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Prenatal and Postnatal Exposure to Environmental Tobacco Smoke and Children's Cognitive and Non-cognitive Skills[*]

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Abstract

This study explores the effects of prenatal and postnatal exposure to environmental tobacco smoke (ETS) on cognitive and non-cognitive skills of children. We account for an extensive set of controls and evaluate the robustness of the estimation results to omitted variable bias using the coefficient stability approach. Our results show that prenatal and postnatal exposure to ETS significantly increases the percentile scores of internalizing behavior problems (e.g., depression, anxiety), externalizing behavior problems (e.g., aggression, impulsivity), and attention deficit hyperactivity disorder (ADHD) at ages 5-7. The early exposure to ETS also decreases percentile scores in standardized cognitive skills tests and school grades.

Keywords:

Environmental tobacco smoke; cognitive skill; non-cognitive skill; prenatal; postnatal; coefficient stability approach

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JEL Classification: I10, I12, I18

1. INTRODUCTION

Protecting children from harmful environments and supporting their healthy development are critical social challenges. These are especially important because conditions experienced early in life can have not only short-term but also long-term effects on a child's life. Numerous studies have provided evidence that negative experiences from prenatal to childhood can have substantial long-term impacts (Almond & Currie, 2011; Currie & Almond, 2011; Almond, Currie, & Duque, 2018). One harmful environment that poses a constant threat to children is exposure to smoking. According to the Panel Survey on Korean Children (PSKC), 60.3% of mothers were exposed to environmental tobacco smoke (ETS) during pregnancy, and 50.5% of infants were exposed to ETS more than once a week before their first birthday in South Korea. Given the high rate of exposure to secondhand smoke among pregnant women and infants, it is crucial to analyze the effects of ETS exposure in utero and during early childhood on child outcomes. This study aims to estimate the effects of prenatal and early childhood exposure to ETS on children's cognitive and non-cognitive skills.

Although many previous studies have examined the effects of early childhood exposure to ETS on child outcomes, disentangling the effect of early exposure to ETS from the influence of other confounders remains a challenge (Chen, Clifford, Lang, & Anstey, 2013; Eskenazi & Castorina, 1999; Knopik, 2009; Thapar et al., 2003). This difficulty arises because socioeconomic backgrounds of children exposed to ETS in utero and early childhood may systematically differ from those of children who were not exposed, suggesting that developmental characteristics between the two groups could vary even without the influence of ETS exposure. In other words, it is challenging to determine how much of the differences in cognitive and non-cognitive skills between the two groups are attributable to early exposure to ETS, given the presence of confounders. Ideally, a randomized controlled trial would be conducted. However, due to practical and ethical limitations, it is difficult to use experimental methods to study the effects of prenatal and postnatal exposure to ETS on child development, necessitating an alternative approach.

This study estimates the effects of prenatal and postnatal exposure to ETS on cognitive and non-cognitive abilities of children while controlling for a broad range of parental and child characteristics. Unlike previous studies, this research accounts for potential confounders, including experiences during the mother's pregnancy, childbirth, childhood exposure to ETS, household income, financial assets, the mother's emotional status, and parenting knowledge. These variables, which are associated with prenatal and postnatal exposure to ETS in our data, underline the importance of controlling for these

factors. We examine the extent to which controlling for various regressors affects the estimated coefficients, thereby assessing the direction and magnitude of omitted variable bias under the assumption that selection on unobservables can be inferred from selection on observables. Furthermore, we evaluate the robustness of our estimation results to omitted variable bias more formally using the coefficient stability approach (Altonji, Elder, & Taber, 2005; Oster, 2019).

The estimation results indicate that children exposed to ETS in utero and during infancy exhibit more behavioral problems at ages 5-7. Prenatal and postnatal exposure to ETS increases the percentile scores of internalizing problems (e.g., depression, anxiety), externalizing problems (e.g., aggression, impulsivity), and attention deficit hyperactivity disorder (ADHD) measures at age five by 10.03 percentage points, 8.85 percentage points, and 10.01 percentage points, respectively. The effects on externalizing problems and ADHD measures are similarly pronounced at ages 6-7, while the effect on internalizing problems is minor and not statistically significant. Prenatal and postnatal exposure to ETS also decreases the percentile scores of cognitive tests and the probability of achieving the top 20% of grades in the second grade. Exposure to secondhand smoke before age 1 reduces the percentile scores for diagramming and reasoning at age 8 by 10.17 and 8.17 percentage points, respectively. These estimates remain robust with the inclusion of different regressors. The coefficient stability approach by Oster (2019) also suggests that the estimation results are robust to omitted variables bias.

We also explore the differential effects of early exposure to ETS by categorizing exposure before age 1 into three types: (1) fetal exposure to ETS, (2) exposure to ETS between birth and the first birthday, and (3) exposure during both periods. The results show that all three types of exposure negatively affect children's cognitive and non-cognitive skills. However, it is difficult to conclusively determine whether prenatal or postnatal exposure has a greater negative impact on these skills. Additionally, we investigate the heterogeneous effects of ETS exposure before age 1 by exposure frequency, finding that children exposed more frequently to secondhand smoke before age 1 are more likely to exhibit behavioral problems and lower school performance.

This study complements existing medical and child development studies reporting the negative effects of secondhand smoke during prenatal and early childhood periods. Most previous studies have controlled for only a limited number of parental or child characteristics. Our research supports and extends the findings of previous studies that secondhand smoke in childhood negatively impacts child development, as our estimates remain relatively stable when controlling for a wide range of parental characteristics. Furthermore, we demonstrate for the first time that Oster's (2019) coefficient stability test can be applied to research on this topic.

2. PREVIOUS LITERATURE

2.1. Previous literature

Numerous studies have investigated the relationship between early childhood exposure to ETS and behavior problems of children. Many of them find that maternal smoking during pregnancy is a risk factor for ADHD (Braun, Kahn, Froehlich, Auinger, & Lanphear, 2006; Sagiv, Epstein, Bellinger, & Korrick, 2013; Thapar et al., 2003). Maternal smoking during pregnancy is also associated with higher internalizing behaviors (Ashford, Van Lier, Timmermans, Cuijpers, & Koot, 2008; Indredavik, Brubakk, Romundstad, & Vik, 2007), destructive/delinquent behaviors (Hook & Cross, 1988), and externalizing behaviors (Beauchaine, Gatzke-Kopp, & Mead, 2007). There are also studies that report a significant relationship between postnatal ETS exposure and behavior problems (Cho et al., 2013; Luk et al., 2018). Extensive literature has also investigated the effect of prenatal and postnatal exposure to ETS on cognitive abilities of children. Recent studies generally find that maternal smoking during pregnancy reduces the academic achievement and cognitive skills of children (Clifford, Lang, & Chen, 2012). Low birth weight and reduced in-utero brain growth are considered biological mechanisms through which prenatal exposure to ETS affects child neurodevelopment (Herrmann, King, & Weitzman, 2008; Wehby, Prater, McCarthy, Castilla, & Murray, 2011). There are review papers on the relationship between prenatal exposure to ETS and child outcomes including behavior problems (Eskenazi & Castorina, 1999; Tiesler & Heinrich, 2014), health (DiFranza, Aligne, & Weitzman, 2004), and cognitive abilities (Herrmann et al., 2008; Clifford et al., 2012).

