Effects of Maternal Smoking while Pregnant on Child Outcomes in Adolescence: Results from a Prospective National Longitudinal Study

Charles Jones, *University of Toronto*

Revised April 16 2008

There is a large body of research on the effects of fetal and neonatal events on adolescent and adult outcomes. This paper uses data from a recent prospective and nationally representative longitudinal study in Canada. Focusing on outcomes reported by ten to fourteen-year old children our results clearly demonstrate significant long-term effects of maternal smoking during pregnancy. Adolescents whose mothers had smoked while pregnant with them had worse scores on six out of seven self-report scales measuring both externalizing and internalizing disorders, including anxiety, self-image, general mood, hyperactivity and physical aggression. These effects remain significant after controlling for birth weight, and whether the child was breastfed but disappear when an index of exposure to parental smoking during childhood is controlled through statistical adjustments. Further analysis demonstrates significant regional differences in maternal smoking during pregnancy as well as a secular trend towards a lesser incidence over the 1990s. Implications for provincial health policies are discussed.

Topic to be Studied

A growing literature on the statistical linkages between maternal smoking during pregnancy and subsequent child and adolescent outcomes complements published research on other established risk factors such as low birth weight, premature delivery and family structure. This paper reports on analysis of data from a nationally representative sample of children in Canada, a country where health care is primarily a provincial jurisdiction, though the federal government has developed a role in the maintenance of minimum cross-Canada standards as well as in health promotion.

Theoretical Focus

The 'fetal origins' hypothesis states that many adult outcomes (diabetes, heart disease, hypertension, weight problems, fatigue, susceptibility to illness, and certain social behaviours) have their origins before birth (Barker, 1998, 2003). This general hypothesis has been questioned in some areas (Huxley et al., 2002) but to the extent that it is valid it suggests that much of the inequality observed between adults reflects previous economic and social inequalities during their time in the womb: a narrative that has clear policy consequences. Classic indicators of a problematic fetal environment include premature birth and low birth weight as well as likely causes, such as maternal malnutrition, alcohol abuse, smoking or consuming other harmful drugs during pregnancy. Since these indicators are more common in working class or otherwise deprived social groups it is arguable that social background could be a common cause both of problematic fetal environments and of subsequent unfavourable child, adolescent and adult outcomes. On the other hand there are animal model studies that suggest the existence of biological /

physiological pathways by which exposure to noxious substances *in utero* has impacts on the physiology of the fetus (King et al. 2003). The most important theoretical issues are linked to the ways in which biological / physiological explanations should be preferred to sociological ones (Maughan et al., 2001).

Introduction and Literature Review

There is a growing literature on the effects of maternal smoking during pregnancy upon child outcomes. Recent reviews have been published by Wakschlag et al. (2002) and by Pratt et al. (2006). O'Keane and Scott (2005) point to maternal anxiety during pregnancy as an important causal factor for subsequent childhood, adolescent and adult outcomes.

Maughan et al. (2001) used the 1958 British birth cohort study (the National Child Development Study, NCDS) to demonstrate the relationship between smoking during pregnancy and subsequent childhood conduct problems, and showed that smoking significantly predicts some aspects of antisocial behaviour in 16 year olds. They argue that the relationship between the mother's prenatal smoking and the child's later conduct was mediated by long term exposure to smoking. They found smoking in pregnancy to be strongly associated with poor maternal education, early childbearing, drinking during pregnancy, family instability, social disadvantage, maternal malaise, and subsequent maternal smoking (ibid: 1023).

Data and Research Methods

Our major research questions are modest. We wish to establish the extent to which smoking during pregnancy and other factors such as low birth weight are prospectively correlated with child-reported outcomes a decade later in a nationally representative survey carried out recently in Canada. Subsidiary objectives include determining the prevalence and correlates of maternal smoking during pregnancy and early childhood.

