EFFECT OF MOTHERS' SMOKING HABITS ON BIRTH WEIGHT OF THEIR CHILDREN

BY

C. R. LOWE, M.D., Ph.D., D.P.H.
Lecturer in Social Medicine, University of Birmingham

It has been reported that when pregnant rats and rabbits are exposed to tobacco smoke their offspring weigh less than those of control animals (Essenberg, Schwind, and Patras, 1940; Schoeneck, 1941). A similar observation has been made in respect of pregnant women. Simpson (1957) collected data over a three-year period from American maternity hospitals and found that the incidence of premature births (those weighing 5½ lb.—2.5 kg.—or less) among women who smoked was double that among non-smokers and increased fairly regularly with the amount smoked. No explanation was offered for this observation, but it is clear from the data that age, parity, and social circumstances had little to do with it.

The subject seemed to be of sufficient importance to require further investigation, particularly since Simpson's report left a number of important questions unanswered. For example, it did not indicate whether the low birth weight was attributable to retardation of foetal growth or to early onset of labour.

The present paper gives the results of an inquiry into the effect of smoking upon the pregnancies of 2,042 women delivered in six Birmingham maternity hospitals during the summer of 1958.

Material

In order to obtain accurate information about smoking during pregnancy, it was thought desirable to limit the inquiry to recent deliveries. Two social workers visited six maternity hospitals in Birmingham at frequent intervals over a period of five months. At each visit they completed a questionary for every woman delivered in the hospital since the previous visit. An obstetrical history was recorded in the ward day-room from the hospital record card and a smoking history at the bedside from the mother. In addition each woman was asked what her weight was immediately before she became pregnant. Non-Europeans and women who had had twin births were excluded.

Results

The sample of 2,042 women contained 1,155 who did not smoke at any time during their pregnancy (women who had never smoked or had given up smoking before they conceived), 181 who smoked during the early months of pregnancy but gave up later (all but 7 of them before the end of the fifth month), 38 who stopped early in pregnancy but later began to smoke again, and 668 who smoked regularly throughout pregnancy. Since the data were not complete in every detail for every woman, it will be found that the numbers in these four categories vary a little from table to table.

Birth Weight

The basic data of the investigation are presented in Table I and Fig. 1. Infants of mothers who smoked regularly throughout pregnancy were on the average more than 6 oz. (170 g.) lighter than infants of those who never smoked during pregnancy, referred to subsequently as non-smokers (6.93 lb. and 7.33 lb. respectively—a difference of 0.40 ± 0.06 lb.). There were only 38 women who gave up smoking early in pregnancy but later began to smoke again, so no significance can be attached to the mean weight of their infants. There was no difference between weights of infants of non-smokers and of women who gave up

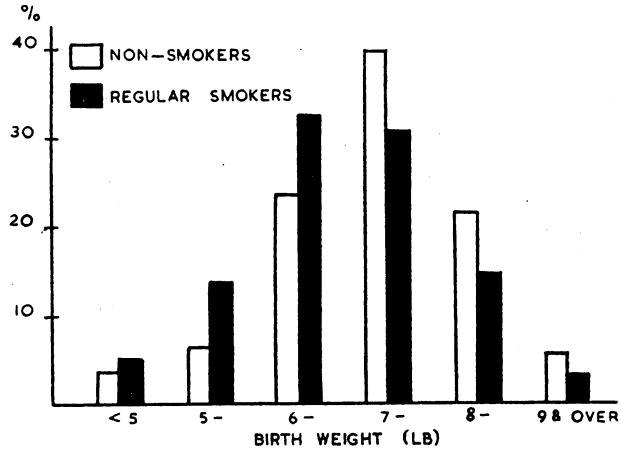

FIG. 1.—Birth weight of infants related to their mothers' smoking habits.

early in pregnancy and did not begin to smoke again. This suggests that the influence of smoking upon birth weight may possibly be greater during the second than during the first half of pregnancy; but again the numbers are rather small. The analysis which follows is concerned only with the non-smokers (1,155) and the regular smokers (668), women in the two small intermediate categories being excluded.