Although the extensive literature has documented the negative relationship between prenatal and postnatal ETS and diverse child outcomes, these associations do not necessarily reflect a causal link due to possible omitted confounding factors. As it is difficult to conduct a randomly controlled experiment, removing the influence of confounding factors remains a challenging task (Chen et al., 2013; Eskenazi & Castorina, 1999; Knopik, 2009; Thapar et al., 2003). Recent studies in economics handle the selection problem using quasi-experimental methods (Simon, 2016; Srivastava & Trinh, 2021; Wehby et al., 2011). Simon (2016) investigates the effect of early life exposure to ETS on child health. He uses the difference-in-differences approach exploiting regional variations in excise taxes on tobacco. Srivastava and Trinh (2021) explore the effect of current parental smoking on children's cognitive and non-cognitive skills using the instrumental variable approach. They use regional tobacco prices as an instrument for parental smoking. Wehby et al. (2011) estimate the impact of maternal smoking during pregnancy on child neurodevelopment using the instrumental variable approach.

This study differs from Simon (2016) and Wehby et al. (2011) in that our outcome variables of interest are children's cognitive and non-cognitive skills. Our study also differs from Srivastava and Trinh (2021) in that we analyze the effects of prenatal, postnatal, and current secondhand smoke simultaneously.

Methodologically, we try to handle the selection problem using the coefficient stability approach. More specifically, we attempt to resolve the selection problem by simultaneously accounting for prenatal, postnatal, and early childhood ETS exposure and various characteristics of parents and children. Early childhood ETS can be seen as an important confounder of the association between prenatal or postnatal ETS and child outcomes because prenatal or postnatal ETS is positively related to early childhood ETS (Eskenazi & Castorina, 1999; Knopik, 2009; Thapar et al., 2003; Cho et al., 2013). Conversely, prenatal or postnatal ETS exposure is also a confounder of the effects of early childhood exposure to ETS if it is not controlled. Furthermore, we extensively control for characteristics of children and parents, including mother's various experiences during pregnancy and at birth, emotional status, and parenting knowledge. Finally, we assess the robustness of the estimates to the omitted variables bias by the coefficient stability procedure, which provides the bound of the omitted variable bias assuming selection on observables is informative about selection on unobservables (Altonji et al., 2005; Oster, 2019).

2.2. Contributions of this paper

We contribute to the research on the impact of early childhood secondhand smoke exposure on child development in several ways. First, we utilize longitudinal data tracking children and their parents from birth through childhood. This enables us to control for a wide range of characteristics about the child and their parents in our regression analysis, estimating the effects of secondhand smoke exposure before the age of one. Compared to previous studies, our research controls for additional variables that could confound the relationship, ranging from experiences during the mother's pregnancy to childhood secondhand smoke exposure. In other words, we estimate the effects of secondhand smoking by controlling for as many confounding factors as possible that could be related to both childhood secondhand smoke exposure and child development.

Second, we employ the latest coefficient stability approach method to check for issues of selection bias using a wide range of control variables. Oster (2019) proposed a method for calculating the treatment effect, assuming that selection on unobservables is proportional to selection on observables. We first examine how the estimates change with the inclusion of control variables and then apply Oster (2019)'s method to assess whether our estimates are robust to selection on observables. When experimental or quasi-experimental analysis methods cannot be used, Oster (2019)'s method can serve as a useful robustness analysis to gauge the amount of selection bias. Conducting experiments on the effects of childhood secondhand smoke exposure can be challenging, making Oster (2019)'s method particularly valuable for this topic. To our knowledge, this study is the first to apply this method in estimating the effects of childhood secondhand smoke exposure.

Finally, this study supports the findings of vast previous research. Our results demonstrate that the effect of Environmental Tobacco Smoke (ETS) exposure before age 1 remains significant even after controlling for numerous explanatory variables, and the result is robust according to Oster's method. Based on these findings, we believe that our results complement the vast body of existing medical studies and research in other fields that do not control for various confounding factors.

3. Data

This study utilizes data from the Panel Survey on Korean Children (PSKC) to estimate the effects of prenatal and postnatal exposure to Environmental Tobacco Smoke (ETS) on children's cognitive and non-cognitive development. The PSKC sampled 2,150 households with newborns born in 2008 in medical institutions handling more than 500 cases annually. A multi-stage stratified sampling method was employed, selecting sample institutions nationwide (excluding Jeju Island), followed by the selection of sample households from those that had deliveries in these institutions. Households with a mother or child in poor health, a mother under 18 years of age, or twins were excluded from the initial sample. This study analyzes data from the 1st and 6th to 9th surveys of the PSKC. The first survey provides information on parental characteristics and experiences when the child was 0 years old, while the sixth through ninth surveys offer data on the child's cognitive tests and behavior problems. The PSKC is particularly suitable for this study due to its extensive survey on child development and socio-economic backgrounds from birth onwards. Of the 2,150 households, 789 provided information on ETS exposure in utero or before age 1. The final sample, which includes data on all necessary independent variables for analysis, consists of 663 observations.

The sixth survey inquired whether mothers experienced secondhand smoke during pregnancy and if their children were exposed to ETS more than once a week within the first 12 months post-birth. Among the initial sample of 789 observations, 354 (44.9%) children were exposed to ETS during both periods, 117 (14.3%) only in utero, 75 (9.5%) solely before age 1, and 243 (30.8%) were not exposed to ETS either in utero or before age 1. Given the significant overlap between prenatal and postnatal ETS exposure, we constructed a dummy variable for prenatal and postnatal ETS exposure, coded as 1 if a child was exposed to ETS in utero or between birth and their first birthday, and 0 otherwise. From the sixth survey onwards, the PSKC also collected data on whether a child was exposed to ETS more than once a week in each survey year after age 4. Based on this, we create a dummy variable indicating ETS exposure in each survey year post-age 4.

