ETS AND BIRTHWEIGHT

1. About 60 studies[1-61] have investigated the possible relationship of birthweight to ETS. Smoking by the father has been the most common index of ETS exposure, while other indices that have been used include smoking in the household, smoking at the workplace and the cotinine level of the mother.

2. Three main endpoints have been used for studying possible effects of ETS exposure on birthweight. One endpoint, used in many of the studies, is the difference in average birthweight between exposed and unexposed mothers. Another endpoint, used in some of the studies, is the risk of having a low birthweight (LBW) infant. This is traditionally defined as less than 2500g.[62] A third endpoint is the risk of having an infant that is "small for gestational age" (SGA).

3. In view of the known associations between maternal smoking and low birthweight[63] and between maternal and paternal smoking[1,64] most of the studies have restricted attention to nonsmoking mothers. However some studies have based their analyses on all mothers, in most cases making statistical adjustment for smoking.

4. Numerous factors have been linked to low birthweight. These include the sex, parity and gestational age of the child, maternal age, the height and weight of the mother and father, socioeconomic and employment status, and maternal alcohol consumption.[65,66] The ETS/birthweight studies vary widely in the extent to which these factors have been taken into account. While 13 studies[22,27,29,31,40,43,47,48,54,58-61] have adjusted for eight or more factors, some of the studies do not correct for any factors at all. Despite evidence that nutritional factors play a role in birthweight[67] only two ETS/birthweight studies[30,34] have reported taking diet into account as a potential confounder.

5. Of 31 studies relating ETS to the risk of having an LBW infant, four[13,30,33,51] reported a significant ($p<0.05$) increase in risk, one reported a reduction that was marginally significant at this level[5], with the rest reporting no significant association.

6. Of 16 studies relating ETS to the risk of having an SGA infant, four[33,48,49,61] reported significant increases in at least one analysis, and one[40] a significant decrease.

7. Most of the 42 studies looking for differences in birthweight associated with ETS exposure did not report a statistically significant relationship. However 12 studies[9,14,18,20,21,25,33,34,39,43,44,58] have reported a significantly reduced birthweight and one study[16] has reported a significant increase.

8. Interpretation of the reported associations is made difficult because:

   - although increases in risk of LBW or SGA or reductions in birthweight associated with ETS have been reported in four[43,48,58,61] of the 13 studies that adjusted for eight or more potential confounding variables, these were only in isolated analyses for specific endpoints and exposure indices. Most analyses of these four studies showed no significant association. Of the remaining nine such studies eight did not find any significant relationship at all, and one[40] reported a significantly lower risk of SGA associated with ETS exposure.

   - some of the studies that have reported significant associations have accounted for no potential confounding variables[9,21,25,33,44,51] or have not restricted attention to nonsmoking mothers.[14,18,48]

   - some of the ETS/birthweight studies[11,13,16,32,35,37,43,48,52] found that adjustment for potential confounding variables markedly weakened the strength of the reported relationship between ETS and reduced birthweight.

9. Almost 30 studies have presented data on the relationship between birthweight and extent of ETS exposure. Only five of these[14,20,30,38,39] found a statistically significant trend. In two studies[20,38] the claimed effect is limited to the highest ETS exposure group, data by level of exposure not being shown in two of the other two studies.[14,39] Confounding, and other sources of bias, may contribute to an observed dose-response relationship.

10. Recent meta-analyses[68] estimate that ETS exposure is, on average, associated with a decrease in birthweight of 25 to 40g. This modest difference, of about an ounce, does not necessarily imply harm to the infant, and can be compared with a recent estimate of 102g for the reduction in birthweight relating to an elevation in altitude of 1000m.[69]

11. Reviewers have noted that in some studies the claimed effects of ETS on birthweight are far greater than would seem biologically plausible and are inconsistent with the results of the remaining studies.[70,71] One recent study, for example,[72] estimated, based on results for maternal smoking during pregnancy, that a 1000 ng increase in mean urinary cotinine was associated with a 59g reduction in birthweight, and that ETS exposure at home was associated with only a 21 ng increase in urinary cotinine. These results would suggest a birthweight reduction associated with ETS of about 1g, not the reduction of 50g or more reported in some studies,[9,12,17-21,28,34,43,44,46] many of which are small and take no, or only a few, potential confounding variables into account.

12. Lack of objective measures of actual ETS exposure during gestation, and reliance on unverified paternal smoking as a measure of exposure, are additional flaws in the existing studies.

13. The evidence, taken as a whole, does not demonstrate that ETS exposure decreases birthweight or increases risk of LBW or SGA.

EPIDEMIOLOGICAL EVIDENCE ON ENVIRONMENTAL TOBACCO SMOKE AND BIRTHWEIGHT

THE DATA

The tables that follow summarize the key evidence relating birthweight to paternal smoking (Table 1), other questionnaire indices of ETS exposure (Table 2) and biochemical markers of ETS exposure (Table 3). The tables show, for each study providing data, estimates of the birthweight decrease, the relative risk of low birthweight or the relative risk of small for gestational age associated with ETS exposure. 95% confidence levels are also shown, where available, as well as details of statistical significance. The tables, supplemented by Appendix A, also give details of the year each paper was published, the study size, the study design, and how smoking by the mother and potential confounding variables were taken into account.

In each table, results are shown first for those studies restricted to nonsmoking mothers, then for studies of ex-smoking mothers, then for studies which have considered both smoking and nonsmoking mothers and adjusted for maternal smoking in analysis, and finally for studies which have ignored maternal smoking. Within each category of maternal smoking, results are shown in order of the number of potential confounding variables taken into account.

For some studies, the birthweight decrements or the relative risks of low birthweight or of small for gestational age, as well as their 95% confidence intervals, have been estimated from data provided in the source papers.

It should be noted that most of the studies record smoking status and ETS exposure during pregnancy. However for some studies the data collected relate to the period before conception or to the time of interview after birth. The nonsmoking mothers generally include both never and former smokers.