Description of the NLSCY

The first wave of Canada's National Longitudinal Survey of Children and Youth (NLSCY) took place in 1994-1995 and was a nationally representative sample of children from newborns through eleven-year olds. Follow-up surveys took place in 1996-1997 (children up to age thirteen), and 1998-1999 (children up to age fifteen). The fourth wave (cycle) was administered in 2000-2001 for children up to age seventeen: the fifth wave in 2002-2003; and the sixth wave in 2004-2005. Statistics Canada intends to continue the follow-up survey every two years. The main sample is drawn from Canada's ten provinces. The NLSCY collects much of the data about children and their families from the "person most knowledgeable" (PMK) about the child (in 90 per cent of cases, the child's mother). Proxy responses were permitted about the characteristics of the spouse or partner in Cycle 1 but after that he or she provided her or his own data about education, occupation and income. The survey also collected data from schoolteachers and school principals but this has been abandoned because of low rates of cooperation. Children aged ten and over provide data from self-completion questionnaires and it is data from this source that form the dependent variables in this study. Geographical location is provided through the household postal code and this allows linkage to small area statistics from the Census. A series of papers resulting from cross-sectional analysis of

the first cycle of the NLSCY was published six years after the data had been collected (Willms, 2002).

The NLSCY asks numerous questions about the mother's pregnancy and the child's neonatal and perinatal periods, including questions about hospitalizations, low birth weight, prematurity of birth, fussy temperament, the age of the child's biological mother when the child was born (maternal age) and whether or not the mother experienced post-partum depression. In order to reduce recall bias, such questions are only asked with respect to the births of children less than two or in some cases three years of age at the time of the interview. Children who were under two at Cycle 1 of the NLSCY were between ten and twelve at Cycle 6 while those in their third year at Cycle 1 were in their thirteenth in 2004-5.

Independent Variables

Gender of the Child

We used gender as recorded at Cycle 1 and report it as the effect of being female.

Age of the child at the time of the Cycle 6 interview. This was recorded as age in months but the effects of age are reported as the effect of an extra year. The range is from 10 to somewhat over 12 years of age[1].

Low Birth weight

This was obtained from the "persons most knowledgeable" (PMK) of children up to three years old at their last birthday at Cycle 1. A child was deemed to have low birth weight if the PMK reported a birth weight below 2,400 grams. For cycle 1 children in the 0 to 3 age group 5.7% were of low birth weight. This includes the 0.8% who were of very low birth weight (less than 1500 grams. It is a general weakness of the NLSCY that important measures that might have been taken from medical records were obtained through questions addressed to the PMK. For this variable at least the weakness is counterbalanced by the fact that Statistics Canada took considerable care at the editing stage. "The records for children with very low birth weights … were examined to verify that the response was legitimate. Other variables considered in the edit were the length of the baby at birth, the number of days early of the delivery, the conditions of the delivery (e.g., multiple birth and special medical care) and the health of the child at birth. If there was nothing to corroborate the low birth weight it was set to not-stated." (Statistics Canada: Cycle 1 Overview). Given this editing, children coded as having low birth weight had also been identified as having other problematic characteristics at birth. Children whose birth weight was coded as "not stated" were excluded from data analysis, as were those aged four years or older at Cycle 1.

Fetal Exposure to Maternal Smoking and other Maternal Substance Use.

---

[1] Age at the interview date is to be distinguished from "effective age": a conceptually distinct variable that is used to determine the questions that will be asked about or of the child. This is done to ensure the child stays in the age group to which he/she is assigned regardless of whether collection takes place before or after the youth's birthday. For Cycle 6, the effective age is calculated as 2004 minus year of birth. For example a child born in 1994 would have an effective age of 10 years old (2004-1994). Note that the actual age of the youth at the time of the interview is sometimes different from the effective age

Smoking and alcohol consumption during pregnancy data were obtained from the PMKs of children up to two years old at their last birthday at Cycle 1. The PMK was asked if the mother smoked during pregnancy and, if so, about the number of cigarettes smoked in a typical day during the pregnancy, as well as the stages of pregnancy at which she smoked. Smoking was reported during their pregnancy for about 22% of children and this did not change significantly by trimester. The PMK was also asked if the mother drank alcohol or took prescription or non prescription drugs during her pregnancy. According to the PMK reports only 17.5% of children had their mothers drink at all during pregnancy and only 3.6% drank more than once a month. Of those children whose mothers drank while pregnant 94.4% had mothers who reported that they confined themselves to one or two drinks on those days they consumed alcohol. Less than one per cent of children had mothers who reported having more than 3 drinks on the days they consumed alcohol. For each of drinking alcohol, consumption of prescription or over the counter drugs and smoking we constructed a variable where the mother's score was the number of trimesters in which she reported each of drinking, smoking etc. We have scaled this to zero or 1.0 with values of .33 and .66 reflecting the exposure of children whose mothers consumed each substance in one or two out of the three trimesters.