The dependent variables include measures of children's cognitive and non-cognitive skills. Non-cognitive skills are assessed through children's behavioral problems at ages 5-7, evaluated via 100 items on a 3-point scale from Achenbach's Child Behavior Checklist (CBCL), indicating that a higher score

signifies more severe problems. Mothers completed these questionnaires at home, rating the extent to which their child's behaviors matched the presented statements. This study examines the impact of early ETS exposure on children's behavioral problems across three dimensions: internalizing problems, externalizing problems, and ADHD. Internalizing problems include behaviors that are internalized and over-controlled, such as passivity, withdrawal, emotional anxiety, and physical symptoms. Externalizing problems encompass uncontrolled behaviors, such as attention issues and aggressive behaviors. ADHD is characterized by inconsistent behaviors, inattention, and significant distress when immediate needs are unmet.

Children's cognitive skills were assessed at age 6 using the Multifactorial Intelligence Test (M-FIT), which comprises six subtests: vocabulary, language inference, diagramming, numeracy, spatial perception, and reasoning. Each subtest includes 20 multiple-choice questions. Inspectors conducted these tests in participants' homes, with children completing tasks within a specified time frame under supervision. Percentile scores from these subtests serve as the measures of cognitive skills. Second-grade school records are another cognitive measure, with mothers reporting their children's performance in quintiles across five subjects: Korean, Social Studies, Mathematics, Science, and English. A dummy variable is created to indicate whether a child's school performance falls within the top 20% for each subject.

We utilize an extensive set of explanatory variables, encompassing characteristics of children, socioeconomic characteristics of parents, mothers' experiences during pregnancy and at birth, mothers' parenting knowledge, and mothers' emotional status. Children's characteristics include gender, birth weight, birth month, and birth order (categorized as first, second, third, fourth, fifth, or higher). Socioeconomic characteristics of parents cover parental education (categorized as high school or lower, 2-year college, 4-year college, master's, or doctoral degree for both father and mother), household income, financial assets, and marital status (categorized as unmarried, married, divorced, or widowed). We also control for family structure (categorized as parents only; parents and grandparents; parents and other relatives; parents, grandparents, and other relatives; other configurations), parental job status (categorized as regular workers, temporary workers, daily workers, others) and occupational dummies (categorized as managers, professionals, clerks, service workers, sales workers, skilled agricultural, forestry and fishery workers, craft and related trades workers, equipment, machine operators and assemblers, elementary occupations, armed forces). The categorical variables are controlled by being converted into dummy variables according to the number of categories. Additionally, we consider parental behaviors such as smoking and drinking habits for both mothers and fathers, including the number of cigarettes smoked per day by each at the child's age of 0, exposure to smoke from any family member during pregnancy, and the child's first year, and dummies for the residential province. Other

maternal characteristics include depression during pregnancy, gestational age, mother's age, height, weight just before pregnancy and childbirth, use of assisted reproductive technology, type of delivery, initial contact with the baby, feelings during pregnancy and at birth, whether the pregnancy was planned, stress levels, depression, parenting behaviors, and three assessments of maternal parenting knowledge surveyed when the child was aged 0-2 years.

Table 1 presents summary statistics for selected variables categorized by the experience of ETS exposure before age 1. Significant differences in characteristics between the two groups are observed. The proportion of boys and firstborns is notably higher in the group exposed to ETS before age 1. Additionally, mothers in the early exposure group tend to have lower levels of education, shorter stature, and lower scores on parenting knowledge tests. This group also has a higher proportion of mothers who worked in the year of childbirth, higher levels of maternal stress, and a higher proportion of mothers who experienced negative feelings at birth. Paternal characteristics differ significantly between the groups as well; fathers in the early exposure group are less likely to be college graduates and white-collar workers. However, monthly household income and financial assets do not show significant differences between the two groups.

The PSKC conducted surveys on the smoking history of family members in various periods: during pregnancy, between birth and the first birthday, and after the first birthday. Children exposed to ETS before age 1 are more likely to have a family member who smoked in each period. The proportion of mothers who smoked after pregnancy is 4.2% in the early exposure group compared to 2.4% in the group without early exposure. Remarkably, only 1.5% of mothers in the early exposure group reported smoking during pregnancy, versus 0.0% in the non-exposure group. This suggests that most prenatal ETS exposure in South Korea is due to external environmental factors rather than maternal smoking. A previous study surveying approximately 1,000 mothers through obstetricians and gynecologists in South Korea found that the self-reported smoking rate among pregnant women was 0.55%, while the rate inferred from measured cotinine concentration in urine was 3.03% (Jhun et al., 2010). This indicates a potential downward bias in self-reported smoking rates, and even the estimated smoking rate based on cotinine concentration remains low in South Korea.

Another significant observation is that children who experienced ETS before their first birthday are more likely to be exposed to ETS during childhood as well. The proportion of children exposed to ETS at age 6 is 74.0% in the early exposure group, compared to 36.4% in the non-exposure group. This strong positive correlation between prenatal and postnatal ETS exposure and childhood ETS exposure underscores the importance of controlling for childhood ETS exposure when estimating the effects of prenatal and postnatal ETS exposure, and vice versa. Additionally, the proportion of parents who consume alcohol is higher in the early exposure group.

4. Econometric Model

We estimate the effect of prenatal and postnatal exposure to ETS on cognitive and non-cognitive skills using the following model:

$$Y_{it} = \beta_0 + \beta_1 T_i + \beta_2 D_{it} + X_i \beta_3 + X_{it} \beta_4 + \epsilon_{it} \quad (1)$$

where Y_{it} is a dependent variable which is measures of cognitive and non-cognitive skills of a child i, T_i is a dummy variable that indicates exposure to ETS before age 1, and D_{it} is a dummy variable that indicates whether a child i was exposed to ETS in the survey year t. As shown in Table 1, children who were exposed to ETS before age 1 are much more likely to be exposed to ETS in childhood. Because exposure to ETS before age 1 can be confounded by ETS exposure in childhood, we control exposure to ETS in childhood. The effect of exposure to ETS in childhood is also an interest to know the differential effects of exposure to ETS by exposure time. X_i is a vector of regressors that includes experiences and characteristics of a child i and his/her parents at birth, X_{it} is a vector of regressors that includes characteristics of a child i and his/her parents in the survey year t, and ϵ_{it} is an error term. The main parameter of interest is β_1, which presents the effects of prenatal and postnatal exposure to ETS on the cognitive and non-cognitive skills of children. β_2 is also a parameter of interest, which presents the effects of exposure to ETS in childhood on cognitive and non-cognitive skills. We report the estimates for β_1 and β_2 and compare the effects of prenatal and postnatal ETS exposure and ETS exposure in childhood.

The key econometric issue is that children who were exposed to ETS before age 1 and those who were not could be systematically different so that confounders can bias estimates. An extensive set of characteristics of parents and children introduced in Section 2 are used as regressors to reduce omitted variable bias. There are, however, concerns about omitted variable bias because there may still be uncontrolled confounders despite the characteristics and experiences of parents and children are extensively controlled.