TABLE 1: Relationship between paternal smoking and birthweight

Ref	Author	Year	Size[a]	Mother smokes[b]	No. of conf.[c]	End-point[d]	Result[e]	Sig.[f]
61	Mitchell	2002	3	NSM	12	RRS	0.99 (0.72 to 1.37)	NS
22	Nakamura	1988	3	NSM	11	RRL	1.40 (0.90 to 2.20)	NS
31	Ahlborg	1991	3	NSM	10	RRL	0.84 (0.32 to 2.24)	NS
43	Rebagliato	1995	2	NSM	9	BWD	-53g (-110g to 4g)	NS
58	Matsubara	2000	3	NSM	9	BWD	11g	NS
					9	RRL	0.92 (0.71 to 1.20)	NS
					8	RRS	0.95 (0.72 to 1.26)	NS
59	Windham	2000	3	NSM	9	BWD	32g (-18g to 81g)	NS
					0[g]	RRL[h]	1.4 (0.9 to 2.2)	NS
60	Jaakkola	2001	2	NSM	8	RRL	1.92 (0.79 to 4.70)	NS
					8	RRS	1.41 (0.52 to 3.82)	NS
30	Yan	1990	2	NSM	7	RRL	1.89 (1.23 to 2.91)	p<0.05
39	Martinez	1994	2	NSM	6	BWD	34g (5g to 63g) per unit[j]	p<0.05
36	Zhang	1993	3	NSM	4	BWD	30g (-7g to 66g)	NS
					0	RRL	1.07 (0.58 to 1.97)	NS
					0	RRS	1.11 (0.83 to 1.48)	NS
35	Pan	1992	2	NSM	3	RRS	1.68 (0.69 to 4.10)	NS
55	Windham	1999	2	NSM	3	RRS	1.5[k] (0.64 to 3.4)	NS
2	MacMahon	1966	3	NSM	1	BWD	21g (-4g to 47g)	NS
3	Ravenholt	1966	3	NSM	1	BWD	33g	NS
7	Yerushalmy	1971	3	NSM	1	RRL	0.95	NS
56	Haug	2000	4	NSM	1	BWD	1g (-15g to 17g)	NS
1	Yerushalmy	1962	2	NSM	0	RRL	1.09 (0.58 to 2.07)	NS
4	Comstock	1967	2	NSM	0	BWD	42g	NS
5	Underwood	1967	4	NSM	0	BWD	5g	NS
					0	RRL	0.90 (0.82 to 1.00)	p≈0.05
8	Mau	1974	3	NSM	0	RRL	1.27 (0.99 to 1.62)	NS
9	Borlee	1978	2	NSM	0	BWD[l]	228g (17g to 439g)	p<0.05
12	Karakostov	1985	2	NSM	0	BWD	84g (-114g to 282g)	NS
17	Schwartz-B.	1987	1	NSM	0	BWD	205g (-32g to 442g)	NS
19	Drozdz	1988	1	NSM	0	BWD	190g (-160g to 540g)	NS
24	Chen	1989	3	NSM	0[g]	BWD	10g (-89g to 109g)	NS
					0[g]	RRL	1.51 (0.79 to 2.90)	NS
26	Kikuchi	1990	2	NSM	0	RRL	1.39 (0.63 to 3.04)	NS
33	Saito	1991	3	NSM	0	BWD	33g (0.5g to 66g)	p<0.05
					0	RRS	1.26 (1.09-1.46)	p<0.05
16	MacArthur	1987	2	ESM	4	BWD	-123g (-242g to -4g)	p<0.05
29	Rantakallio	1990	3	AS	20+	RRL	1.18 (0.98 to 1.41)	NS
48	Horta	1997	3	AS	7	RRL	1.18 (0.94 to 1.48)	NS
					10	RRS	1.33 (1.05 to 1.68)	P<0.05
11	Magnus	1984	3	AS	7	BWD	5g (-13g to 23g) per unit[m]	NS
14	Rubin	1986	2	AS	7	BWD	6.1g (0.2g to 12.0g)/cig	p<0.05
18	Campbell	1988	2	AS	4	BWD	113g (8g to 216g)	p<0.05
45	Wilcox	1995	2	AS	2	IBRD	0.046 (-0.042 to 0.134)	NS
42	Jadsri	1995	1	AS	2	RRL	1.46 (0.79 to 2.69)	NS
15	Little	1987	2	AS	0	BWD	No sig. effect	NS
6	Terris	1969	2	I	0	RRL	0.81 (0.43 to 1.53)	NS

[a] 1,2,3,4 = <100, 100-999, 1000-9999, >10000 infants (see Appendix A)
[b] NSM = nonsmoking mothers ; ESM = ex smoking mothers; AS = adjusted for maternal smoking; I = ignoring smoking
[c] See Appendix A for the confounders considered
[d] BWD = birthweight decrement; IBRD = individual birth ratio decrement; RRL = relative risk of low birthweight; RRS = relative risk of small for gestational age
[e] 95% confidence intervals shown in brackets where available
[f] NS = not significant (p≥0.05)
[g] Adjustment for confounders stated to have little effect
[h] Data came from reference[73]
[j] Units are 0,1,2,3 = 0,1-10,11-20,21+ cigarettes/day
[k] RR is for >10 cigs/day. Results for lower amounts and low birthweight showed weaker associations and not presented
[l] Includes over 50% malformed births
[m] Units are 1,2,3,4 = 0, <10,10-20 and 21 cigarettes/day

TABLE 2: Relationship between other questionnaire indices of ETS exposure and birthweight