Table II shows that the mean weight of infants of heavy smokers (10 or more cigarettes a day) was less than that of infants of light smokers (fewer than 10

TABLE II.—*Mean Birth Weight (lb.) of Infants Related to Maternal Smoking Habits During Pregnancy*

Sex of Infant	Non-smokers	Regular Smokers		Total
		<10 Cigs. a Day	10 or More Cigs. a Day	
Male ..	7·43 (607)	7·18 (187)	7·05 (165)	7·32 (959)
Female ..	7·23 (539)	6·74 (163)	6·67 (147)	7·04 (849)
Total ..	7·33 (1,146)	6·98 (350)	6·87 (312)	7·18 (1,808)

TABLE I.—*Percentage Distribution of Birth Weights of Infants Related to Maternal Smoking Habits during Pregnancy*

Smoking Habits During Pregnancy	Birth Weight (lb.)								
	<4	4-	5-	6-	7-	8-	9+	Total	Mean±S.E.
Never smoked*	1·7 (19)	1·9 (22)	6·5 (74)	23·8 (273)	39·8 (456)	21·5 (241)	5·4 (61)	100 (1,146)	7·33±0·03
Gave up early in pregnancy ..	0·6 (1)	2·2 (4)	6·7 (12)	26·7 (48)	38·3 (69)	18·3 (33)	7·2 (13)	100 (180)	7·36±0·29
Gave up but later began again	2·6 (1)	2·6 (1)	10·5 (4)	28·9 (11)	34·2 (13)	15·8 (6)	5·3 (2)	100 (38)	7·11±0·59
Smoked regularly	2·7 (18)	2·4 (16)	13·9 (92)	32·3 (214)	30·8 (204)	14·8 (98)	3·1 (20)	100 (662)	6·93±0·05

* Women who never smoked during pregnancy are referred to as "non-smokers" in the figures and in subsequent tables.

cigarettes a day). This was true of both male and female infants. The influence of smoking on birth weight was so pronounced that male infants of regular smokers were appreciably lighter than female infants of non-smokers—a reversal of the usual sex difference in weight.

Duration of Gestation

The possibility that the low birth weight of infants of women who smoked during pregnancy was attributable to shortening of the duration of gestation was examined. Intravenous nicotine is known to release antidiuretic hormone, which can be found in human urine after smoking (Burn, 1951), so it is not impossible that smoking might have an oxytocic effect.

To explore this possibility the duration of gestation was examined in smokers and non-smokers. Since the question considered was whether tobacco smoking induces early onset of labour, it was of course necessary to exclude from the comparison pregnancies which had been terminated by surgical induction and elective caesarean section. There was no substantial difference between duration of gestation of smokers and of non-smokers (Table III). That tobacco does not have an oxytocic effect was confirmed by the observation that, with one interesting exception, whatever the duration of gestation the mean birth weight of children born to smokers was always less than that of children born to non-smokers (Fig. 2). The fact that gestations of less than 260 days did not conform to this general pattern lends some support to the suggestion made in the preceding section, that the influence of smoking upon birth weight may lie mainly in the later months of pregnancy. Further confirmation of the finding that smoking has little or no effect upon duration of gestation is provided in Table IV, in which it is shown that for a given birth weight the percentage of mothers who were smokers bore little relation to duration of gestation. On the other hand, at each duration of gestation there was a striking inverse relation between birth weight and percentage of smokers. For gestations of 290 days and over, 57% of the mothers of infants weighing 6 lb. (2.7 kg.) or less were smokers, compared with 17% of those of infants weighing 9 lb. (4 kg.) or more. Again the shorter durations of gestation (less than 260 days) were exceptional.

Maternal Weight

Although the matter does not appear to have been scientifically investigated, it is common knowledge that tobacco has an adverse effect upon appetite and that smokers who give up the habit tend to put on weight. Since the birth weight of an infant is directly related to the weight of its mother (McKeown and Record, 1957) the possibility has to be considered that the observed relationship between smoking and birth weight

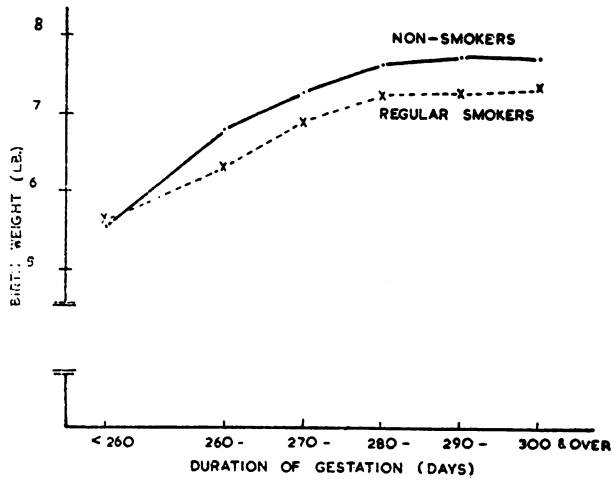

FIG. 2.—Birth weight related to duration of gestation and maternal smoking habits.