To compensate for this problem, we investigate how the estimated coefficient change as more regressors are controlled. If the estimated coefficients are not sensitive to the inclusion of different regressors, we can regard it as a sign that the influence of omitted variables bias is restrictive assuming selection on observables is informative about selection on unobservables.

Altonji et al. (2005) provide a more formal approach that gauges the amount of selection on unobservables from the amount of selection on observables. Based on the work by Altonji et al. (2005), Oster (2019) shows that the following estimator is consistent under the assumption that selection on unobservables is proportional to selection on observables.

$$\beta^* = \tilde{\beta} - [\beta^o - \tilde{\beta}]\frac{R_{max} - \tilde{R}}{\tilde{R} - R^o} \quad (2)$$

where $\tilde{\beta}$ and $\tilde{R}$ are the estimate of β and R^2 in the regression with all regressors, respectively, and β^o and R^o are the estimate of β and R^2 in the regression without regressors. R_{max} is set to be $1.3\tilde{R}$, which is recommended by Oster (2019).

We report the bias-corrected estimates β_1^* suggested by Oster (2019) for the impacts of pre-and postnatal exposure to ETS, β_1. If the interval $[\tilde{\beta}_1, \beta_1^*]$ or $[\beta_1^*, \tilde{\beta}_1]$ does not include zero, the estimate is considered robust.

The treatment variable in equations (1) and (2) includes three cases: (1) fetal exposure to ETS, (2) exposure to ETS between birth and first birthday, and (3) both. These three cases are mixed as ETS exposure before age 1 in equations (1) and (2). We further investigate whether these three cases have differential impacts on cognitive and non-cognitive skills of children by estimating the following model:

$$Y_{it} = \beta_0 + \beta_{1,1}T_{1i} + \beta_{1,2}T_{2i} + \beta_{1,3}T_{3i} + \beta_2 D_{it} + X_i\beta_3 + X_{it}\beta_4 + \epsilon_{it} \quad (3)$$

where T_{1i} is a dummy variable which is 1 if a child i was exposed to ETS in utero and was not exposed to ETS between birth and first birthday and 0 otherwise, T_{2i} is a dummy variable which is 1 if a child i was exposed to ETS between birth and first birthday and was not exposed to ETS in utero, and T_{3i} is a dummy variable that indicates whether a child i was exposed to ETS both in utero and between birth and first birthday. D_{it} is a dummy variable that indicates whether a child i was exposed to ETS in the survey year t. Other variables (X_i, X_{it}) are equal to those in equation (1). The parameters $\beta_{1,1}$, $\beta_{1,2}$, and $\beta_{1,3}$ represent the effect of ETS exposure in utero, during infancy, and both in utero and during infancy, respectively.

Finally, we explore whether the effect of ETS exposure before age 1 varies by the cause of exposure. We distinguish the causes of exposure into the following two: (1) ETS exposure due to a family member at home and (2) ETS exposure due to other causes. The PSKC data did not directly investigate the location or cause of ETS. It, however, surveyed whether there were any family members smoked during pregnancy or before the first birthday. This is not a complete measure for ETS exposure at home since a mother and her child might not be exposed to ETS at home if the family member smoked outside the home. Given the limited information in the data, however, we take this as an indirect method for investigating the differential effects of ETS by the cause. More specifically, we use the following model:

$$Y_{it} = \gamma_0 + \gamma_{1,1}H_{1i} + \gamma_{1,2}H_{2i} + \gamma_2 D_{it} + X_i\gamma_3 + X_{it}\gamma_4 + \epsilon_{it} \quad (4)$$

where H_{1i} is a dummy variable that is one if a child was exposed to ETS before age 1 and there was

a family member who smoked before age 1, and zero otherwise. H_{2i} is a dummy variable that is one if a child was exposed to ETS before age 1 and there was not a family member who smoked before age 1, and zero otherwise. Other control variables are the same with equations (1)-(3). The parameters $\gamma_{1,1}$ represents the effect ETS exposure at home and $\gamma_{1,2}$ represents the effect of ETS exposure in other places.

5. RESULTS

5.1 Non-cognitive Skills

In this section, we analyze the effects of ETS exposure before age 1 and ETS exposure in the survey year, respectively, on behavior problems measured by three subscales of the CBCL. Table 2 shows the estimation results for the effects of ETS exposure before age 1 and that in the survey year on the percentile scores of the internalizing problems, externalizing problems, and ADHD assessed by the Child Behavior Checklist at age 5-7. Higher percentile scores present a greater level of behavior problems. Different columns report the results obtained from regressions that control a different set of explanatory variables. Column (1) shows the results from regressions that only control for the gender of children and parental education levels. Column (2) presents the results from regressions that additionally control for the characteristics and experiences of children and parents in the birth year (first survey year) to the model in column (1). Column (3) shows the regression results that control for characteristics and experiences of children and parents in the survey year in addition to regressors in the model of column (2).

Table 2 shows that most of the estimated effects of prenatal and postnatal exposure to ETS are positive and statistically significant, indicating that children who were exposed to ETS before age 1 have more behavior problems than children without ETS exposure before age 1. For example, in regressions with full regressors, ETS exposure before age 1 increases the percentile scores of IBP (internalizing behavior problems), EBP (externalizing behavior problems), and ADHD at age five by 10.03, 8.85, and 10.0 percentage points, respectively. The large and significant effects of ETS exposure before age 1 on behavior problems are also found at older ages. While the impacts on IBP scores are small and significant at ages 6 and 7, the negative effects on EBP and ADHD are larger and statistically significant at age 7 than at age 5 in the regression with full regressors. The negative effects of ETS exposure before age 1 on behavior problems appear to persist in childhood. It is also worth noting that the estimated coefficients are quite stable with the inclusion of a wide range of explanatory variables. Although the estimated effects at ages 5 and 6 appear to decrease as more regressors are included, the magnitude of this reduction is relatively small compared to the increase in R^2. The estimated effects

on EBP and ADHD scores at age 7 increase slightly when more regressors are controlled.

On the other hand, ETS exposure in the survey year does not significantly affect the behavior problems of children. All estimates are small in magnitude and statistically insignificant. We also conduct robustness tests that additionally control for current and all previous ETS exposure for the percentile scores of behavior problems at ages 6 and 7. That is, we include dummy variables of ETS exposure at ages 5 and 6 in the regression for behavior problems at age 7. We report that the estimated effects of ETS exposure before age 1 remain similar in most cases. Besides ETS exposure before age 1, the PSKC only surveyed ETS exposure from age 5. Therefore, we do not have information on the experience of ETS from age 1 to age 4. It is thus impossible to rule out the possibility that exposure to ETS in these periods could be a confounding factor. That said, based on the results that the estimates are stable with the inclusion of various regressors, it appears that ETS exposure before age 1 has a significant influence on children's behavior problems.

