

# BMJ Open In utero and early childhood exposure to secondhand smoke in Taiwan: a population-based birth cohort study

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## ABSTRACT

**Objectives** This study provides secondhand smoke (SHS) exposure data in utero and after birth when children were at 18 months, 36 months and 66 months old, and it identifies risk factors for the early childhood SHS among 18-month-old infants living in smoker and non-smoker households.

**Study design** The data come from the Taiwan Birth Cohort Study, a longitudinal survey of a birth cohort born in 2005. This study used the survey wave when children were 18 months old (n=18 845) for statistical analysis of early childhood SHS exposure. Logistic regression was used to identify the risk factors of the SHS exposure.

**Results** Approximately 62% of the 18-month-old infants lived in a household with at least one smoker, with the father being the smoker in 84% of those households. Among these infants living in a smoker household, 70% were exposed to SHS and 36% were exposed to heavy SHS in utero, and the prevalence was approximately 66% and 17% after birth for SHS and heavy SHS, respectively. The number and the existence of smokers in the household, parents' smoking status, father's educational attainment and being a first-born baby are strong predictors of early childhood heavy SHS exposure.

**Conclusions** Encouraging families to have a smoke-free home environment, empowering women to ensure their perspectives and rights are embedded into tobacco control efforts and educating families about the health risks from childhood SHS exposure, especially among people living in households with smokers, will protect non-smoking adults and children from SHS exposure.

## INTRODUCTION

Secondhand smoke (SHS) puts non-smoking adults and children at higher risk of premature death, illness and other adverse effects. The health risk from SHS is especially substantial among children given that their lungs are still developing. Newborns exposed to SHS, either in utero or after birth, have higher risk of premature birth, low birth weight and sudden infant death syndrome and children exposed to SHS have higher risk of acute respiratory illness, middle ear infections, bronchi, reduced lung function and asthma development.<sup>1-3</sup>

## Strengths and limitations of this study

- A unique dataset, which randomly selected newborns from all live births in 2005, tracks secondhand smoke (SHS) exposure in utero and when the children were 18 months, 36 months and 66 months old.
- Sample size is large, over 19 000 children for all waves.
- The response rate is high (>92%) for all waves.
- Parents or primary caregivers may under-report infant's SHS due to lack of awareness or social desirability bias.

Globally, it is estimated that over 40% of men smoke tobacco, whereas only approximately 10% of women smoke, and this gender discrepancy in tobacco smoking exists especially in middle and lower income countries.<sup>4</sup> Although worldwide smoking prevalence is low among women, women and children comprise the major population exposed to SHS with a global profile such that 35% of non-smoking women and 40% of children were exposed to SHS in 2004.<sup>5</sup>

The home is a major setting for SHS exposure. Children, particularly children of preschool ages, are most likely to be exposed to SHS at home given that very young children spend most of their time in the home and smoking restrictions in the home are usually rare.<sup>6</sup> The existence of smoking household members serves as a strong predictor for SHS exposure among children.<sup>7 8</sup> Findings from the global Youth Tobacco Survey conducted by the WHO indicated that approximately 44% of youths worldwide are exposed to SHS at home, 47% of whom have at least one parent who smokes.<sup>9</sup>

Taiwan is similar to other developing countries in that men are the main subgroup of smokers, whereas the smoking rate for women is very low (40.0% for men, 4.8% for women in 2005, decreasing to 33.5% for men and 4.4% for women in 2011).<sup>10</sup> The



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prevalence of SHS exposure among non-smoking women and children is substantial given the high male smoking rate and the limited restrictions of smoking in homes and some public places; consequently, the risk of adverse health associated with SHS for women and children who live with smokers is particularly high.<sup>11–14</sup> Previous studies using cross-sectional survey data in Taiwan indicated that over 60% of smoking parents with school-aged children smoke in the presence of their children,<sup>12</sup> and approximately 45% of junior and senior high school students have been exposed to SHS at home.<sup>10</sup>

However, few studies have investigated SHS exposure among children under 5 years old, the subgroup with developing lung systems that are most susceptible to SHS. These young children spend most of their time at home and are more likely to be exposed to SHS through their smoking household members than are older children.