Childhood Exposure to Parental Smoking

Each of the six waves of the survey included questions to the Person Most Knowledgeable about the child (usually the mother or mother-figure) about whether she smoked and whether her partner (if any) smoked. Adding up the number of "yes" answers yields a count with a minimum score of zero and a maximum score of six for each of the PMK and his or her partner. We use this as an indicator of the child's exposure to parental smoking.

Single Parent status of the PMK at Cycle 1

This is coded as a simple dichotomy.

Age of the biological mother at the birth of the child

This is coded as under 25 against 25 or over.

Immigration status of the mother

The reference category here is "not an immigrant" and the other categories are, "first immigrated to Canada less than five years ago", "first immigrated five to nine years ago" and "first immigrated to Canada ten or more years ago".

Whether or not the child was ever breastfed.

This is coded as a simple dichotomy. Around 77% of children had been breastfed for one week or more.

Dependent Variables

These consist of multiple item scales that have been used in previous research and have good scores on Cronbach's Alpha which is a measure of internal consistency. Response categories for the constituent items were: Never or not true; Sometimes or somewhat true; Often or very true: these being weighted 0, 1 and 2 respectively and summed to form the scale scores.

Symptoms of Internalizing Disorders.

Anxiety and Emotional Disorder Scale (self completion in Cycle 6). Asked of respondents 10 to 15 years old. High scores indicate behaviour associated with anxiety. Cronbach's Alpha ranges from 0.71 to 0.75 over three age-groups. There are seven items as follows:

I am unhappy or sad.

I am not as happy as other people my age.

I am too fearful or nervous.

I worry a lot.

I cry a lot.

I am nervous, high-strung or tense.

I have trouble enjoying myself.

The Anxiety and Emotional Disorder scale scores ranged from zero to a theoretical maximum of 14. The modal score was zero, reflecting the fact that most respondents reported that these statements were, "never or not true".

General Self-Image Scale (self completion in Cycle 6). Asked of respondents 10 to 17 years old. High score indicates positive general self image. Cronbach's Alpha ranges from 0.79 to 0.86 over four age-groups. There are four items as follows:

In general, I like the way I am.

Overall I have a lot to be proud of.

A lot of things about me are good.

When I do something, I do it well.

General Mood (self completion in Cycle 6). Asked of respondents 10 to 17 years old. A high score indicates a higher level of self-motivation. Cronbach's Alpha ranges from 0.67 to 0.70 over four age-groups. There are three items as follows:

It is easy to tell people how I feel.

I hope for the best.

I enjoy the things I do.

Symptoms of Externalizing Disorders

There were four multi-item scales completed by children aged 10-15 years of age. Except for the Inattention/Hyperactivity scale, the modal scale scores were zero, reflecting the fact that the overwhelming majority of respondents reported that each of these behaviours was, "rarely true of me".

Property Offences Scale (self completion in Cycle 6). Six items. Asked of respondents 10 to 15 years old. High scores indicate the presence of behaviours associated with property

offences. Cronbach's Alpha ranges from 0.63 to 0.71 over three age-groups. There are six items as follows:

I destroy my own things.

I steal at home.

I destroy things belonging to my family or other young people.

I tell lies or cheat.

I vandalize.

I steal outside my home.

Further self completion scales for externalizing disorders were as follows.

Conduct Disorder / Physical Aggression (self completion in Cycle 6). Asked of respondents 10 to 15 years old. High scores indicate the presence of behaviours associated with conduct disorders and physical aggression. Several items are taken from the Montreal Longitudinal Study. Cronbach's Alpha ranges from 0.76 to 0.80 over three age-groups. There are six items as follows:

I get into many fights.

I physically attack people.

I am cruel, bully or am mean to others.

I assume, when another kid accidentally hurts me (such as by bumping into me), that the other kid meant to do it, and then I react with anger and fighting.

I kick, bite, hit other people my age.

Indirect Aggression (self completion in Cycle 6). Asked of respondents 10 to 15 years old. High scores indicate behaviours associated with indirect aggression. Cronbach's Alpha ranges from 0.71 to 0.75 over three age-groups. There are five items as follows:

I try, when I am mad at someone, to get others to dislike him/her.

When I am mad at someone, I become friends with another as revenge.