5.2 Cognitive Skills

We explore the effects of ETS exposure before age 1 and in the survey on cognitive skills of children. We use the percentile scores of six subtests of the Multi-Factorial Intelligence Test (M-FIT) at age 8 and school grades of children in five subjects reported by their parents.

Table 3 presents the results for the M-FIT. Results show that all estimated effects of ETS exposure before age 1 are negative. Exposure to ETS before age 1 reduces the percentile score of diagraming by 10.17 points in the regression with full regressors and the estimate is statistically significant at a 1% level. It also reduces the percentile score of reasoning by 8.17 points and the estimate is statistically significant at a 5% level. The estimated impacts on the percentile scores of vocabulary and spatial perception are -5.15 and -5.36, respectively, thought they are not statistically significant. For these outcomes, the estimated coefficients tend to increase in size as more regressors are controlled. On the other hand, all the estimated effects of ETS exposure in the survey on the percentile scores of the M-Fit are statistically insignificant and the sign of the estimates differs by the subtests.

Table 4 reports the estimation results for the effect of ETS exposure before age 1 and in the survey year on the probability that parents report that their child's school grade is within the top 20% in each subject. While we arbitrarily set the 20% percentile, we report that the results are qualitatively similar even if we use different percentiles. All the estimates are negative regardless of specification and subject. The regression result with full regressors shows that exposure to ETS before age 1 reduces the probability that a child is in the top 20% in Korean by 14.8 percentage points. It also reduces the probability in social studies by 12.2 percentage points and the probability in science by 12.5 percentage points. The estimated impacts on the probability in math and English are -0.087 and -0.060, respectively,

though they are not statistically significant. The estimates become larger when more regressors are controlled. All estimated effect of exposure to ETS in the survey year on the probability are small and statistically insignificant. The signs of the estimates also vary by specification and subject.

While we converted the categorical variable for school grade in a binary variable for the consistency of the analysis and the robustness test proposed by Oster (2019), we also conduct the Ordered Logistic Regression using the original categorical variable for school grade. Table 5 reports the estimation results from the full model that controls all available control variables. It also shows that children who were exposed to ETS before age 1 tend to have lower school grades. Especially, the negative effect is statistically significant for Korean, social studies, and science.

As with the results for non-cognitive abilities, the estimation results for cognitive skills consistently show that ETS exposure before age 1 negatively affects the cognitive skills of children, while the effect of ETS exposure in the survey year is not significant. Since the estimated effect of ETS exposure before age 1 tends to increase when more regressors are controlled, it may not be the case that the significant effects are derived from omitted variables bias given the direction of selection on unobservables is the same with the direction of selection on observables. We also report that the estimated effects of ETS exposure before age 1 are still robust to the inclusion of all dummy variables that indicate exposure to ETS in childhood.

5.3 Coefficient Bounds

As a robustness test, we report the coefficient bounds calculated using the method by Oster (2019) in Table 6. β_1^* presents the coefficient bound and $\tilde{\beta}_1$ is the estimate from the regression with full regressors. In Table 6, we show that the values of β_1^* and $\tilde{\beta}_1$ are comparable in most cases. Their signs are equal except for IBP at age 6 and language inference of the M-Fit. All of the statistically significant estimates shown in Tables 2-4 are comparable to the corresponding bounds. This is because the estimate from the model controlling for an extensive set of independent variables and the estimate from the model without controlling for the variables are not much different. We confirm this as supportive evidence that our estimates are robust.

5.4 Prenatal Exposure vs. Postnatal Exposure

We obtain consistent results that exposure to ETS before age 1 has negative impacts on the cognitive and non-cognitive skills of children. Our treatment includes three cases by exposure time: (1) exposure in utero, (2) exposure to ETS between birth and first birthday, and (3) both. We further investigate whether these three cases have heterogeneous impacts on cognitive and non-cognitive skills of children using equation (3).

Table 7 reports the estimation results. All three events have negative effects on cognitive and non-cognitive skills. Overall, the estimates for children who were exposed to ETS both in utero and during infancy are more precisely and consistently estimated for more outcomes. It is however difficult to conclude which exposure, prenatal or postnatal, has a greater impact on child development because there is no discernable distinction. It would be more appropriate to conclude that both prenatal exposure to ETS and exposure to ETS between birth and first birthday negatively affect children's cognitive and non-cognitive skills.

5.5 Effect of ETS by Frequency of Exposure

We analyze whether the negative effects of ETS exposure before age 1 increase with a higher frequency of exposure. We use the information on the frequency of ETS exposure after birth and before age 1 because there is no information in the data on the frequency of prenatal exposure to ETS in the data. We define “low-frequency exposure” if the average number of ETS exposures in a week is at least once and no more than three times, and “high-frequency exposure” if it is 4 or more. The base is the case where the average number of ETS exposures in a week is fewer than one.

Table 8 shows the estimation results. Children who were exposed to ETS more frequently before age 1 tend to have more behavior problems than children who were exposed less frequently. For example, in panel (a), children who were exposed to ETS 1-3 times per week before age 1 have 7.589 points higher IBP percentile score than children with less than one ETS exposure per week. Children who experienced ETS exposure four or more times a week have 17.43 points higher IBP percentile score. For the M-fit test, children who experienced ETS exposure less frequently scored lower on some outcomes, but for school performance, children who experienced ETS more frequently have lower grades in all subjects.

5.6 Effect of ETS by Place of Exposure

We explore whether the effects of ETS exposure before age 1 on cognitive and non-cognitive skills differ by place of exposure using equation (4). Table 9 reports the estimation results. It shows that both ETS exposure at home and in other places negatively affect cognitive and non-cognitive skills. For the behavior problems and the M-fit, the negative effect of ETS exposure in other places tends to be greater than that at home. On the other hand, the negative effect of ETS exposure at home tends to be greater for the school grades at age 8. We, however, note that the estimated effects of ETS exposure at home and in other places are substantially different only in a few cases. Regardless of the place of ETS

exposure, ETS exposure before age 1 has a negative impact on child development.

6. DISCUSSION

This study analyzes the effects of prenatal and postnatal exposure to ETS on the cognitive and non-cognitive abilities of young children. To address the problem of omitted variables bias, we use an extensive set of control variables and assess whether estimated effects are sensitive to the inclusion of controls. We also implement Oster (2019)'s test of coefficient stability when there is omitted variable bias, which extends the approach by Altonji et al. (2005).

The estimation results consistently show that children who were exposed to ETS in utero and during infancy have more behavior problems at ages 5-7. Prenatal and postnatal exposure to ETS also reduces the percentile scores of cognitive tests and the probability of receiving top school grades in the second grade. The inclusion of the controls does not change the estimated coefficients of the ETS effect. The bounds of the estimates calculated using a method by Oster (2019) show that the estimation results are robust to omitted variables bias. Overall, we do not find much evidence that our estimates are biased by omitted variables.