may be due to the effect of smoking upon maternal nutrition. It was indeed found (Table V) that smokers weighed significantly less than non-smokers. (Maternal weights were based on mothers' statements about their weights immediately before pregnancy, but there seems to be no reason why they should be biased in relation to smoking habits.) However, the difference—less than 4 lb. (1.8 kg.)—hardly seems sufficient to account for the difference in birth weight, since dietary deficiencies have little influence upon birth weight unless they are severe

TABLE III.—*Percentage Distribution of Non-smokers and Regular Smokers According to Duration of Gestation**

Gestation (Days)	<250	250–	260–	270–	280–	290–	300+	Total	Mean±S.E.
Non-smokers	3·7 (33)	2·7 (24)	9·2 (81)	26·9 (237)	39·1 (345)	14·9 (131)	3·5 (31)	100 (882)	279·9±1·5
Regular smokers	5·5 (30)	5·1 (28)	10·5 (57)	24·6 (134)	35·8 (195)	14·3 (78)	4·2 (23)	100 (545)	278·5±1·7

* Pregnancies terminated by surgical induction or elective caesarean section are excluded.

TABLE IV.—*Percentage of Mothers who Were Smokers Related to Birth Weight and Duration of Gestation (all Deliveries)*

Gestation (Days)	Birth Weight (lb.)					Total
	<6	6–	7–	8–	9+	
<260	45·8 (83)	41·0 (39)	42·1 (19)	(6)	(1)	43·2 (148)
260–	46·9 (49)	42·6 (61)	22·4 (58)	16·7 (12)	—	35·6 (180)
270–	50·9 (53)	34·8 (158)	28·2 (174)	27·1 (70)	21·4 (14)	32·6 (469)
280–	57·1 (35)	40·1 (167)	27·6 (286)	26·2 (164)	17·9 (39)	31·3 (691)
290+	57·1 (21)	48·3 (87)	28·8 (170)	27·3 (110)	16·7 (36)	32·8 (424)
Total	51·5 (241)	40·2 (512)	28·0 (707)	26·2 (362)	18·9 (90)	33·3 (1,912)

TABLE V.—*Percentage Distribution of Mothers According to Their Weight Before Pregnancy*

Mother's Weight (st.)*	<7	7–	8–	9–	10–	11–	12+	Total	Mean±S.E.
Non-smokers	1·7 (19)	14·5 (158)	30·2 (330)	28·8 (314)	13·8 (151)	6·8 (74)	4·1 (45)	100 (1,091)	9·29±0·04
Regular smokers	3·2 (20)	19·2 (121)	32·2 (203)	24·6 (155)	13·5 (85)	5·1 (32)	2·4 (15)	100 (631)	9·02±0·05

*14 lb.

(Thomson, 1951). This view is supported by the observation that when the mothers were grouped according to their weights the infants or non-smokers were heavier than the infants of smokers for each maternal weight group (Table VI). At the same time, of course, for both smokers and non-smokers birth weight increased regularly with maternal weight.

TABLE VI.—*Mean Birth Weight (lb.) of Infants Related to Mother's Weight (st.)*

Mother's Weight (st.)	Non-smokers (a)	Regular Smokers (b)	Difference (a-b)
<7 ..	6·50 (19)	6·05 (20)	+0·45
7– ..	6·87 (156)	6·46 (121)	+0·41
8– ..	7·24 (328)	6·80 (201)	+0·44
9– ..	7·24 (313)	7·23 (153)	+0·01
10– ..	7·50 (149)	7·14 (84)	+0·36
11+ ..	7·82 (117)	7·59 (46)	+0·23
Total ..	7·33 (1,082)	6·92 (625)	+0·41

Maternal Age and Parity

It is necessary now to inquire whether the relation between birth weight and maternal smoking habits is influenced by maternal age or parity. It is known that birth weight increases with parity fairly consistently to the third birth rank (McKeown and Gibson, 1951), and it is not unlikely that smoking habits may be related either to parity or to age (with which parity is closely correlated). The data showed no consistent change in smoking habits with age, but there was a marked and rather unexpected relationship with parity (Table VII).

TABLE VII.—*Percentage of Mothers who were Smokers Related to Age and Parity (All Deliveries)*

Age	Parity*				Total
	1	2	3	4+	
<25	27·8 (724)	42·5 (181)	41·9 (43)	50·0 (10)	32·0 (958)
25–	31·2 (285)	31·8 (132)	34·7 (49)	40·5 (42)	31·3 (508)
30–	40·4 (99)	32·6 (92)	38·5 (39)	50·0 (64)	32·5 (294)
35+	31·8 (44)	23·3 (60)	35·3 (34)	42·2 (102)	34·6 (240)
Total	29·9 (1,152)	35·1 (465)	37·6 (165)	44·5 (218)	33·3 (2,000)

* In assessing parity, stillbirths were included.