This study uses birth cohort data, a longitudinal survey of a birth cohort born in 2005, and provides the prevalence of SHS exposure in utero and in children aged 18, 36 and 66 months. This study identifies risk factors of heavy SHS exposure among 18-month infants, aiming to explore potential sociodemographic disparities associated with the early childhood SHS exposure.

## METHODS

### Data

Data come from the Taiwan Birth Cohort Study (TBCS), a longitudinal survey of a nationally representative birth cohort born in 2005 in Taiwan. The TBCS used a two-stage stratified random sampling design and drew the study sample from the population-based birth database (National Birth Report Database) with an 11.7% sampling rate, resulting in a nationally representative cohort of 24200 newborn individuals born in 2005. Among those eligible newborns, 21 248 infants completed a baseline survey at 6 months of age with a response rate of 87.8%. These infants were subsequently recruited as cohort members. Three waves of follow-up surveys were conducted when the infants and young children were at 18 months, 36 months and 66 months of age, with response rates of 94.9%, 93.7% and 92.8%, respectively. The TBCS is sponsored by Taiwan Health Promotion Administration designed to document the health and developmental trajectories of children in Taiwan, and the survey has been widely used in studies investigating topics in child development and health.<sup>15–17</sup> Detailed information about the TBCS can be found in previous publications.<sup>18–20</sup>

The survey was conducted via face-to-face interviews using standardised questionnaires with either the mother or a primary caregiver by trained interviewers, providing the information about children's health and development, child care, lifestyle and social and physical environment exposures. According to the 18-month survey, 98% of the respondents are mothers, 1.23% are primary caregivers and 0.76% are both mothers and

primary caregivers. Among the primary caregivers, the majority of them (90%) are fathers or grandparents. The TBCS survey protocol and questionnaires have been reviewed and approved by the Institutional Review Board (IRB) of the Bureau of Health Promotion, Department of Health and the Directorate-General of Budget, Accounting, and Statistics, Executive Yuan, Republic of China (No 94-C3-0940005257). This study is approved by the IRB at National Taiwan University Hospital (ID number: 201503081RINB). The survey, the wave when children were 18 months, is attached as a supplementary file (see online supplementary file).

This study uses four waves of the TBCS, when the infants and young children were 6 months, 18 months, 36 months and 66 months old, to provide a time trend of SHS exposure across four time periods (in utero, 18 months, 36 months and 66 months).

The 6-month wave provided retrospective information regarding women's SHS exposure during their pregnancy. The 18-month, 36-month and 66-month waves provided information regarding young children's current SHS exposure. However, the 6-month wave did not provide information on children's current SHS exposure. The sample sizes are 21 248, 20 172, 19 910 and 19 721 for the 6-month, 18-month, 36-month and 66-month waves, respectively.

This study restricts the study sample to the respondents who consistently answered 6-month, 18-month, 36-month and 66-month survey waves, and that leads in the sample size equalling 18845. Furthermore, this study uses the 18-month wave, the first wave of the TBCS, including children's current SHS information conducted between 2006 and 2007 for bivariate and multivariate analyses of early childhood SHS exposure.

The *in utero* SHS is retrospectively reported in the 6-month wave and coded as '1' if the mother answered '1–2 days per week', '3–5 days per week' or 'almost every day' to the question "During your pregnancy, did anyone smoke anywhere in front of you?" and '0' if the mother answered 'never'. The *in utero heavy* SHS is coded as '1' if the mother answered either 'almost every day' or '3–5 days per week' to that question and '0' if the mother answered '1–2 days per week', 'less than 1 day per week' or 'never'. The *childhood* SHS is measured separately in the 18-month, 36-month and 66-month waves and coded as '1' if the mother or primary caregiver answered 'occasionally', 'often' or 'every day' to the question "How often is your baby exposed to secondhand smoke?" and '0' if the mother answered 'never'. The *heavy childhood* SHS is coded as '1' either 'every day' or 'often' to that question and '0' either 'never' or 'occasionally'.

Parent's smoking status was '1' if one answered 'yes' to the question "Did you smoke during the past month?" and '0' otherwise. If a smoker smoked over 20 cigarettes a day, he or she was defined as a heavy smoker, otherwise not a heavy smoker. Smoker household was coded '1' if any parent or other household members smoked and '0' if none of them smoked.

All control variables of the statistical analysis, including characteristics of the parents, children and household, were measured when the child was 18 months except for the parents' age at the birth of child (answered at 6 months).