When mad at someone, I say bad things behind his/her back.

When mad at someone, I say to others: let's not be with him/her.

When mad at someone, I tell the other one-s secrets to a third person.

Inattention (Hyperactivity) Disorder (self completion in Cycle 6). Asked of respondents 10 to 15 years old. Cronbach's Alpha ranges from 0.76 to 0.80 over three age-groups. There are seven items as follows:

I can't sit still, am restless or hyperactive.

I fidget.

I can't concentrate, can't pay attention.

I am impulsive, act without thinking.

I have difficulty awaiting my turn in games or groups.

I cannot settle to anything for more than a few moments.

I am inattentive, have difficulty paying attention to someone.

Data Analysis

We fitted the cumulative logit model using PROC LOGISTIC and PROC SURVEYLOGISTIC in the SAS package. This is effectively a kind of "ordinal regression" where the estimated coefficients are to be interpreted as the increase in the log of the odds that a respondent will be in the next highest category of the dependent variable (Allison, 1999). Where the higher or lower end of the distribution for one of the dependent variables showed small numbers of cases in the response categories those adjacent categories were merged together in order that stable estimates of the coefficients could be estimated (ibid). The Property Offences score has small numbers of cases in the intervals above 4 so these were combined into a highest category that was coded 5. Similarly the Anxiety and Emotional Disorder scale had small numbers of cases in the intervals above 10 so these were combined into a highest category that was coded as 11. In the same way the General Self Image score had few cases in the intervals below 6 so these were combined into a lowest category that was coded 5.

Being based on the Labour Force Survey's sampling frame the NLSCY has a disproportionately stratified design that over-samples rural areas and certain small provinces. To correct for this, as well as to introduce post-stratification adjustments, we used the "longitudinal weight" calculated by Statistics Canada. Post-stratification adjustments are important because they correct for biases introduced by sample attrition which had become quite significant (loss of 24.3% of the original panel) by Cycle 6. The weight was normalized to the actual sample size so that tests of statistical significance were unaffected. Using PROC SURVEYLOGISTIC specifying 50 sampling strata allowed us to get take account of the sample design in order to get better estimates of standard errors. These turned out to be slightly higher than those estimated with PROC LOGISTIC with the result that some effects that were highly significant without taking account of the sample design were less highly significant or even non-significant when the data analysis was more sophisticated.

Findings

PMK-reported alcohol consumption was unrelated to adolescent mental health outcomes. However our results clearly demonstrate significant long-term effects of maternal smoking during pregnancy on seven outcomes reported by ten to twelve-year olds.

We begin by reporting the simplest associations between our predictor variables and the mental health scales based on self-reports by children ten years and older. Analysis with PROC LOGISTIC shows the strongest statistically significant associations with each outcome measure to be as follows:

General Self-Image: fetal exposure to smoking.
General Mood: fetal exposure to smoking; mother under 25 at birth of the child.

Anxiety/Emotional Disorder: childhood exposure to smoking; mother under 25 at birth of the child

Inattention/Hyperactivity: gender; childhood exposure to smoking: mother under 25 at birth of the child.

Indirect Aggression; childhood exposure to smoking.

Physical Aggression: gender, childhood exposure to smoking

Property Offences: gender; fetal exposure to smoking.

It is quite striking that either fetal or childhood exposure to parental smoking recur as predictors of these outcomes. Other predictors that were associated more weakly or not at all with these outcome measures include such classic indicators of social disadvantage as low birth-weight, single parent status of the child at the first wave of the follow-up survey, immigration status of the child's mother and whether the child was breastfed for one week or longer.

More extensive analyses are shown in tables 1 and 2.

Table 1 shows the estimated effects of fetal exposure to maternal smoking with controls only for gender and the age of the child (in months) at which he or she completed questionnaires at cycle 6 of the survey. These estimates were obtained from PROC SURVEYLOGISTIC that takes account of the sample design. Only one of the seven outcome measures is unrelated to fetal exposure to tobacco smoke, this being Indirect Aggression: however all seven of them are significantly associated with childhood exposure to parental smoking, albeit that in the case of Indirect Aggression again, the association is relatively weak, being only just significant at the conventional 5% level.