It is also worth noting that the effects of prenatal and postnatal exposure on cognitive and non-cognitive skills are persistent in childhood as its effects on externalizing problems and ADHD measures do not decrease between age 5 and age 8 and the negative impacts on cognitive skills are still found at age 8. On the other hand, exposure to ETS at age 5 or older does not have a significant effect on any cognitive and non-cognitive skill measures. These findings are consistent with recent large literature showing that mild negative shocks in utero and early childhood can have long-term negative effects (Almond et al., 2018).

We analyze the effects of early exposure to ETS by exposure time by dividing exposure to ETS before age 1 into three cases: (1) fetal exposure to ETS, (2) exposure to ETS between birth and first birthday, and (3) exposure in both periods. The estimation results show all three cases negatively affect children's cognitive and non-cognitive skills. We also explore heterogeneous effects of ETS exposure before age 1 by demographics. The negative impacts of early ETS exposure tend to be smaller for children from households with high-income or high financial assets in some cognitive skills measures, while no such heterogeneous effects are found in behavior problem measures. We also show that both ETS exposure at home and in other places negatively affect children's cognitive and non-cognitive skills.

Our results consistently show that preserving mothers and infants from secondhand smoke is essential for child development. As the ratio of mothers and infants exposed to secondhand smoke is currently

very high in South Korea, there is much room for improvement through various policies and social recognition of the negative impacts of early exposure to ETS. In light of previous studies (Simon, 2016; Wehby et al., 2011), raising tobacco taxes and prices can reduce secondhand smoke. According to statistics in 2017, the average cigarette price in OECD countries was 7.36 dollars, whereas the price of a cigarette was about 4.0 dollars in South Korea. In addition, cigarette prices have not changed for six years due to the backlash of smokers in South Korea. It is necessary to be aware of the wide range of negative externalities of smoking and to have smoking control policies, including setting appropriate tobacco prices and reducing secondhand smoke.

We would like to note the limitations of this study. First, the variables representing ETS are constructed based on self-reported answers. Due to the data limitation, variables based on objective measurements, such as urine cotinine concentrations, could not be used. Second, the effects of ETS exposure before age 1 are analyzed only for children aged 5-8 years. The analysis of the effects on younger children up to 1-4 years of age or longer-term effects after 8 years of age should be performed in follow-up studies. Finally, our study has a limitation in identifying the causal effect of early ETS exposure in that it used observational data, although the latest statistical techniques, such as Oster (2019)'s robustness test, are used. As it is difficult to conduct a randomized controlled trial for ethical reasons, it needs to be supplemented by subsequent studies using quasi-experimental methods.

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Table 1: Summary Statistics for Selected Variables by Exposure to ETS before Age 1

Variables	Exposure to ETS before age 1	Non-exposure to ETS before age 1	Difference (t-statistic)
Gender(male=1)	0.546	0.460	0.086**
	(0.498)	(0.500)	[1.97]
Birth order(firstborn=1)	0.491	0.427	0.064
	(0.500)	(0.496)	[1.46]
Birth weight(kg)	3.27	3.26	0.008
	(0.428)	(0.430)	[0.21]
Gestation(days)	274.4	275.0	-0.593
	(9.426)	(8.575)	[-0.74]
Mother's age at birth	31.16	31.41	-0.258
	(3.683)	(3.632)	[-0.81]
Mother's education	0.656	0.687	-0.031
(college=1)	(0.475)	(0.465)	[-0.74]
Mother's height(cm)	160.7	161.4	-0.763*
	(4.492)	(4.642)	[-1.93]
Mother work	0.289	0.221	0.067*
in the year of childbirth	(0.454)	(0.416)	[1.74]
Mother parenting Knowledge	8.052	8.515	-0.463*
(# of correct answers)	(3.125)	(3.011)	[-1.71]
Maternal Stress	2.828	2.520	0.308
	(2.367)	(2.175)	[1.47]
Mother bad feeling at birth	0.064	0.032	0.032
	(0.245)	(0.176)	[1.61]
Father's education	0.621	0.766	-0.145***
(college=1)	(0.486)	(0.425)	[-3.51]
Father occupation	0.584	0.717	-0.133***
(White-collar=1)	(0.493)	(0.452)	[-3.15]
Father regular worker	0.779	0.775	0.005
	(0.415)	(0.418)	[0.10]
Monthly household income	2490.6	2444.0	46.63
(USD)	(1126.2)	(977.5)	[0.49]
Financial assets (USD)	21744.9	22291.4	-546.5
	(39171.9)	(39129.8)	[-0.12]
Family member's smoking	0.565	0.252	0.313***
during pregnancy	(0.496)	(0.434)	[7.45]
Family member's smoking	0.650	0.311	0.338***
between age 0 and age 1	(0.478)	(0.464)	[8.16]
Family member's smoking	0.612	0.301	0.311***
after age 1	(0.488)	(0.460)	[7.40]
Mother ever smoking	0.042	0.024	0.019
	(0.202)	(0.153)	[1.13]
Maternal smoking during	0.015	0.0	0.015
pregnancy	(0.121)	(0.0)	[1.62]
Passive smoking at age 6	0.740	0.364	0.375***
	(0.439)	(0.439)	[0.040]
Father drinking	0.842	0.751	0.092***
	(0.365)	(0.434)	[2.58]
Mother drinking	0.350	0.262	0.088**
	(0.478)	(0.441)	[2.15]
Observations	485	178	663

Notes: 1. Standard deviations are in parentheses. 2. The characteristics are those of the first year survey.