## Statistical methods

### Descriptive analysis

The sample was classified into two groups: young children living in a smoker household and those living in a non-smoker household. The crude proportion of the in utero and heavy childhood SHS exposure, when they were 18 months, 36 months and 66 months old, was provided for all children, those in smoker and non-smoker households alike.

Summary statistics for outcome (heavy early childhood SHS exposure) and covariates (parents' characteristics, child's characteristics and household characteristics) are provided for the 18-month-old infants in both smoker and non-smoker households.

Bivariate associations of each covariate with heavy and non-heavy early childhood SHS exposure were tested with  $\chi^2$  tests for categorical variables and analysis of variance for continuous variables.

### Statistical analysis

This study used logistic regression to estimate the odds of heavy early childhood SHS exposure for two groups (infants living in a smoker household and infants living in a non-smoker household), separately. This approach identifies the risk factors associated with heavy early childhood SHS exposure, and it captures potential differences in the associations between heavy early childhood SHS exposure and covariates among infants living in smoker and non-smoker households.

All statistical analyses were conducted by SAS version 9.3.

## RESULTS

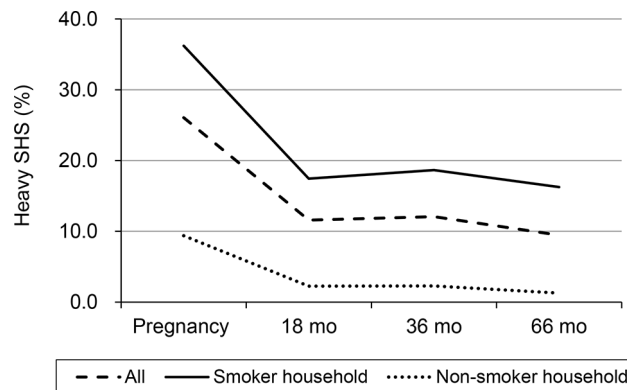
### Trends of childhood SHS exposure

In general, the proportion of young children who were exposed to heavy SHS was 26.1% in utero, and it declined significantly after birth to 11.6%, 12.1% and 9.5% when the children were 18 months, 36 months and 66 months old, respectively (figure 1).

When the sample was divided into those who live in smoker versus non-smoker households, the trend presents similar patterns between the two subsamples (the heavy SHS prevalence declined significantly after birth). The percentage of young children exposed to heavy SHS is consistently high for those living in smoker households.

### Baseline summary statistics

Among the 18-month-old infants, 61.8% lived in a smoker household and 37.8% lived in a non-smoker household. The average age was 36.5 years for fathers and 29.9 years for mothers. Educational attainment was



**Figure 1** Prevalence of early childhood secondhand smoke (SHS) exposure in utero and after birth in smoker and non-smoker households. The proportion of young children who were exposed to heavy SHS declined significantly after birth. The percentage of children exposed to heavy SHS is consistently higher for those living in smoker households than for those living in non-smoker households.

higher for parents living in non-smoker households than for those living in smoker households. Approximately half of the infants (47%) had the father as the only smoker in the household, 0.5% had the mother as the only smoker, 4.9% had both parents as smokers and 46.5% had neither parent as a smoker. Similarly, among infants living in smoker households, 76% had the father as the only smoker, 7.9% had the mother as the only smoker and 14% had other family member as the only smoker. On average, smoking fathers smoked approximately 15 cigarettes per day and smoking mothers smoked approximately 9 cigarettes per day (table 1).

Among the 18-month-old infants, 52% were boys and 50% were first-born children. On average, 55.2% of the 18-month-old infants were exposed to SHS, with 66% exposed to SHS in a smoker household and 37.7% exposed to SHS in a non-smoker household. A total of 11.6% of the infants were exposed to heavy SHS, with 17.3% exposed to heavy SHS from living in a smoker household and 2.3% exposed from living in a non-smoker household. On average, family income for infants living in non-smoker households (<30 000: 6.3%, 30 000–100 000: 74.6%, >100 000: 18.9%) was higher than that for smoker households (<30 000: 14.6%, 30 000–100 000: 77.2%, >100 000: 7.7%). The average number of smokers living in a smoker household with infants was 1.4.