Fetal exposure to maternal smoking is prospectively related to General Self-Image and General Mood as well as to Property Offences at well beyond the .001 level of significance. The directions of the effects are consistent with this exposure being associated with negative outcomes. Fetal exposure to maternal smoking also increases adolescent anxiety, Inattention/Hyperactivity and Physical Aggression, these effects being significant at the 0.01 level.

Table 2 introduces further controls and shows results from two predictive models. Model 1 predicts adolescent mental health outcomes using from maternal smoking and other covariates (birth-weight, age of the mother at the birth of the child, immigration status of the mother, and whether the child was breast-fed for one week or more) measured at the first wave of the longitudinal survey. Adolescents whose mothers had smoked while pregnant with them had significantly worse scores on six of the seven self-report scales measuring both externalizing and internalizing disorders, including anxiety, self-image, general mood and two of the three forms of aggression. As noted above, the exception was indirect aggression which has no relationship fetal exposure to maternal smoking. These effects are small in size but this is to be expected, given that we are establishing a relationship between adolescents' scores on self-completion scales and what their mothers were doing more than ten years previously.

Model 2 includes the same predictors as Model 1 but adds a measure of the child's total exposure to maternal smoking from birth to the final interview date. After this control variable has been introduced the estimated effect of fetal exposure becomes non-significant at the 5% level for five out of the seven outcome measures, leaving only Self Image and General Mood still significantly associated with it. Childhood exposure remains significantly related only to the Inattention/Hyperactivity self-completion scale.

This is consistent with the view that maternal smoking during pregnancy and parental smoking after it are measuring broadly similar things since, given the addictive nature of smoking it is unlikely that significant proportions of mothers would smoke during pregnancy only to give it up afterwards. We examined this by taking the 411 children whose mothers smoked during pregnancy and estimating the percentage of cases where the mother smoked either "daily" or "occasionally" at each of the subsequent waves of the follow-up. At the first wave of the survey the figure was 95% and this gradually declined at each of the roughly two-year intervals between waves so that at wave 2 the figure was 90%, at wave 3 it was still 90%, at wave 4 it was 84%, at wave 5 it was 80% and by wave 6 had declined to 73%. Looking at the relationship between fetal and childhood exposure in another way, only three per cent of children whose biological mothers smoked while pregnant with them were brought up by a PMK who never smoked at any of the cycles of the survey, while 60 per cent of them were raised in households where the PMK smoked "daily" or "occasionally" at all six cycles. In similar fashion 79 per cent of children who had no fetal exposure to maternal smoking were raised by a PMK who did not smoke in any of the cycles of the follow-up, while only three per cent of them had the highest score on childhood exposure.

Taken overall these findings are consistent with those reported by Maughan et al. (2001) with data from the 1958 British birth cohort study. A mother's prenatal smoking is indeed correlated with the child's later long term childhood exposure to smoking and, as we have seen, controlling for the latter markedly reduces the estimated effect of the former. While the data themselves do not permit us to establish whether prenatal or postnatal exposure to smoking is the causal agent that affects adolescent mental health there is a stronger basis in animal and other physiological studies for the belief that prenatal exposure should be more important than postnatal exposure.

Further analysis (not shown) demonstrates significant provincial differences in maternal smoking during pregnancy as well as a gradual secular trend towards a lesser incidence over the decade from 1994-5 tot 2004-5. Comparing successive cohorts the percentage of children under two who had been exposed to maternal smoking before birth declined fairly smoothly from 24 per cent in 1994-95 17 per cent in 2004-2005. Using Ontario as a reference point, children from Quebec have significantly greater odds of exposure to maternal smoking before birth while those from British Columbia have lesser odds. Exposure to maternal smoking *in utero* is statistically associated with indicators of social disadvantage including lower household income, being in a single parent family, having a mother with a low level of years of schooling and having a mother who gave birth under age 25. As compared with children of parents born in Canada or with the children of longer established immigrants the children of recent immigrants have markedly lower

odds of being exposed to maternal smoking before birth. Since this is independent of the effects of parental years of schooling, age of the mother at the birth of the child, lone parent status and income adequacy we may need to explore cultural explanations. A parallel analysis predicting the odds that a child had a PMK (usually the mother) who smoked reveal a similar pattern though, in this case, the effects of province become non-significant after family-level predictors have been introduced. From a policy perspective this paper suggests that at least some provinces should devote extra efforts to create a climate of opinion that makes it as socially unacceptable for mothers to smoke during pregnancy as it is for them to consume alcohol.