Table 2: The Effect of Environmental Tobacco Smoking on Behavior Problems

Dependent variable	Independent variable	(1)	(2)	(3)
(a)BP at Age 5				
IBP	ETS before age 1	10.814***	11.507***	10.032***
		(3.210)	(3.425)	(3.715)
	Current ETS	-3.073	-0.099	2.444
		(4.027)	(4.318)	(4.688)
	R-squared	0.050	0.276	0. 540
EBP	ETS before age 1	11.302***	10.095***	8.852**
		(3.044)	(3.338)	(3.677)
	Current ETS	-1.494	1.123	2.232
		(3.891)	(4.169)	(4.821)
	R-squared	0.083	0.272	0.530
ADHD	ETS before age 1	11.398***	10.899***	10.006***
		(2.945)	(3.145)	(3.521)
	Current ETS	0.202	1.338	0.427
		(3.755)	(4.044)	(4.617)
	R-squared	0.090	0.277	0.512
(b)BP at Age 6				
IBP	ETS before age 1	6.439**	6.364*	1.899
		(3.206)	(3.312)	(4.102)
	Current ETS	-0.471	5.225	3.834
		(2.869)	(3.402)	(3.938)
	R-squared	0.016	0.280	0.476
EBP	ETS before age 1	11.303***	10.547***	8.347**
		(3.101)	(3.476)	(4.012)
	Current ETS	-2.060	2.039	0.755
		(2.962)	(3.482)	(3.649)
	R-squared	0.077	0.314	0.512
ADHD	ETS before age 1	9.886***	9.335***	5.456
		(3.110)	(3.580)	(4.149)
	Current ETS	-3.051	-1.355	-1.106
		(2.914)	(3.498)	(3.600)
R-squared		0.076	0.288	0.479
(c)BP at Age 7				
IBP	ETS before age 1	3.330	4.199	3.196
		(2.815)	(3.254)	(3.383)
	Current ETS	2.772	3.111	1.708
		(3.126)	(3.646)	(4.161)
	R-squared	0.024	0.216	0.497
EBP	ETS before age 1	8.555***	11.138***	11.985***
		(2.975)	(3.190)	(3.274)
	Current ETS	3.091	2.821	4.085
		(2.860)	(3.106)	(3.808)
	R-squared	0.049	0.269	0.529
ADHD	ETS before age 1	10.225***	11.981***	11.195***
		(2.671)	(2.873)	(3.182)
	Current ETS	0.944	1.236	1.740
		(2.752)	(3.280)	(3.937)
	R-squared	0.069	0.277	0.515

Notes: 1. *** p<0.01, ** p<0.05, * p<0.1. 2. Robust standard errors in parentheses.

Table 3: The Effect of Environmental Tobacco Smoking on the Percentile Scores of the Multi-Factorial Intelligence Test at Age 6

Dependent variable	Independent variable	(1)	(2)	(3)
(a)Vocabulary	ETS before age 1	-5.896**	-5.350*	-5.153
		(2.809)	(3.190)	(4.184)
	Current ETS	4.126	5.144	4.479
		(3.285)	(3.624)	(4.283)
	R-squared	0.125	0.382	0.565
(b)Language inference	ETS before age 1	-1.892	-0.916	-0.785
		(2.747)	(3.049)	(3.711)
	Current ETS	2.572	1.429	4.600
		(2.742)	(3.117)	(3.710)
	R-squared	0.079	0.338	0.566
(c)Diagraming	ETS before age 1	-6.231**	-8.046***	-10.166**
		(2.768)	(3.065)	(3.979)
	Current ETS	-2.738	-3.489	-1.353
		(2.849)	(3.154)	(3.782)
	R-squared	0.088	0.348	0.568
(d)Numeracy	ETS before age 1	-3.256	-4.421	-2.430
		(2.852)	(3.411)	(4.312)
	Current ETS	2.461	-0.152	3.284
		(3.260)	(3.692)	(4.418)
	R-squared	0.048	0.258	0.485
(e)Spatial perception	ETS before age 1	-3.633	-3.988	-5.361
		(3.181)	(3.390)	(4.070)
	Current ETS	0.873	-1.919	-0.889
		(3.630)	(3.720)	(4.167)
		0.034	0.302	0.571
(f)Reasoning	ETS before age 1	-5.281*	-6.965**	-8.165**
		(3.145)	(3.245)	(4.051)
	Current ETS	-1.435	-1.680	-3.785
		(3.150)	(3.373)	(3.787)
	R-squared	0.041	0.325	0.527

Notes: 1. *** p<0.01, ** p<0.05, * p<0.1. 2. Robust standard errors in parentheses.

Table 4: The Effect of Environmental Tobacco Smoking on School Records at Age 8

Dependent variable	Independent variable	(1)	(2)	(3)
(a)Korean	ETS before age 1	-0.071	-0.077	-0.148**
		(0.054)	(0.057)	(0.073)
	Current ETS	0.020	0.005	-0.001
		(0.054)	(0.061)	(0.074)
	R-squared	0.031	0.273	0.508
(b)Social studies	ETS before age 1	-0.087	-0.081	-0.122
		(0.057)	(0.063)	(0.076)
	Current ETS	-0.017	-0.043	-0.042
		(0.056)	(0.065)	(0.075)
	R-squared	0.037	0.262	0.499
(c)Mathematics	ETS before age 1	-0.090	-0.099*	-0.087
		(0.057)	(0.059)	(0.076)
	Current ETS	0.033	0.053	0.055
		(0.050)	(0.062)	(0.076)
	R-squared	0.028	0.316	0.612
(d)Science	ETS before age 1	-0.061	-0.083	-0.125
		(0.055)	(0.060)	(0.082)
	Current ETS	0.055	0.085	0.098
		(0.047)	(0.057)	(0.080)
	R-squared	0.028	0.346	0.617
(e)English	ETS before age 1	-0.036	-0.050	-0.060
		(0.050)	(0.049)	(0.073)
	Current ETS	0.012	0.016	0.029
		(0.042)	(0.048)	(0.068)
	R-squared	0.037	0.335	0.595

Notes: 1. *** p<0.01, ** p<0.05, * p<0.1. 2. Robust standard errors in parentheses.

Table 5. The Effect of Environmental Tobacco Smoking on School Records at Age 8: Ordered Logit Regression

	(1) Korean	(2) Social Studies	(3) Math	(4) Science	(5) English
ETS before age 1	-0.639**	-0.501*	-0.505	-0.836*	-0.350
	(0.081)	(0.290)	(0.455)	(0.470)	(0.553)
Current ETS	0.209	-0.068	0.299	0.331	-0.201
	(0.320)	(0.299)	(0.512)	(0.521)	(0.589)

Notes: 1. *** p<0.01, ** p<0.05, * p<0.1. 2. Standard errors in parentheses.

Table 6: Coefficient Bounds Based on Oster(2019)

	β^o	R^o	$\tilde{\beta}$	$\tilde{R}$	R_{max}	β^*
(a)BP at age 5						
IBP	9.593	0.022	10.03	0.540	0.702	10.43
EBP	11.71	0.032	8.852	0.530	0.689	6.240
ADHD	12.86	0.038	10.01	0.512	0.666	7.338
(b)BP at age 6						
IBP	6.204	0.010	1.899	0.476	0.619	-1.651
EBP	12.94	0.040	8.347	0.512	0.666	5.081
ADHD	11.95	0.034	5.456	0.479	0.623	1.456
(c)BP at age 7						
IBP	4.223	0.005	3.196	0.497	0.646	1.603
EBP	9.761	0.025	11.99	0.529	0.688	11.69
ADHD	11.79	0.037	11.20	0.515	0.670	10.96
(d)M-FIT						
Vocabulary	-7.703	0.015	-5.153	0.565	0.686	-3.097
Language inference	-2.971	0.003	-0.785	0.566	0.688	0.940
Diagraming	-8.471	0.020	-10.17	0.568	0.714	-11.55
Numeracy	-3.517	0.003	-2.430	0.485	0.619	-1.569
Spatial perception	-4.910	0.006	-5.361	0.571	0.715	-5.719
Reasoning	-5.906	0.010	-8.165	0.527	0.673	-9.961
(e)School record						
Korean	-0.086	0.007	-0.148	0.508	0.660	-0.198
Math	-0.107	0.011	-0.122	0.499	0.649	-0.135
English	-0.093	0.012	-0.087	0.612	0.796	-0.080
Social Science	-0.058	0.005	-0.125	0.617	0.802	-0.204
Natural Science	-0.056	0.006	-0.060	0.595	0.774	-0.063

Notes: 1. The coefficient bounds are calculated using the method by Oster (2019). 2. We use δ=1 and R_{max}= $1.3\tilde{R}$ in the calculation.