### Bivariate analysis

Results from bivariate analyses (table 2) indicate that presence of heavy SHS is significantly associated with parents' younger age, lower education level, not employed, currently smoking and higher smoking intensity (all  $p < 0.01$ ). Heavy SHS was significantly higher among non-first-born children than first-born children ( $p < 0.01$ ).

Household characteristics such as lower family income, smoking parents and more smokers in the household

**Table 1** Baseline summary descriptive data (measured when the children were 18 months old), n (% or mean±SD)

Variables	No of observations		
	All households	Non-smoker households	Smoker households
Total	18 845 (100.0)	7 130 (100.0)	11 651 (100.0)
<b>Parent's characteristics</b>			
Father's age (years)	18 845 (36.5±13.8)	7 130 (35.7±9.1)	11 651 (36.9±15.6)
<25	475 (2.5)	53 (0.7)	419 (3.6)
25–29	3 440 (18.3)	858 (12.0)	2 574 (22.1)
30–34	6 592 (35.0)	2 729 (38.3)	3 859 (33.1)
≥35	8 338 (44.2)	3 490 (49.0)	4 799 (41.2)
Mother's age (years)	18 845 (29.9±4.8)	7 130 (31.4±4.3)	11 651 (28.9±4.9)
<25	2 707 (14.4)	409 (5.7)	2 283 (19.6)
25–29	6 117 (32.4)	1 848 (25.9)	4 251 (36.5)
30–34	6 760 (35.9)	3 236 (45.4)	3 510 (30.1)
≥35	3 261 (17.3)	1 637 (23.0)	1 607 (13.8)
<b>Father's education level</b>			
Junior high or below	2 500 (13.3)	409 (5.7)	2 079 (17.8)
Senior high	7 454 (39.6)	1 772 (24.9)	5 664 (48.6)
Junior college	4 134 (21.9)	1 790 (25.1)	2 332 (20.0)
College and above	4 623 (24.5)	3 140 (44.0)	1 479 (12.7)
Missing	134 (0.7)	19 (0.3)	97 (0.8)
<b>Mother's education level</b>			
Junior high or below	2 637 (14.0)	521 (7.3)	2 103 (18.1)
Senior high	7 526 (39.9)	1 927 (27.0)	5 571 (47.8)
Junior college	4 797 (25.5)	2 147 (30.1)	2 638 (22.6)
College and above	3 852 (20.4)	2 527 (35.5)	1 314 (11.3)
Missing	33 (0.2)	8 (0.1)	25 (0.2)
<b>Parents' employment status</b>			
Father employed	18 053 (95.8)	6 969 (97.7)	11 075 (95.1)
Missing	182 (1.0)	9 (0.1)	121 (0.6)
Mother employed	11 475 (60.9)	4 698 (65.9)	6 733 (57.8)
Missing	108 (0.6)	9 (0.1)	92 (0.5)
<b>Parents' smoking status</b>			
Only father smokes	8 854 (47.0)	0 (0.0)	8 854 (76.0)
Only mother smokes	87 (0.4)	0 (0.0)	87 (0.7)
Both parents smoke	923 (4.9)	0 (0.0)	923 (7.9)
None of them smoke	8 760 (46.5)	7 130 (100.0)	1 630 (14.0)
Missing	221 (1.2)	0 (0.0)	157 (1.4)
<b>Parents' smoking intensity (smokers)</b>			
Father's cigarettes per day	9 782 (15.2±9.5)	0 (–)	9 782 (15.2±9.4)
Mother's cigarettes per day	1 052 (9.3±6.8)	0 (–)	1 052 (9.3±6.8)
<b>Children's characteristics</b>			
Child being a boy	9 912 (52.6)	3 765 (52.8)	6 144 (52.5)
<b>First-born child</b>			
Yes	9 468 (50.2)	3 579 (50.2)	5 845 (50.2)
No	9 367 (49.7)	3 551 (49.8)	5 796 (49.7)