Ref	Author	Year	Size[a]	Mother smokes[b]	No.of conf.[c]	ETS exposure[d]	End-point[e]	Result[f]	Sig.[g]
54	Sadler	1999	3	NSM	18	Any	BWD	1g (-43g to 41g)	NS
					13	Any	RRS	0.82 (0.51 to 1.33)	NS
27	Lazzaroni	1990	2	NSM	15	Home or work	BWD	38g (-31g to 107g)	NS
61	Mitchell	2002	3	NSM	12	Home(not father)	RRS	0.83 (0.57 to 1.22)	NS
					12	Workplace/social	RRS	1.48 (1.03 to 2.12)	p<0.05
31	Ahlborg	1991	3	NSM	10	Home only	RRL	0.69 (0.21 to 2.27)	NS
					10	Work	RRL	1.09 (0.33 to 3.62)	NS
					10	Home or work	RRL	0.99 (0.45 to 2.21)	NS
47	Ahluwalia	1997	4	NSM	10	Home	BWD	4g (-29g to 37g)	NS
					10	Home	RRL	1.17 (0.95 to 1.45)	NS[h]
40	Chen	1995	2	NSM	9	Any	RRS	0.54 (0.30 to 0.96)	p<0.05
					9	Work only	RRS	1.02 (0.39 to 2.68)	NS
					9	Home only	RRS	0.47 (0.12 to 1.89)	NS
					9	Car only	RRS	1.15 (0.22 to 6.00)	NS
					9	All three	RRS	0.51 (0.17 to 1.50)	NS
43	Rebagliato	1995	2	NSM	9	Work	BWD	61g (3g to 119g)	p<0.05
					9	Public places	BWD	66g (7g to 126g)	p<0.05
					9	Others at home	BWD	-43g (-127g to 42g)	NS
					9	Any source	BWD	52g (-36g to 141g)	NS
58	Matsubara	2000	3	NSM	9	Any	BWD	19g	p<0.05
					9	Any	RRL	0.99 (0.75 to 1.30)	NS
					8	Any	RRS	0.95 (0.71 to 1.26)	NS
59	Windham	2000	3	NSM	9	Home or work	BWD	-2g (-45g to 41g)	NS
					5	Home or work	RRL	1.1 (0.71 to 1.7)	NS
					5	Home or work	RRS	1.01 (0.72 to 1.42)	NS
60	Jaakkola	2001	2	NSM	8	Home only	RRL	1.13 (0.34 to 3.78)	NS
					8	Work only	RRL	1.43 (0.50 to 4.12)	NS
					8	Home and work	RRL	2.08 (0.44 to 9.73)	NS
					8	Home only	RRS	1.06 (0.30 to 3.73)	NS
					8	Work only	RRS	1.02 (0.31 to 3.31)	NS
					8	Home and work	RRS	1.47 (0.23 to 9.32)	NS
34	Mathai	1992	2	NSM	7	Home	BWD	63g (12g to 114g)	p<0.05
					0	Home	RRL	0.99 (0.46 to 2.14)	NS
32	Ogawa	1991	3	NSM	6	Any >2hr/day	RRL	1.0 (0.7 to 1.5)	NS
					6	Any >2hr/day	BWD	11g (-11g to 32g)	NS
49	Dejin-Karlsson	1998	2	NSM	5	Home or work	RRS	3.9 (1.4 to 10.7)	p<0.01
					0	Home or work	RRL	1.3 (0.7 to 2.5)	NS
53	Hanke	1999	3	NSM	3	Any	BWD	13g (-37g to 63g)	NS
					5	Any	RRS	0.98 (0.67 to 1.45)	NS
13	Martin	1986	3	NSM	3	Home/wk>2hr/day	BWD	24g (-13g to 60g)	NS
					4	Home/wk>2hr/day	RRLT	2.17 (1.05 to 4.50)	p<0.05
23	Brooke	1989	3	NSM	4	Home	BWD	18g	NS
28	Mathai	1990	2	NSM	0	Home	BWD	66g (-79g to 211g)	NS
					4	Home	BPD	4.1% (-4.8% to 13.0%)	NS
37	Fortier	1994	3	NSM	4	Home only	RRS	0.98 (0.67 to 1.44)	NS
					4	Work only	RRS	1.18 (0.90 to 1.56)	NS
					4	Home and work	RRS	0.94 (0.60 to 1.49)	NS
					4	Home or work	RRS	1.09 (0.85 to 1.39)	NS
38	Mainous	1994	3	NSM	0	Any	BWD	37g (-6g to 80g)[j]	NS
					4	Any	RRL	1.39 (0.98 to 1.95)	NS
55	Windham	1999	2	NSM	4	Home or work	BWD	-14g (-81g to 54g)	NS
					3	Home or work	RRL	1.0 (0.52 to 2.1)	NS
					3	Home or work	RRLT	1.8 (0.64 to 4.8)	NS
					3	Home or work	RRS	1.4 (0.79 to 2.5)	NS
35	Pan	1992	2	NSM	3	Home	RRS	0.87 (0.42 to 1.78)	NS
					3	Work	RRS	0.63 (0.31 to 1.31)	NS

TABLE 2: Relationship between other questionnaire indices of (cont/d.) ETS exposure and birthweight

Ref	Author	Year	Size[a]	Mother smokes[b]	No.of conf.[c]	ETS exposure[d]	End-point[e]	Result[f]	Sig.[g]
21	Hamada	1988	2	NSM	0	Home or work	BWD	182g (110g to 254g)	p<0.001
					0	Home or work	RRS	0.89 (0.35 to 2.25)	NS
24	Chen	1989	3	NSM	0[k]	Home	BWD	11g (-79g to 101g)	NS
					0[k]	Home	RRL	1.33 (0.64 to 2.75)	NS
25	Ueda	1989	2	NSM	0	Any	BWD	No association	NS
44	Roquer	1995	1	NSM	0	Home or work	BWD	192g (19g to 365g)	p<0.05
					0	Home or work	RRS	1.86 (0.57 to 6.06)	NS
51	Nafstad	1998	2	NSM	0[k]	Home or work	RRL	0.82 (0.35 to 1.95)	NS
					0[k]	Home and work	RRL	1.39 (0.44 to 4.41)	NS
50	Janghorbani	1998	2	NSM	0	Home or work	BWD	22g (-52g to 96g)	NS
					0	Home or work	RRL	0.75 (0.44 to 1.18)	NS
57	Hrubá	2000	3	NSM	0	Any	BWD	46g (-31g to 124g)	NS
					0	Home only	BWD	45g (-68g to 158g)	NS
					0	Work only	BWD	52g (-55g to 159g)	NS
					0	Home and work	BWD	35g (-162g to 233g)	NS
					0	Any	RRL	0.95 (0.63 to 1.45)	NS
					0	Home only	RRL	1.09 (0.61 to 1.93)	NS
					0	Work only	RRL	0.88 (0.48 to 1.61)	NS
					0	Home and work	RRL	0.84 (0.32 to 2.21)	NS
46	Jedrychowski	1996	3	AS	3	Home or work	BWD	58g (-3g to 119g)	NS[l]
					3	Home or work	RRL	1.46 (0.83 to 2.60)	NS

