)	Interpregnancy intervals 0–6 months OR (95% CI)[b]	7+ months OR (95% CI)[b]
Last pregnancy terminated by induced abortion at ⩽8 gestational weeks			
One induced abortion			
All methods	1.7 (1.3, 2.2)	1.6 (0.5, 4.9)	1.7 (1.3, 2.3)
One vacuum aspiration	1.9 (1.4, 2.4)	1.3 (0.3, 4.9)	1.9 (1.4, 2.5)
One evacuation	0.3 (0.0, 2.1)	4.5 (0.5, 39.6)	ND
Last pregnancy terminated by induced abortion at ⩾9 gestational weeks			
One induced abortion			
All methods	2.0 (1.6, 2.5)	1.2 (0.4, 3.3)	2.1 (1.7, 2.6)
One vacuum aspiration	2.0 (1.6, 2.5)	1.3 (0.5, 3.6)	2.1 (1.7, 2.6)
One evacuation	1.9 (1.0, 3.6)	ND	2.1 (1.1, 3.9)

[a] Adjusted for maternal age (6 levels) and residence at time of informative pregnancy (3 levels), interpregnancy intervals (2 levels), gender of newborn (2 levels), number of previous spontaneous abortions, and number of previous low birthweight infants (control cohort only).

[b] As above but without interpregnancy intervals.

ND = too few observations.

are causal or whether they reflect differential pregnancy planning.[42] Our cohorts start with primigravidae, and all women therefore have the same gravidity, but only those giving birth in the control cohort advance their parity. Comparing equal parity and gravidity thus requires use of different segments of the study base for comparison, and in most of our analyses we have used gravidity, by counting all abortions (induced and spontaneous) and births, as the point of reference.

Maternal age, previous spontaneous abortion, previous LBW, and gender of newborn are all known determinants of LBW,[25,28–30] which is also seen in our study. We had no data on smoking during pregnancy,[17,20,28,29] mother's own birthweight,[18,19] diet in pregnancy,[18,30] maternal gestational weight gain,[20,29,30] maternal working conditions during pregnancy,[22] hypertensive disorders in pregnancy,[23] or low socioeconomic status.[30,43] It is likely that some of these risk factors will bias our result towards high OR.

Unfortunately the registries have no data on smoking habits and so standard adjustment for this confounder is therefore not an option. We can, however, estimate the confounding effect of smoking since we have data from a large cohort of Danish pregnant women from 1984 to 1987.[44] In this study 43% of the pregnant women without a history of induced abortion smoked during pregnancy compared with 56% of the pregnant women with a history of induced abortion (data not shown). In this study, smoking was associated with an increased risk of LBW in singleton newborns of ⩾36 weeks of gestation (OR = 2.8). If we assume a similar difference in smoking habits between our two cohorts and a similar association between smoking and LBW in singleton term live births, the OR for induced abortion and

LBW should be reduced by a factor 1.13 due to confounding by smoking. We thus expect that the smoking adjusted OR for induced abortion is 1.77 instead of 2.00 found in the analyses without adjustment for smoking. We expect this adjustment to be quite accurate and find it unlikely that the association is entirely due to smoking.

We compare outcomes with similar gravidity but most of the women in the control cohort are of parity one and all exposed are of parity 0. We do this because gravidity is found to be equally associated with birthweight compared to parity.[45] Furthermore, it is unclear if these associations are driven by selection rather than biological mechanisms.[42]

Our study did not show any strong association between induced abortion and LBW and it is possible that the association observed is due to confounding.

Acknowledgement

The activities of the Danish Epidemiology Science Centre are financed by a grant from the Danish National Research Foundation. The study was supported by Helsefonden (grant no. 11/100–96).

References

1 Ferris LE, McMain-Klein M, Colodny N, Fellows GF, Lamont J. Factors associated with immediate abortion complications. *Can Med Assoc J* 1996;**154:**1677–85.

2 Hakim-Elahi E, Tovell HM, Burnhill MS. Complications of first-trimester abortion: a report of 170 000 cases. *Obstet Gynecol* 1990; **76:**129–35.

3 Stubblefield PG. Surgical techniques of uterine evacuation in first- and second-trimester abortion. *Clin Obstet Gynaecol* 1986;**13:**53–70.