Although the change was greatest for young mothers, the proportion of women who smoked regularly throughout pregnancy increased fairly regularly with parity for each age group. Under 25 years of age 43.4% of the women in their third or later pregnancy were regular smokers, compared with only 27.8% of the primiparae. Clearly this can have played no part in determining the relationship between smoking and birth weight. Indeed, since both the proportion of smokers and birth weight increased with parity, it will, if anything, have decreased the overt effect of the one upon the other. This point is underlined in Table VIII.

TABLE VIII.—*Mean Birth Weight (lb.) Related to Maternal Parity*

Parity	Non-smokers	Regular Smokers	Total
1	7·27 (684)	6·83 (342)	7·12 (1,026)
2+ ..	7·43 (462)	7·03 (319)	7·27 (781)
Total ..	7·33 (1,146)	6·93 (661)	7·19 (1,807)

For both primiparae and multiparae the infants of smokers weighed less than the infants of non-smokers. The effect of smoking is so marked that it can apparently override the usual pattern of parity and birth weight, for the infants of primiparous non-smokers were heavier than the infants of multiparae who smoked.

Complications of Pregnancy and Labour

Apart from reports by Mgalobeli (1931) and Athayde (1948) that women who work in the tobacco industry are more subject to abortion and stillbirth than women in the general population, there does not appear to be any reference in the literature to the effect of tobacco upon the frequency of complications of pregnancy and labour in the human female. So far as the present inquiry is concerned there was nothing to suggest that cigarette smoking was related to complications of pregnancy. The incidence of toxaemia and of ante-partum and post-partum haemorrhage was much the same for smokers and for non-smokers (Table IX), and there was no great difference in the frequency with which delivery was effected by caesarean section or with obstetrical forceps (Table X).

TABLE X.—*Type of Delivery*

	Caesarean Section	Forceps	Other	Total
Non-smokers ..	5·5 (63)	6·8 (79)	87·7 (1,013)	100% (1,155)
Regular smokers	5·5 (37)	5·1 (34)	89·4 (597)	100% (668)

However, smoking had one noticeable effect upon the course of pregnancy. It was shown in Table III that the tobacco habit had little effect upon the length of gestation when it was naturally determined—that is, when labour began spontaneously. But the proportion of pregnancies in which labour was surgically induced was substantially lower among the women who smoked throughout pregnancy than among those who did not smoke (Table XI). The difference, although small, was

TABLE XI.—*Percentage of Pregnancies in Which Labour was Surgically Induced**

Sex of Infant	Percentage of Surgical Inductions		Difference±S.E. (a–b)
	Non-smokers (a)	Regular Smokers (b)	
Male ..	20·0 (610)	16·4 (353)	3·6±2·6
Female ..	20·7 (545)	13·3 (315)	7·4±2·6
Total ..	20·3 (1,155)	15·0 (668)	5·3±1·8

* Includes elective caesarean section.

highly significant. Smoking apparently provides a measure of insurance against surgical interference with the normal course of pregnancy. This is not altogether unexpected. Suspected disproportion is a common reason for surgical induction, and, as we have shown, the size of the foetus is influenced by maternal smoking habits.

Foetal Complications

The question whether maternal smoking habits have any effect upon the foetus other than upon its birth

TABLE IX.—*Percentage Incidence of Complications of Pregnancy*

	Toxaemia	Threatened Abortion	Ante-partum Haemorrhage	Post-partum Haemorrhage	Other*	None	Total
Non-smokers	5·8 (67)	1·8 (21)	1·9 (22)	2·3 (27)	7·7 (89)	80·4 (929)	100 (1,155)
Regular smokers ..	3·3 (22)	1·9 (13)	2·8 (19)	2·1 (14)	6·6 (44)	83·2 (556)	100 (668)

* Albuminuria from causes other than toxaemia, severe oedema, pyelitis, etc.

weight is clearly of considerable importance. There is no answer to this question in the literature, and the evidence in the present inquiry is inconclusive. Minor foetal abnormalities are irregularly and incompletely recorded in hospital records (from which the data were obtained), and major abnormalities are relatively uncommon. A much larger sample would therefore be required to uncover any but the grossest effects.