Bibliography

Allison, Paul D. Logistic Regression Using the SAS System: Theory and Applications. Cary NC: The SAS Institute. 1999.

Al Mamun, A., F. V O'Callaghan, R. Alati, M. O'Callaghan, J. M Najman, G. M Williams, and W. Bor. 2006. Does maternal smoking during pregnancy predict the smoking patterns of young adult offspring? A birth cohort study. Tobacco Control, December 1, 2006; 15(6): 452 - 457.

Barker, David. Mothers, Babies and Health in Later Life. Elsevier. 1998. There is a second edition.

Barker, David. 2003. Fetal origins: biological basis and size of effects. Second World Congress on Fetal Origins of Adult Diseases. Brighton UK. June 2003.

Belsky, Jay. 2001. "Emanuel Miller Lecture. Developmental Risks (Still) Associated with Early Childcare." Journal of Child Psychology and Psychiatry 42(7), pp. 845-859

Bennett K.E. and M.P. Haggard. 1999. "Behaviour and cognitive outcomes from middle ear disease". Archives of Disease in Childhood 80(1): 28-35.

Bentley T. and R. Gurumurthy. Destination Unknown. London: Demos. 1999.

Cooper C., D. Kuh, P. Egger, M. Wadsworth and D Baker, 1996. "Childhood Growth and Age at Menarche". British Journal of Obstetrics and Gynaecology 103: 814-817.

Button, T.M.M., A. Thapar and P. McGuffin. 2005. Relationship between antisocial behaviour, attention-deficit hyperactivity disorder and maternal prenatal smoking
Br. J. Psychiatry, August 1, 2005; 187(2): 155 - 160.

Currie, Janet and Rosemary Hyson. 1998. "Is the Impact of Health Shocks Cushioned by Socio-Economic Status? The Case of Low Birth weight." UCLA and NBER. Draft of December 1998.

DiFranza, J.R., C. A. Aligne, and M. Weitzman. 2004. Prenatal and Postnatal Environmental Tobacco Smoke Exposure and Children's Health. Pediatrics, April 1, 2004; 113(4/S1): 1007 - 1015.

Ferri E. 1998. "Forty Years On: Neville Butler and the British Cohort Studies". Paediatric and Perinatal Epidemiology 12, supp.1: 31-44.

Ferri, Elsa, John Bynner and Michael Wadsworth (Eds.) 2003. Changing Britain, Changing Lives: Three Generations at the Turn of the Century. London: Institute of Education. 2003.

Fombonne E. 1995. "Depressive disorders: Time trends and possible explanatory mechanisms". In M. Rutter and D. Smith (Eds.) Psychosocial Disorders in Young People. Chichester: Wiley.

Frisch, R. E., and R. Revelle. 1970. "Height and weight at menarche and a hypothesis of critical body weights and adolescent events". Science 169, 397-399.

Guo, Guang and Kathleen M. Harris. 2000. "The Mechanisms Mediating the Effects of Poverty on Children's Intellectual Development." Demography, 37: 431-47.

Hardy R, M. Wadsworth and D. Kuh. 2000. "The influence of childhood weight and socioeconomic status

on change in adult body mass index in a British national cohort". International Journal of Obesity 24: 725-34.

Hardy R. and M. Wadsworth. 2001. "The British Birth Cohort Studies: Childhood influences on adult life". American Statistical Association's 2000 Proceedings of the Section on Government Statistics and Section of Social Statistics: 28-34.

Hofhuis, W., J C de Jongste, and P J F M Merkus. 2003. Adverse health effects of prenatal and postnatal tobacco smoke exposure on children. Arch. Dis. Child., December 1, 2003; 88(12): 1086 - 1090.

Hotopf, M., C. Wilson-Jones, R. Mayou, M. Wadsworth and S. Wessely. 2000. "Childhood Predictors of Adult Medically Unexplained Hospitalizations: Results from a National Birth Cohort Study". British Journal of Psychiatry 176: 273-280.

Human Resources Development Canada and Statistics Canada. 1997. Special Surveys: National Longitudinal Survey of Children and Youth. User's Handbook and Microdata Guide. Cycle 1. Catalogue no. 89M0015GPE. Ottawa, Ontario.