[a] 1,2,3,4 = <100, 100-999, 1000-9999, >10000 infants (see Appendix A for numbers)
[b] NSM = nonsmoking mothers; AS = adjusted for maternal smoking
[c] See Appendix A for the confounders considered
[d] Exposures relate to period of pregnancy except for Ueda where this is unclear
[e] BPD = adjusted birthweight percentile decrement; BWD = birthweight decrement; RRL = relative risk of low birthweight; RRLT = relative risk of low birthweight at term; RRS = relative risk of small for gestational age
[f] 95% confidence intervals shown in brackets where available
[g] NS = not significant ($p \geq 0.05$)
[h] Ahluwalia reported that in mothers aged 30+ there was a significant ($p<0.001$) RRL of 2.42 (1.51 to 3.87); results cited are for all ages
[j] For high and moderate versus low and very low ETS exposure
[k] Adjustment for confounders stated to have little effect
[l] Stated as significant at p = 0.004 but data given as 57.9 with SE 31.1 which is not significant even at $p<0.05$

TABLE 3: Relationship between birthweight and biochemical markers of ETS exposure in nonsmoking mothers

Ref	Author	Year	Size[a]	No. of conf.[b]	Marker/ restriction[c]	End-point[d]	Result[e]		Sig.[f]
43	Rebagliato	1995	2	9	SAC (<14 ng/ml)	BWD	0.0 to 0.5 ng/ml: 0.6 to 0.8 ng/ml: 0.9 to 1.1 ng/ml: 1.2 to 1.7 ng/ml: >1.7 ng/ml	comparison group 42g (-39g to 122g) 53g (-37g to 143g) -54g (-142g to 35g) 87g (1g to 174g)	 NS NS NS p<0.05
60	Jaakkola	2001	2	8	MHN (none)	RRL	<0.75 μg/g 0.75 to <4.00 μg/g >=4.00 μg/g per μg/g	comparison group 1.28 (0.59 to 2.60) 1.55 (0.55 to 4.43) 1.06 (0.96 to 1.17)	 NS NS NS
						RRS	<0.75 μg/g 0.75 to <4.00 μg/g >=4.00 μg/g per μg/g	comparison group 1.05 (0.44 to 2.49) 1.18 (0.34 to 4.19) 1.04 (0.92 to 1.19)	 NS NS NS
41	Eskenazi	1995	3	7	SEC (<10 ng/ml)	BWD	<2.0 ng/ml: 2.0+ ng/ml:	comparison group 45g(-36g to 126g)	 NS
				0		RRL	<2.0 ng/ml: 2.0+ ng/ml:	comparison group 1.35 (0.60 to 3.03)	 NS
20	Haddow	1988	3	6	SEC (<10 ng/ml)	BWD	<0.5 ng/ml: 0.5-1.0 ng/ml: >1.0 ng/ml:	-4g (-73g to 65g) comparison group 104g (35g to 173g)	NS p<0.001
						RRL	≤1.0 ng/ml: >1.0 ng/ml:	comparison group 1.29	 ?
52	Peacock	1998	2	4	SEC (<15 ng/ml)	BRD[g]	0 to 0.180 ng/ml: 0.180 to 0.291 ng/ml: 0.292 to 0.480 ng/ml: 0.481 to 0.795 ng/ml: 0.796+ ng/ml:	comparison group 0.001 (-0.025 to 0.027) 0.003 (-0.022 to 0.028) -0.004 (-0.030 to 0.022) 0.002 (-0.024 to 0.028)	 NS NS NS NS
10	Hauth	1984	2	0	UCT (none)	BWD	No relationship of UCT to birthweight in women exposed to ETS at home or work (r = 0.02) or those unexposed to ETS (r = 0.15)		NS
25	Ueda[h]	1989	2	0	SEC (none)	RBW	<9 ng/ml: >9 ng/ml:	102.4% 96.2%	 p<0.001
51	Nafstad	1998	2	0[j]	MHN (none)	RRL	<0.75 μg/g 0.75 to 4.00 μg/g >4.00 μg/g	comparison group 3.35 (1.31 to 8.60) 2.08 (0.43 to 10.1)	 p<0.05 NS
					OHN (none)	RRL	undetectable detectable	comparison group 2.62 (0.85 to 8.08)	 NS

[a] 1,2,3,4 = <100, 100-999, 1000-9999, >10000 infants (see Appendix A)
[b] See Appendix A for the confounders considered
[c] MHN = maternal hair nicotine, OHN = offspring hair nicotine, SAC = saliva cotinine, SEC = serum cotinine, UCT = umbilical cord thiocyanate; analysis limited to those with levels below cut-point stated in brackets
[d] BRD = decrement in adjusted birthweight ratio; BWD = birthweight decrement; RBW = birthweight relative to national standard for gestational age; RRL = relative risk of low birthweight; RRS = relative risk of small for gestational age
[e] 95% confidence limits shown in brackets where available
[f] NS = not significant (p≥0.05); ? = significance can not be estimated
[g] A BRD of 0.001 corresponds to a BWD of about 3.35g in this study
[h] It is unclear whether active smokers were excluded from this analysis
[j] Adjustment for confounders stated to have little effect

REFERENCES

1. Yerushalmy J. Statistical considerations and evaluation of epidemiological evidence. In: James G, Rosenthal T, editors. *Tobacco and health*. Springfield, Illinois, USA: Charles C Thomas, 1962;208-30.