4 Castadot RG. Pregnancy termination: techniques, risks, and complications and their management. *Fertil Steril* 1986;**45:**5–17.

5 Muhlemann K, Germain M, Krohn M. Does an abortion increase the risk of intrapartum infection in the following pregnancy? *Epidemiology* 1996;**7:**194–98.

6 Germain M, Krohn MA, Daling JR. Reproductive history and the risk of neonatal sepsis. *Paediatr Perinat Epidemiol* 1995;**9:**48–58.

7 Heisterberg L. Preventive antibiotics in induced first-trimester abortion. *Ugeskr Laeger* 1992;**154:**3056–60.

8 Heisterberg L, Gnarpe H. Preventive lymecycline therapy in women with a history of pelvic inflammatory disease undergoing first-trimester abortion: a clinical, controlled trial. *Eur J Obstet Gynecol Reprod Biol* 1988;**28:**241–47.

9 Heisterberg L, Kringelbach M. Early complications after induced first-trimester abortion. *Acta Obstet Gynecol Scand* 1987;**66:**201–04.

10 Frank PI, Kay CR, Scott LM, Hannaford PC, Haran D. Pregnancy following induced abortion: maternal morbidity, congenital abnormalities and neonatal death. Royal College of General Practitioners/Royal College of Obstetricians and Gynaecologists Joint Study. *Br J Obstet Gynaecol* 1987;**94:**836–42.

11 Parazzini F, Pirotta N, La Vecchia C, Fedele L. Determinants of perinatal and infant mortality in Italy 1980–1983. *Ann Ostet Ginecol Med Perinat* 1990;**111:**9–146.

12 Rich-Edwards JW, Stampfer MJ, Manson JE *et al.* Birth weight and risk of cardiovascular disease in a cohort of women followed up since 1976. *Br Med J* 1997;**315:**396–400.

13 Sørensen HT, Sabroe S, Olsen J, Rothman KJ, Gillman MW, Fischer P. Birth weight and cognitive function in young adult life: historical cohort study. *Br Med J* 1997;**315:**401–03.

14 Forsen T, Eriksson JG, Tuomilehto J, Teramo K, Osmond C, Barker DJ. Mother's weight in pregnancy and coronary heart disease in a cohort of Finnish men: follow up study. *Br Med J* 1997;**315:**837–40.

15 Barker DJ. *Mothers, Babies and Disease in Later Life*. London: BMJ Publishing Group, 1994.

16 Johnson MR, Riddle AF, Grudzinskas JG, Sharma V, Collins WP, Nicolaides KH. Reduced circulating placental protein concentrations during the first trimester are associated with preterm labour and low birth weight. *Hum Reprod* 1993;**8:**1942–47.

17 Wang X, Tager IB, Van Vunakis H, Speizer FE, Hanrahan JP. Maternal smoking during pregnancy, urine cotinine concentrations, and birth outcomes. A prospective cohort study. *Int J Epidemiol* 1997;**26:**978–88.

18 Godfrey KM, Barker DJ, Robinson S, Osmond C. Maternal birth-weight and diet in pregnancy in relation to the infant's thinness at birth. *Br J Obstet Gynaecol* 1997;**104:**663–67.

19 Klebanoff MA, Schulsinger C, Mednick BR, Secher NJ. Preterm and small-for-gestational-age birth across generations. *Am J Obstet Gynecol* 1997;**176:**521–26.

20 Weijin Z, Olsen J. Is fetal growth reduction induced by smoking modified by body mass or gestational weight gain? *Scand J Soc Med* 1996;**24:**155–56.

21 Rawlings JS, Rawlings VB, Read JA. Prevalence of low birth weight and preterm delivery in relation to the interval between pregnancies among white and black women. *N Engl J Med* 1995;**332:**69–74.

22 Fortier I, Marcoux S, Brisson J. Maternal work during pregnancy and the risks of delivering a small-for-gestational-age or preterm infant. *Scand J Work Environ Health* 1995;**21:**412–18.

23 Ananth CV, Peedicayil A, Savitz DA. Effect of hypertensive diseases in pregnancy on birthweight, gestational duration, and small-for-gestational-age births. *Epidemiology* 1995;**6:**391–95.