Huxley, Rachel, Andrew Neil and Rory Collins. 2002. "Unravelling the fetal origins hypothesis: is there really an inverse association between birth-weight and subsequent blood pressure?" Lancet 360: 659-65

Jefferis H., C. Power and C. Hertzman. 2002. "Birth weight, childhood socioeconomic environment, and cognitive development in the 1958 British birth cohort study". British Medical Journal 325: 305-305.

Jones P., B. Rodgers, R. Murray and M. Marmot. 1994. "Child developmental risk factors for adult schizophrenia in the British 1946 birth cohort". Lancet 344: 1398-1402.

King, S. L., M. J. Marks, S. R. Grady, B. J. Caldarone, A. O. Koren, A. G. Mukhin, A. C. Collins, and M. R. Picciotto. 2003. Conditional Expression in Corticothalamic Efferents Reveals a Developmental Role for Nicotinic Acetylcholine Receptors in Modulation of Passive Avoidance Behavior. J. Neurosci., May 1, 2003; 23(9): 3837 – 3843

Kuh D., R. Hardy, N. Chaturvedi and Michael E.J. Wadsworth. 2002. "Birthweight, childhood growth and abdominal obesity in adult life". International Journal of Obesity 26:40-7.

Layard, Richard (Lord). 2005a. Happiness: Lessons from a New Science. London: Penguin.

Layard, Richard (Lord). 2005b. "Mental Health: Britain's Biggest Social Problem?" Appendix to Richard Layard Happiness: Lessons from a New Science. London: Penguin. [Appendix available online at: http://www.strategy.gov.uk/downloads/files/mh_layard.pdf

Linnet, K.M., K. Wisborg, C. Obel, N. J. Secher, P. H. Thomsen, E. Agerbo, and T. B. Henriksen. 200-5. Smoking During Pregnancy and the Risk for Hyperkinetic Disorder in Offspring. Pediatrics, August 1, 2005; 116(2): 462 - 467.

Lucas A. Fewtrell M. and T.J. Cole. 1999. "Fetal Origins of Adult Disease – the hypothesis revisited". British Medical Journal 319:245-249.

Lummaa, Virpi, Jenni E. Pettay and Andrew R. Russell. 2007. "Male Twins Reduce Fitness of Female Co-Twins in Humans". Proceedings of the National Academy of Sciences. 104: 10915-10920

Massey, Douglas S. 2004. "Segregation and Stratification: A Biosocial Perspective." The Du Bois Review: Social Science Research on Race 1(1), pp. 1-19.

Maughan B., C. Taylor and A. Taylor. 2001. "Pregnancy Smoking and Childhood Conduct problems: A causal association?" Journal of Child Psychology and Psychiatry and Allied Disciplines 42(8): 1021-1028.

Maughan, B., A. Taylor, A. Caspi, and T. E. Moffitt. 2004. Prenatal Smoking and Early Childhood Conduct Problems: Testing Genetic and Environmental Explanations of the Association. Arch Gen Psychiatry, August 1, 2004; 61(8): 836 - 843.

McGloin, J. M., T. C. Pratt, and A. R. Piquero. 2006. A Life-Course Analysis of the Criminogenic Effects of Maternal Cigarette Smoking During Pregnancy: A Research Note on the Mediating Impact of Neuropsychological Deficit. Journal of Research in Crime and Delinquency, November 1, 2006; 43(4): 412 - 426.

Moffitt, Terrie E., Michael Rutter, Phil A. Silva. Sex Differences in Antisocial Behavior: Conduct Disorder, Delinquency and Violence in the Dunedin Longitudinal Study Cambridge University Press. 2001.

O'Connor, T.G., J. Heron, J. Golding, et al. 2002. Maternal antenatal anxiety and children's behavioural/emotional problems at 4 years: report from the Avon Longitudinal Study of Parents and Children. British Journal of Psychiatry, 180, 502 -508.

O'Keane, Veronica and Jan Scott. 2005. From 'obstetric complications' to a maternal–fetal origin hypothesis of mood disorder. The British Journal of Psychiatry (2005) 186: 367-368.

Paradise J. L. 1992. "Does early-life otitis media result in lasting developmental impairment? Why the question persists and a proposed plan for addressing it". Advanced Pediatrics 39:157-65.

Pless I.B., H.A. Cripps, and J.M.C. Davies. 1989. "Chronic Physical Illness in Childhood and Psychological and Social Circumstances in Adolescence and Early Adult Life". Developmental Medicine and Child Neurology, 31: 905-916.