2. MacMahon B, Alpert M, Salber EJ. Infant weight and parental smoking habits. *Am J Epidemiol* 1966;**82**:247-61.

3. Ravenholt RT, Levinski MJ, Nellist DJ, Takenaga M. Effects of smoking upon reproduction. *Am J Obstet Gynecol* 1966;**96**:267-81.

4. Comstock GW, Lundin FE, Jr. Parental smoking and perinatal mortality. *Am J Obstet Gynecol* 1967;**98**:708-18.

5. Underwood PB, Kesler KF, O'Lane JM, Callaghan DA. Parental smoking empirically related to pregnancy outcome. *Obstet Gynecol* 1967;**29**:1-8.

6. Terris M, Gold EM. An epidemiologic study of prematurity. I. Relation to smoking, heart volume, employment, and physique. *Am J Obstet Gynecol* 1969;**103**:358-70.

7. Yerushalmy J. The relationship of parents' cigarette smoking to outcome of pregnancy - implications as to the problem of inferring causation from observed associations. *Am J Epidemiol* 1971;**93**:443-56.

8. Mau G, Netter P. Die Auswirkungen des väterlichen Zigarettenkonsums auf die perinatale Sterblichkeit und die Mißbildungshäufigkeit (The effects of paternal cigarette smoking on perinatal mortality). *Dtsch Med Wochenschr* 1974;**99**:1113-8.

9. Borlee I, Bouckaert A, Lechat MF, Misson CB. Smoking patterns during and before pregnancy: weight, length and head circumference of progeny. *Eur J Obstet Gynecol Reprod Biol* 1978;**8**:171-7.

10. Hauth JC, Hauth J, Drawbaugh RB, Gilstrap LC, Pierson WP. Passive smoking and thiocyanate concentrations in pregnant women and newborns. *Obstet Gynecol* 1984;**63**:519-22.

11. Magnus P, Berg K, Bjerkedal T, Nance WE. Parental determinants of birth weight. *Clin Genet* 1984;**26**:397-405.

12. Karakostov K. Passive smoking among pregnant women and its effect on the weight and height of the newborn [Abstract]. *Akusherstvo i Ginekologiia* 1985;**24**:31.

13. Martin TR, Bracken MB. Association of low birth weight with passive smoke exposure in pregnancy. *Am J Epidemiol* 1986;**124**:633-42.

14. Rubin DH, Kraskilnikoff PA, Leventhal JM, Weile B, Berget A. Effect of passive smoking on birth weight. *Lancet* 1986;**ii**:415-7.

15. Little RE, Sing CF. Father's drinking and infant birth weight: report of an association. *Teratology* 1987;**36**:59-65.

16. MacArthur C, Knox EG. Passive smoking and birthweight [Letter]. *Lancet* 1987;**i** :37-8.

17. Schwartz-Bickenbach D, Schulte-Hobein B, Abt S, Plum C, Nau H. Smoking and passive smoking during pregnancy and early infancy: effects on birth weight, lactation period, and cotinine concentrations in mother's milk and infant's urine. *Toxicol Lett* 1987;**35**:73-81.

18. Campbell MJ, Lewry J, Wailoo M. Further evidence for the effect of passive smoking on neonates. *Postgrad Med J* 1988;**64**:663-5.

19. Dróżdż M, Strzelczak Z, Jendryczko A. Palenie papierosów i palenie bierne w czasie ciąży i po porodzie: wpływ nà mase urodzeniową, długość okresu laktacji oraz steżenie kotyniny w mleku matki i wydalanie kotyniny w moczu dziecka. (Smoking and passive smoking during pregnancy and after delivery: its influence on the birth weight, lactation period length and concentration of cotinine in mother's milk and cotinine excretion in the urine of a baby). *Ginekol Pol* 1988;**59**:528-33.

20. Haddow JE, Knight GJ, Palomaki GE, McCarthy JE. Second-trimester serum cotinine levels in non-smokers in relation to birth weight. *Am J Obstet Gynecol* 1988;**159**:481-4.

21. Hamada H, Oka H, Sadatsuki M, Fujii H. The effect of maternal active and passive smoking on pregnancy and delivery. *Shusanki Igaku* 1988;**18**:1585-90.

22. Nakamura M, Oshima A, Hiyama T, Kubota N, Wada K, Yano K. Effect of passive smoking during pregnancy on birth weight and gestation: A population-based prospective study in Japan. In: Aoki M, Hisamichi S, Tominaga S, editors. *Smoking and health 1987, Proceedings of the 6th World Conference on Smoking and Health, Tokyo, 9-12 November 1987*. Amsterdam: Elsevier Science Publishers B.V. (Biomedical Division), 1988;267-9. International Congress Series No. 780.

23. Brooke OG, Anderson HR, Bland JM, Peacock JL, Stewart CM. Effects on birth weight of smoking, alcohol, caffeine, socioeconomic factors, and psychosocial stress. *BMJ* 1989; **298**:795-801.

24. Chen Y, Pederson LL, Lefcoe NM. Passive smoking and low birthweight [Letter]. *Lancet* 1989; **ii**:54-5.

25. Ueda Y, Morikawa H, Funakoshi T, Kobayashi A, Yamasaki A, Takeuchi K, *et al*. Estimation of passive smoking during pregnancy by cotinine measurement and its effect on fetal growth. *Acta Obstet Gynaecol Jpn* 1989;**41**:454-60.

26. Kikuchi S, Takahashi T. Effect of paternal smoking on fetuses. In: Kasuga H, editor. *Indoor air quality, International Conference on Indoor Air Quality, Tokyo, November 4-6, 1987*. Berlin Heidelberg: Springer-Verlag, 1990;

27. Lazzaroni F, Bonassi S, Manniello E, Morcaldi L, Repetto E, Ruocco A, *et al*. Effect of passive smoking during pregnancy on selected perinatal parameters. *Int J Epidemiol* 1990;**19**:960-6.