24 Nieto A, Matorras R, Serra M, Valenzuela P, Molero J. Multivariate analysis of determinants of fetal growth retardation. *Eur J Obstet Gynecol Reprod Biol* 1994;**53:**107–13.

25 Lekea-Karanika V, Tzoumaka-Bakoula C. Past obstetric history of the mother and its association with low birthweight of a subsequent child: a population based study. *Paediatr Perinat Epidemiol* 1994;**8:**173–87.

26 Algert C, Roberts C, Adelson P, Frommer M. Low birth-weight in NSW, 1987: a population-based study. *Aust N Z J Obstet Gynaecol* 1993; **33:**243–48.

27 Williams MA, Goldman MB, Mittendorf R, Monson RR. Subfertility and the risk of low birth weight. *Fertil Steril* 1991;**56:**668–71.

28 Ferraz EM, Gray RH, Cunha TM. Determinants of preterm delivery and intrauterine growth retardation in north-east Brazil. *Int J Epidemiol* 1990;**19:**101–08.

29 Kliegman RM, Rottman CJ, Behrman RE. Strategies for the prevention of low birth weight. *Am J Obstet Gynecol* 1990;**162:**1073–83.

30 Kramer MS. Determinants of low birth weight: methodological assessment and meta-analysis. *Bull World Health Organ* 1987;**65:**663–737.

31 Seidman DS, Ever-Hadani P, Slater PE, Harlap S, Stevenson DK, Gale R. Child-bearing after induced abortion: reassessment of risk. *J Epidemiol Community Health* 1988;**42:**294–98.

32 Mandelson MT, Maden CB, Daling JR. Low birth weight in relation to multiple induced abortions. *Am J Public Health* 1992;**82:**391–94.

33 Hogue CJ. Impact of abortion on subsequent fecundity. *Clin Obstet Gynaecol* 1986;**13:**95–103.

34 Frank PI, Kay CR, Lewis TL, Parish S. Outcome of pregnancy following induced abortion. Report from the joint study of the Royal College of General Practitioners and the Royal College of Obstetricians and Gynaecologists. *Br J Obstet Gynaecol* 1985;**92:**308–16.

35 Hogue CJ, Cates W Jr, Tietze C. Impact of vacuum aspiration abortion on future childbearing: a review. *Fam Plann Perspect* 1983;**15:**119–26.

36 The National Board of Health. Copenhagen. *Sundhedsstatistikken* 1997:**1**.

[37] The National Board of Health. Copenhagen. *Sundhedsstatistikken* 1997:**6**.

[38] Knudsen LB. Induced abortions in Denmark. *Acta Obstet Gynecol Scand Suppl* 1997;**164:**54–59.

[39] Heidam LZ, Olsen J. Self-reported data on spontaneous abortions compared with data obtained by computer linkage with the hospital registry. *Scand J Soc Med* 1985;**13:**159–63.

[40] Krebs L, Johansen AM, Helweg-Larsen K. Reporting of induced abortions in 1994. A comparison between the data in the registry of legally induced abortions and the national patient registry. *Ugeskr Laeger* 1997;**159:**1607–11.

[41] Atrash HK, Hogue CJ. The effect of pregnancy termination on future reproduction. *Baillières Clin Obstet Gynaecol* 1990;**4:**391–405.

[42] Olsen J. Options in making use of pregnancy history in planning and analysing studies of reproductive failure. *J Epidemiol Community Health* 1994;**48:**171–74.

[43] Basso O, Olsen J, Johansen AM, Christensen K. Change in social status and risk of low birth weight in Denmark: population based cohort study. *Br Med J* 1997;**315:**1498–502.

[44] Olsen J, Pereira A da C, Olsen SF. Does maternal tobacco smoking modify the effect of alcohol on fetal growth? *Am J Public Health* 1991; **81:**69–73.

[45] Lapeer RJ, Dalton KJ, Prager RW, Forsstrom JJ, Selbmann HK, Derom R. Application of neural networks to the ranking of perinatal variables influencing birthweight. *Scand J Clin Lab Invest* 1995;**222(Suppl.):** 83–93.