Power C. and S. Matthews. 1997. "Origins of Health Inequalities in a National Population Sample". Lancet 350:1584-1589.

Pratt, T. C., J. M. McGloin, and N. E. Fearn. 2006. Maternal cigarette smoking during pregnancy and criminal/deviant behavior: a meta-analysis. Int. J. Offender Ther. Comp. Criminol., December 1, 2006; 50(6): 672 – 690.

Richards M. R. Hardy, D. Kuh and M.E. Wadsworth. 2001. "Birth weight and cognitive function in the British 1946 birth cohort: longitudinal population based study". British Medical Journal 322:199-203.

Richards M, R. Hardy, D. Kuh and M.E. Wadsworth. 2002. "Birthweight, postnatal growth and cognitive function in a national UK birth cohort". International Journal of Epidemiology 31(2): 342-348.

Rodgers B. 1990. "Behaviour and personality in childhood as predictors of adult psychiatric disorder". Journal of Child Psychology and Psychiatry 31: 393-414.

Rodgers B. 1994. "Pathways between Parental Divorce and Adult Depression". Journal of Child Psychology and Psychiatry 35: 1289-1308.

Wakschlag, Lauren S., Kate E. Pickett, Edwin Cooke Jr., Neal L. Benowitz and Bennett L. Leventhal. 2002. Maternal Smoking during Pregnancy and Severe Antisocial Behaviour in Offspring: a review. American Journal of Public Health, Vol 92, No. 6: 966-974 June 2002.

Wadsworth Michael E.J. 1987. "Follow-up of the first British National Birth Cohort: findings from the MRC National Survey of Health and Development" Paediatric and Perinatal Epidemiology 1: 95-117.

Wadsworth Michael E.J. 1991. The Imprint of Time: Childhood, History and Adult Life. Oxford: Oxford University Press.

Willms, J. Douglas. (Ed.) Vulnerable Children: Findings from Canada's National Longitudinal Survey of Children and Youth. University of Alberta Press. 2002.

Table 1.
Relationships between Children's early exposure to cigarette smoke
and their mental health at ages 10-14 years

Simple Effects controlling only for Gender and age in months at cycle 6

Dependent Variables:	Model 1 Fetal Exposure b	Prob	Model 2 Childhood Exposure b	Prob	N of Cases
Self-Image	-0.618	0.0001	-0.08	0.002	2006
General Mood	-0.492	0.008	-0.053	0.04	1949
Anxiety	0.376	0.01	0.071	0.0001	1883
Inattention/Hyperactivity	0.375	0.01	0.09	0.0001	1877
Indirect Aggression	0.223	ns	0.058	0.04	1924
Physical Aggression	0.393	0.01	0.0781	0.0001	1906
Property Offences	0.615	0.0003	0.101	0.0004	1890

Results from PROC SURVEYLOGISTIC, using the longitudinal weight

Childhood exposure to smoking is the number of waves at which the PMK smoked (0 to 6)
Fetal exposure to smoking is the number of trimesters in which the mother
smoked and takes values 0, 0.33, 0.66, 1.0
Almost all the mothers who reported smoking during the 1st trimester
        also reported smoking during 2nd & 3rd trimesters.

Table 2 — Effects with Many Controls

Dependent Variables:	Model 3 Fetal exposure only Fetal Exposure b	Prob	Model 4 Both fetal and childhood exposure Fetal Exposure b	Prob	Childhood Exposure b	Prob
Self-Image	-0.521	0.001	-0.549	0.01	-0.007	ns
General Mood	-0.391	0.009	-0.560	0.01	-0.039	ns
Anxiety	0.301	0.05	0.140	ns	0.039	ns
Inattention/Hyperactivity	0.297	ns	0.085	ns	0.089	0.02
Indirect Aggression	0.190	ns	0.075	ns	0.064	ns
Physical Aggression	0.382	0.026	0.133	ns	0.059	ns
Property Offences	0.522	0.002	0.351	ns	0.039	ns

Other predictors used in models 3 and 4 (not shown) include child's age & gender at cycle 6
single parent status, low birth-weight and whether the child was breastfed.
as well as age of the mother at the child's birth and her recency of immigration.

Results from PROC SURVEYLOGISTIC, using the longitudinal weight