28. Mathai M, Skinner A, Lawton K, Weindling AM. Maternal smoking, urinary cotinine levels and birth-weight. *Aust N Z J Obstet Gynaecol* 1990;**30**:33-6.

29. Rantakallio P, Hartikainen-Sorri A-L, Leino T. The effect of parental smoking and industrial pollution on birth weight. In: Kasuga H, editor. *Indoor air quality, International Conference on Indoor Air Quality, Tokyo, November 4-6, 1987*. Berlin Heidelberg: Springer-Verlag, 1990;219-25.

30. Yan Y. Study on the risk factors of low birth weight. *Zhonghua Liu Xing Bing Xue Za Zhi (Chin J Epidemiol)* 1990;**11**:92-5.

31. Ahlborg G, Jr., Bodin L. Tobacco smoke exposure and pregnancy outcome among working women. A prospective study at prenatal care centers in Örebro County, Sweden. *Am J Epidemiol* 1991;**133**:338-47.

32. Ogawa H, Tominaga S, Hori K, Noguchi K, Kanou I, Matsubara M. Passive smoking by pregnant women and fetal growth. *J Epidemiol Community Health* 1991;**45**:164-8.

33. Saito R. The smoking habits of pregnant women and their husbands, and the effect on their infants. *Nippon Koshu Eisei Zasshi* 1991;**38**:124-31.

34. Mathai M, Vijayasri R, Babu S, Jeyaseelan L. Passive maternal smoking and birthweight in a South Indian population. *Br J Obstet Gynaecol* 1992;**99**:342-3.

35. Pan M, Zhang Z, Wang C, He X. The influence of passive smoking on the fetus during pregnancy. *Zhonghua Fu Chan Ke Za Zhi* 1992;**27**:348-50.

36. Zhang J, Ratcliffe JM. Paternal smoking and birthweight in Shanghai. *Am J Public Health* 1993;**83**:207-10.

37. Fortier I, Marcoux S, Brisson J. Passive smoking during pregnancy and the risk of delivering a small-for-gestational-age infant. *Am J Epidemiol* 1994;**139**:294-301.

38. Mainous AG, III, Hueston WJ. Passive smoke and low birth weight. Evidence of a threshold effect. *Arch Fam Med* 1994;**3**:875-8.

39. Martinez FD, Wright AL, Taussig LM, the Group Health Medical Associates. The effect of paternal smoking on the birthweight of newborns whose mothers did not smoke. *Am J Public Health* 1994;**84**:1489-91.

40. Chen LH, Petitti DB. Case-control study of passive smoking and the risk of small-for-gestational-age at term. *Am J Epidemiol* 1995;**142**:158-65.

41. Eskenazi B, Prehn AW, Christianson RE. Passive and active maternal smoking as measured by serum cotinine: the effect on birthweight. *Am J Public Health* 1995;**85**:395-8.

42. Jadsri S, Jadsri C. Parental smoking habits and infant birth weight. *Asia Pac J Public Health* 1995;**8**:134-7.

43. Rebagliato M, Florey CdV, Bolumar F. Exposure to environmental tobacco smoke in nonsmoking pregnant women in relation to birth weight. *Am J Epidemiol* 1995;**142**:531-7.

44. Roquer JM, Figueras J, Botel F, Jiménez R. Influence on fetal growth of exposure to tobacco smoke during pregnancy. *Acta Paediatr* 1995;**84**:118-21.

45. Wilcox MA, Newton CS, Johnson IR. Paternal influences on birthweight. *Acta Obstet Gynecol Scand* 1995;**74**:15-8.

46. Jedrychowski W, Flak E. Confronting the prenatal effects of active and passive tobacco smoking on the birth weight of children. *Cent Eur J Public Health* 1996;**4**:201-5.

47. Ahluwalia IB, Grummer-Strawn L, Scanlon KS. Exposure to environmental tobacco smoke and birth outcome: increased effects on pregnant women aged 30 years or older. *Am J Epidemiol* 1997;**146**:42-7.

48. Horta BL, Victora CG, Menezes AM, Halpern R, Barros FC. Low birthweight, preterm births and intrauterine growth retardation in relation to maternal smoking. *Paediatr Perinat Epidemiol* 1997;**11**:140-51.

49. Dejin-Karlsson E, Hanson BS, Östergren P-O, Sjöberg N-O, Marsal K. Does passive smoking in early pregnancy increase the risk of small-for-gestational-age infants? *Am J Public Health* 1998;**88**:1523-6.

50. Janghorbani M, Nakhai HR. Effect of passive smoking during pregnancy on weight, length and cranial circumference at birth in Kerman, Iran. *Medical Journal of the Islamic Republic of Iran* 1998;**12**:31-6.

51. Nafstad P, Fugelseth D, Qvigstad E, Zahlsen K, Magnus P, Lindemann R. Nicotine concentration in the hair of nonsmoking mothers and size of offspring. *Am J Public Health* 1998;**88**:120-4.

52. Peacock JL, Cook DG, Carey IM, Jarvis MJ, Bryant AE, Anderson HR. Maternal cotinine level during pregnancy and birthweight for gestational age. *Int J Epidemiol* 1998;**27**:647-56.

53. Hanke W, Kalinka J, Florek E, Sobala W. Passive smoking and pregnancy outcome in central Poland. *Hum Toxicol* 1999;**18**:265-71.

54. Sadler L, Belanger K, Saftlas A, Leaderer B, Hellenbrand K, McSharry J-E, *et al*. Environmental tobacco smoke exposure and small-for-gestational-age birth. *Am J Epidemiol* 1999;**150**:695-705.

55. Windham GC, Eaton A, Hopkins B. Evidence for an association between environmental tobacco smoke exposure and birth weight: a meta-analysis and new data. *Pediatr Perinat Epidemiol* 1999;**13**:35-57.