Table 7: The Effects of Environmental Tobacco Smoking by Exposure Time

	Prenatal ETS	Postnatal ETS	Both
(a)BP at age 5			
IBP	5.591	6.479	12.716***
	(4.585)	(5.803)	(4.257)
EBP	7.088	3.249	10.740**
	(5.038)	(5.846)	(4.171)
ADHD	9.156*	10.740**	10.986***
	(4.977)	(4.171)	(4.145)
(b)BP at age 6			
IBP	-6.389	-1.145	5.083
	(5.326)	(5.955)	(4.420)
EBP	3.787	0.202	11.867**
	(5.401)	(5.566)	(4.585)
ADHD	1.701	-0.760	7.484
	(5.646)	(5.956)	(4.769)
(c)BP at age 7			
IBP	5.297	2.265	3.705
	(5.253)	(4.905)	(3.662)
EBP	13.560***	11.466**	12.718***
	(4.813)	(5.075)	(3.600)
ADHD	8.328*	16.531***	10.365***
	(4.636)	(4.839)	(3.578)
(d)M-FIT			
Vocabulary	-0.564	-5.024	-8.242*
	(6.427)	(6.363)	(4.774)
Language inference	2.131	1.458	-1.832
	(5.371)	(5.572)	(4.146)
Diagraming	-15.028***	-13.534**	-8.429*
	(5.695)	(5.759)	(4.587)
Numeracy	-1.289	1.879	-3.453
	(5.881)	(6.463)	(4.872)
Spatial perception	-0.487	-0.930	-7.382*
	(5.983)	(6.150)	(4.404)
Reasoning	-11.817**	-8.912	-6.230
	(5.607)	(5.603)	(4.627)
(e)School grade			
Korean	-0.081	-0.178*	-0.199**
	(0.112)	(0.102)	(0.083)
Social studies	-0.148	-0.186*	-0.122
	(0.107)	(0.110)	(0.087)
Mathematics	-0.089	-0.092	-0.108
	(0.118)	(0.121)	(0.080)
Science	-0.166	-0.104	-0.125
	(0.121)	(0.137)	(0.089)
English	-0.105	-0.060	-0.046
	(0.102)	(0.102)	(0.078)

Notes: 1. *** p<0.01, ** p<0.05, * p<0.1. 2. Robust standard errors in parentheses.

Table 8. The Effects of Environmental Tobacco Smoking by Frequency of the Exposure

	Low frequency	High frequency
(a)BP at age 5		
IBP	7.589*	17.431***
	(4.529)	(5.297)
EBP	6.531	12.316**
	(4.253)	(4.966)
ADHD	9.849**	15.630***
	(4.350)	(5.094)
(b)BP at age 6		
IBP	3.046	10.047*
	(4.645)	(5.690)
EBP	8.253*	17.746***
	(4.484)	(5.722)
ADHD	6.694	14.233**
	(4.710)	(6.019)
(c)BP at age 7		
IBP	1.300	6.668
	(3.573)	(4.575)
EBP	9.756***	10.946**
	(3.605)	(4.650)
ADHD	12.376***	12.199**
	(3.538)	(4.813)
(d)M-FIT		
Vocabulary	-5.414	-5.665
	(4.739)	(5.769)
Language inference	-1.588	-1.978
	(4.259)	(5.656)
Diagraming	-12.090***	-10.073*
	(4.442)	(5.502)
Numeracy	-5.087	0.617
	(4.904)	(5.328)
Spatial perception	-6.493	-6.399
	(4.750)	(5.956)
Reasoning	-10.829**	-6.272
	(4.331)	(5.854)
(e)School grade		
Korean	-0.173**	-0.174*
	(0.077)	(0.099)
Social studies	-0.107	-0.119
	(0.089)	(0.109)
Mathematics	-0.016	-0.103
	(0.093)	(0.133)
Science	-0.040	-0.136
	(0.109)	(0.140)
English	-0.028	-0.051
	(0.086)	(0.104)

Notes: 1. *** p<0.01, ** p<0.05, * p<0.1. 2. Robust standard errors in parentheses.

Table 9: The Effects of Environmental Tobacco Smoking by Place of Exposure

	(1) Home	(2) Other place
(a)BP at age 5		
IBP	7.530	12.029**
	(4.890)	(4.886)
EBP	7.814*	9.680**
	(4.640)	(4.799)
ADHD	7.662	11.875***
	(4.833)	(4.535)
(b)BP at age 6		
IBP	-5.610	7.495
	(6.170)	(5.432)
EBP	1.898	13.154**
	(5.886)	(5.226)
ADHD	4.260	6.348
	(6.030)	(5.242)
(c)BP at age 7		
IBP	-4.572	8.029*
	(4.746)	(4.727)
EBP	7.607	14.790***
	(4.764)	(4.463)
ADHD	8.519**	13.160***
	(4.287)	(4.636)
(d)M-FIT		
Vocabulary	0.869	-10.003*
	(5.902)	(5.517)
Language inference	5.452	-5.807
	(5.107)	(4.977)
Diagraming	-4.109	-15.044***
	(5.866)	(4.880)
Numeracy	0.023	-4.405
	(6.220)	(5.535)
Spatial perception	-1.323	-8.613
	(5.434)	(5.419)
Reasoning	-2.529	-12.704**
	(5.522)	(5.137)
(e)School grade		
Korean	-0.139	-0.155
	(0.099)	(0.099)
Social studies	-0.086	-0.153
	(0.108)	(0.102)
Mathematics	-0.106	-0.070
	(0.106)	(0.110)
Science	-0.150	-0.101
	(0.108)	(0.113)
English	-0.064	-0.056
	(0.093)	(0.105)

Notes: 1. *** p<0.01, ** p<0.05, * p<0.1. 2. Robust standard errors in parentheses.