When stillbirths and deaths within the first 24 hours were grouped together, mortality among the infants of smokers was a little higher than among those of non-smokers (30 and 23 per 1,000 total births respectively). Since the total number of deaths was only 47, this could easily be a chance effect. In the same way, although the incidence of major malformations was rather higher among smokers than among non-smokers (15 and 11 per 1,000 respectively), the numbers were too small to permit any conclusion to be drawn (Table XII).

TABLE XII.—*Major Malformations*

Malformation	Non-smokers	Regular Smokers
Anencephalus (with or without spina bifida)	6	2
Hydrocephalus (with or without spina bifida)	4	3
Spina bifida alone	—	1
Renal conditions	2	—
Imperforate anus	—	2
Exomphalos	1	1
Congenital heart	—	1
Total	13	10
Number of pregnancies	1,155	668
Incidence per 1,000 births	11	15

Smoking appeared to have no influence upon the incidence of foetal asphyxia, which was 70 per 1,000 for smokers and 81 per 1,000 for non-smokers.

Discussion

In this investigation it is shown that smoking during pregnancy reduces the birth weight of the infant. The reduction in weight is by no means trivial. Infants of mothers who smoked throughout pregnancy weighed on the average 6 oz. (170 g.) less than infants of mothers who did not smoke. This was much more than the difference between male and female infants and between first and later births. It appeared to be great enough to lower significantly the incidence of surgical induction among smokers.

Since the effect of smoking upon birth weight is not due to a shortening of gestation, it must be attributed to a direct retardation of foetal growth. It is not difficult to suggest possible explanations for this. It is conceivable, for example, that tobacco might have a direct pharmacological action on the foetus, since the foetal heart rate increases when a pregnant woman smokes a cigarette (Sontag and Wallace, 1935; Doerfel, 1952). An even more credible explanation is that smoking during pregnancy may restrict the placental circulation, retarding the growth of the foetus by limiting its blood supply. In most normal adults smoking causes a peripheral vasoconstriction which may last for half an hour or longer, and is associated with a rise in both systolic and diastolic blood pressures and a measurable decrease in the temperature of fingers and toes (Simon, Iglauer, and Braunstein, 1954 : Eckstein, Wood, and Wilkins, 1957; Roth and Shick, 1958). Moreover, there is some evidence that women are more sensitive than men to these effects (Friedell, 1953). It is therefore quite possible that vasoconstriction, repeated ten or more times a day, might have an appreciable effect upon the nutrition of the foetus, particularly during the later months of pregnancy.

If the effect of smoking on birth weight is as considerable as this inquiry indicates, it is evident that it must make a substantial contribution to the frequency of "premature births," defined according to weight. Moreover, it suggests a possible explanation for the observation that there has been no significant decline in the incidence of premature births in a period when obstetric services have improved considerably. In the same period the proportion of women who smoke has risen steadily, and this must have contributed in some degree to the relative constancy of the proportion of infants born at low weights.

Summary

Obstetrical and smoking histories were recorded for 2,042 pregnant women delivered in six Birmingham maternity hospitals during the summer of 1958.

The mean weight of infants of mothers who smoked regularly throughout pregnancy was 6 oz. (170 g.) less than that of infants of mothers who never smoked during pregnancy (6.93 lb. and 7.33 lb. respectively). This was more than the difference in weight between male and female infants and between first and later births. It was sufficient to lower significantly the incidence of surgical induction among smokers.

The effect of smoking upon birth weight was unrelated to maternal weight, age, and parity, or to the complications of pregnancy. It was not due to shortening gestation (brought about by early onset of labour). It is concluded, therefore, that smoking during pregnancy substantially retards foetal growth.

It is with pleasure that I acknowledge my indebtedness to the obstetricians at Dudley Road, the Queen Elizabeth and St. Chad's Hospitals, and at Heathfield Road, Lordswood, and Marston Green Maternity Hospitals. I also thank Miss Ida Giles and Mrs. Eileen Armstrong, who interviewed the patients and helped to sort the data.

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A group of senior public health administrators from 25 European countries including the United Kingdom participated in a travelling seminar in the U.S.S.R. from September 15 to October 17, sponsored by the Regional Office for Europe of the World Health Organization. The seminar was designed to acquaint its members with public-health administration in various parts of the U.S.S.R. Visits were made to various medical institutions, medical schools, research establishments, and to health services in cities, in factories, in rural areas, as well as in sanatoria and spas. The itinerary included Moscow, Leningrad, Minsk, Kiev, Yalta, and Stalingrad. Professor M. KACKPRZAK, Rector of the Medical Academy of Warsaw, acted as consultant during the seminar (W.H.O. Euro/103).