56. Haug K, Irgens LM, Skjærven R, Markestad T, Baste V, Schreuder P. Maternal smoking and birthweight: effect modification of period, maternal age and paternal smoking. *Acta Obstet Gynecol Scand* 2000;**79**:485-9.

57. Hrubá D, Kachlík P. Influence of maternal active and passive smoking during pregnancy on birthweight in newborns. *Cent Eur J Public Health* 2000;**8**:249-52.

58. Matsubara F, Kida M, Tamakoshi A, Wakai K, Kawamura T, Ohno Y. Maternal active and passive smoking and fetal growth: a prospective study in Nagoya, Japan. *J Epidemiol* 2000;**10**:335-43.

59. Windham GC, Hopkins B, Fenster L, Swan SH. Prenatal active or passive tobacco smoke exposure and the risk of preterm delivery or low birth weight. *Epidemiology* 2000;**11**:427-33.

60. Jaakkola JJK, Jaakkola N, Zahlsen K. Fetal growth and length of gestation in relation to prenatal exposure to environmental tobacco smoke assessed by hair nicotine concentration. *Environ Health Perspect* 2001;**109**:557-61.

61. Mitchell EA, Thompson JMD, Robinson E, Wild CJ, Becroft DMO, Clark PM, *et al*. Smoking, nicotine and tar and risk of small for gestational age babies. *Acta Paediatr* 2002;**91**:323-8.

62. Kramer MS. Determinants of low birthweight: methodological assessment and meta-analysis. *Bull World Health Organ* 1987;**65**:663-737.

63. US Surgeon General. *The health consequences of smoking for women, a report of the Surgeon General*. Rockville, Maryland: US Department of Health and Human Services; Public Health Service; 1980.

64. Lee PN. *Environmental tobacco smoke and mortality. A detailed review of epidemiological evidence relating environmental tobacco smoke to the risk of cancer, heart disease and other causes of death in adults who have never smoked*. Basel: Karger; 1992.

65. US Surgeon General. *Smoking and health, a report of the Surgeon General*. Rockville, Maryland: US Department of Health, Education, and Welfare; Public Health Service; 1979. DHEW Publication No. (PHS) 79-50066.

66. Berkowitz GS, Papiernik E. Epidemiology of preterm birth. *Epidemiol Rev* 1993;**15**:414-43.

67. Haste FM, Brooke OG, Anderson HR, Bland JM. The effect of nutritional intake on outcome of pregnancy in smokers and non-smokers. *Br J Nutr* 1991;**65**:347-54.

68. Lindbohm M-L, Sallmén M, Taskinen H. Effects of exposure to environmental tobacco smoke on reproductive health. *Scand J Work Environ Health* 2002;**28 (Suppl 2)**:84-96.

69. Jensen GM, Moore LG. The effect of high altitude and other risk factors on birthweight: independent or interactive effects? *Am J Public Health* 1997;**87**:1003-7.

70. Independent Scientific Committee. *Fourth report on smoking and health*. London: HMSO; 1988.

71. Witorsch RJ, Witorsch P. Environmental tobacco smoke and birthweight of offspring: a critical review and analysis of the epidemiological literature. *Indoor Built Environ* 1996;**5**:219-31.

72. Wang X, Tager IB, van Vukakis 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.

73. Windham GC, Hopkins B, Fenster L, Swan SH. Passive smoking and low birthweight in a prospective study [Abstract]. *Epidemiology* 1996;**7**:37S.

APPENDIX A : Further details of studies

Ref	Author	Year	Location	Study type[a]	Sample size[b]	Dose-resp.[c]	Confounders accounted for[d] PA	SX	GE	MA	MH	MW	MB	PH	PW	PE	SES	EM	AC	Others[d]
1	Yerushalmy	1962	USA	PC	606	-														
2	MacMahon	1966	USA	RC	5935	No		+												
3	Ravenholt	1966	USA	RC	1240	No		+												
4	Comstock	1967	USA	RC	238	-														
5	Underwood	1967	USA	RC	24773	No														
6	Terris	1969	USA	CC	214	No														
7	Yerushalmy	1971	USA	PC	6015	-														ET
8	Mau	1974	Germany	PC	3696	Yes														
9	Borlee	1978	Belgium	RC	238	-														
10	Hauth	1984	USA	RC	134	-														
11	Magnus	1984	Norway	PC	3130	No		+			+	+		+	+	+	+			
12	Karakostov	1985	Bulgaria	RC	118	-														
13	Martin	1986	USA	PC	2473	-	+		+	+[e]										ET
14	Rubin	1986	Denmark	RC	500	Yes	+	+		+							+		+	CP,MS
15	Little	1987	USA	PC	377	-														
16	MacArthur	1987	England	RC	180	No	+	+	+		+									
17	Schwartz-B.	1987	Germany	RC	54	-														
18	Campbell	1988	England	RC	518	-	+			+							+		+	
19	Drozdz	1988	Poland	RC	54	-														
20	Haddow	1988	USA	PC	1231	Yes	+	+		+	+	+				+				
21	Hamada	1988	Japan	RC	734	-														
22	Nakamura	1988	Japan	PC	2005	-	+			+							+	+	+	BP,CP,GR, MD,MS,RH
23	Brooke	1989	UK	PC	1018	-	+	+	+		+									
24	Chen	1989	China	RC	1163	No	+	+		+						+	+			
25	Ueda	1989	Japan	RC	242	-														
26	Kikuchi	1990	Japan	RC	778	-														
27	Lazzaroni	1990	Italy	RC	647	No	+	+	+	+	+	+		+	+	+		+	+	BP,CC,CP,WG,Others
28	Mathai	1990	England	PC	187	-	+[f]	+[f]	+[f]				+[f]							

APPENDIX A : Further details of studies (Continued/1)

Ref	Author	Year	Location	Study type[a]	Sample size[b]	Dose-resp.[c]	Confounders accounted for[d] PA	SX	GE	MA	MH	MW	MB	PH	PW	PE	SES	EM	AC	Others[d]
29	Rantakallio	1990	Finland	PC	9478	-	+	+		+	+	+		+	+	+	+	+	+	AB,CP,MD,MS, PB,PP,PR,RH, SB,Others
30	Yan	1990	China	CC	385	Yes			+		+[g]			+[g]						CP,CX,DI,MM
31	Ahlborg	1991	Sweden	PC	2940	No	+	+	+	+						+		+	+	AB,PP,PR
32	Ogawa	1991	Japan	PC	5336	-	+		+	+	+							+	+	
33	Saito	1991	Japan	RC	2713	-														
34	Mathai	1992	India	RC	994	-	+[h]	+[h]	+[h]	+[h]	+[h]						+[h]			DI[h]
35	Pan	1992	China	PC	253	-														CB,CK,HT
36	Zhang	1993	China	RC	1785	No	+[h]		+[h]	+[h]								+[h]		
37	Fortier	1994	Canada	RC	4644	No	+					+								CC,PB
38	Mainous	1994	USA	RC	3253	Yes	+[e]			+[e]							+[e]			ET[e]
39	Martinez	1994	USA	RC	907	Yes	+	+	+	+						+				ET
40	Chen	1995	USA	CC	235	No	+			+			+			+	+	+	+	PC,WG
41	Eskenazi	1995	USA	PC	2243	No	+[h]		+[h]	+[h]			+[h]			+[h]				ET[h],WG[h]
42	Jadsri	1995	Thailand	PC?	77	-														CP,PT
43	Rebagliato	1995	Spain	PC	710	No	+	+	+	+	+	+				+	+			CP
44	Roquer	1995	Spain	RC	74	-														
45	Wilcox	1995	UK	RC	571	-								+	+					
46	Jedrychowski	1996	Poland	RC	1165	-	+	+	+											
47	Ahluwalia	1997	USA	RC	13497	-	+			+			+			+			+	AL,ET,MS,PR, WG
48	Horta	1997	Brazil	RC	5166	-	+			+[j]	+	+[j]				+[j]	+			BI,MS[j],PB,PC, SC[j]
49	Dejin-Karlsson	1998	Sweden	PC	575	-				+[j]	+[j]	+[j]				+[j]				MN[j]
50	Janghorbani	1998	Iran	RC	702	-	[k]													
51	Nafstad	1998	Norway	CC	122	No														
52	Peacock	1998	UK	PC	818	No	+	+	+		+									
53	Hanke	1999	Poland	RC	1751	No	+[j]		+[h]	+	+							+[j]		MS[j]

APPENDIX A : Further details of studies (Continued/2)

Ref	Author	Year	Location	Study type[a]	Sample size[b]	Dose-resp.[c]	Confounders accounted for[d] PA	SX	GE	MA	MH	MW	MB	PH	PW	PE	SES	EM	AC	Others[d]
54	Sadler	1999	USA	PC	2283	No	+	+	+[h]	+			+			+		+[h]	+[h]	ET,HT,MS[h],PB, PD[h],PE,PM,RE, WG,XS
55	Windham	1999	USA	RC	992	No			+[h]										+	CC,ET
56	Haug	2000	Norway	RC	16430	-				+										
57	Hrubá	2000	Czech Republic	RC	1097	-														
58	Matsubara	2000	Japan	PC	6335	No	+	+	+[l]	+	+		+			+		+	+	
59	Windham	2000	USA	PC	4454	No	+			+[h]			+			+			+[h]	CC[h],ET,LE,MS[h]
60	Jaakkola	2001	Finland	RC	389	No	+	+		+			+				+	+	+	MS
61	Mitchell	2002	New Zealand	CC	1248	-	+	+	+	+	+	+				+		+		HT,MF,MJ,MS

[a] CC = case control, PC = prospective cohort (i.e. smoking and ETS data obtained before birth), RC = retrospective cohort (i.e. data obtained after birth)

[b] Sample size is of nonsmoking mothers except for studies which included smoking mothers in the analysis where sample size is of all mothers

[c] Yes = significant dose response seen, No = dose response investigated but not significant, - = dose response not investigated

[d] Abbreviations used for main confounders:
PA = parity/previous pregnancies/birth order, SX = sex of child, GE = gestation time at delivery, MA = maternal age, MH = maternal height, MW = maternal weight, MB = maternal body mass, PH = paternal height, PW = paternal weight, PE = parental education, SES = socioeconomic status/income, EM = employment status, AC = alcohol consumption
Abbreviations used for other confounders:
AB = previous abortions, AL = altitude, BI = birth interval, BP = birth place of mother, CB = coal burning, CC = coffee consumption of mother, CK = cooking time spent, CP = complications of pregnancy/illness of mother, CX = chemical exposures of parents, DI = diet of mother, ET = ethnicity/race, GR = gestational week at report of pregnancy, HT = hypertension, LE = life events, MD = medical history of mother, MF = maternal age first pregnancy, MJ = marijuana use of mother, MM = maternal medication use in pregnancy, MN = maternal nationality, MS = marital status, PB = previous birthweights, PC = prenatal care, PD = placental disorders, PE = preeclampsia/eclampsia, PM = passive marijuana, PP = pregnancy planned, PR = place of residence, PT = preterm birth, RE = religion, RH = reproductive history, SB = previous still births, SC = skin colour, WG = weight gain in pregnancy, XS = past smoking

[e] Only accounted for in analyses of low birthweight

[f] Only accounted for in analyses of birthweight percentile decrement

[g] Maternal and paternal height were considered as a single variable

[h] Only accounted for in analyses of birthweight decrement

[j] Only accounted for in analyses of small-for-gestational-age

[k] Multivariate analyses carried out but inappropriately included variables such as cranial circumference and length at birth so only unadjusted analyses included in Table 2

[l] Only accounted for in analyses of low birthweight and birthweight decrement