Continued



Table 1 Continued

Variables	No of observations		
	All households	Non-smoker households	Smoker households
Missing	10 (0.1)	0 (0.0)	10 (0.1)
Children's SHS exposure			
General SHS exposure			
Never	8441 (44.8)	4439 (62.3)	3961 (34.0)
Ever	10 401 (55.2)	2691 (37.7)	7690 (66.0)
Missing	3 (0.0)	0 (0.0)	0 (0.0)
SHS intensity*			
Non-heavy SHS exposure	16 659 (88.4)	6968 (97.7)	9632 (82.7)
Heavy SHS exposure	2183 (11.6)	162 (2.3)	2019 (17.3)
Missing	3 (0.0)	0 (0.0)	0 (0.0)
<b>Household characteristics</b>			
Family income (NTD)			
<30 000	2195 (11.6)	449 (6.3)	1705 (14.6)
30 000–1 00 000	14 332 (76.1)	5319 (74.6)	8996 (77.2)
>1 00 000	2249 (11.9)	1348 (18.9)	900 (7.7)
Missing	69 (0.4)	14 (0.2)	50 (0.4)
No of smokers in the family	18 821 (0.9±1.0)	7130 (0.0±0.0)	11 628 (1.4±0.9)

40 New Taiwan Dollars (NTD)≈£1; 30 NTD≈1 US\$.

\*Heavy SHS: mother reported 'often' or 'every day' to the question "How often is your baby exposed to secondhand smoke?"; non-heavy SHS: 'never' or 'occasionally' to that question.

SHS, secondhand smoke.

were found to be significantly associated with heavy SHS exposure (all  $p < 0.01$ ).

### Multivariate analysis

The results from multivariate logistic regression (table 3) indicate that among all of the 18-month-old infants, the presence of a smoker in the household increased the likelihood for them to be exposed to heavy SHS. The more smokers present in the household, the more likely they are to be exposed to heavy SHS. The older the mother is, the less likely child is to be exposed to heavy SHS. The higher the father and mother's educational status is, the less likely the child is to be exposed to heavy SHS. Being a first-born child is associated with decreased likelihood of heavy SHS exposure.

After dividing the infants into those living in smoker versus non-smoker households, parental characteristics such as age of mother and education of father and mother are significantly associated with the heavy early childhood SHS exposure for those living in smoker households but not among those living in non-smoker households. We found that among children living in smoker households, the older their mother is and the higher their father or mother's education is, the less likely the child is to be exposed to heavy SHS. Among infants living in a smoker household, the subgroup of infants having both smoker parents have significant

higher likelihood to be exposed to heavy SHS compared with their counterparts. The mother's employment status was found to be significantly associated with increased SHS exposure for infants in a smoker household but decreased SHS exposure for infants in non-smoker households. Being a first-born child was found to be associated with decreased likelihood of SHS exposure for infants living in either a non-smoker or smoker household.

### DISCUSSION

To our knowledge, this is the first study using a birth cohort data and investigating SHS exposure in utero and among young children at different ages under 5 years old. This study uses a unique dataset, the TBCS data, which randomly selected newborns from among all live births in 2005, and tracks SHS exposure in utero and when the children were 18 months, 36 months and 66 months old.

Our results indicate that among the 18-month-old infants, 61.8% of them lived in a household with at least one smoker, with the father being the smoker in 84% of those households. This result confirms previous studies in East Asia indicating that most childhood SHS may come from the father and other household members, whereas 76% of infants living in a smoker

**Table 2** Early childhood SHS exposure by household, parental and children's characteristics, n (%)

Characteristics	Total (n)	Non-heavy SHS	Heavy SHS	p Value
Total	18845	16 659 (88.4)	2183 (11.6)	
<b>Parent's characteristics</b>				
Father's age (years)				<0.0001
<25	475	373 (78.5)	102 (21.5)	
25–29	3440	2939 (85.4)	501 (14.6)	
30–34	6592	5909 (89.6)	683 (10.4)	
≥35	8338	7438 (89.2)	897 (10.8)	
Mother's age (years)				<0.0001
<25	2707	2171 (80.2)	535 (19.8)	
25–29	6117	5281 (86.3)	835 (13.7)	
30–34	6760	6195 (91.6)	564 (8.3)	
≥35	3261	3012 (92.4)	249 (7.6)	
Father's education level				<0.0001
Junior high or below	2500	1934 (77.4)	564 (22.6)	
Senior high	7454	6337 (85.0)	1117 (15.0)	
Junior college	4134	3808 (92.1)	325 (7.9)	
College and above	4623	4469 (96.7)	154 (3.3)	
Mother's education level				<0.0001
Junior high or below	2637	2076 (78.7)	559 (21.2)	
Senior high	7526	6442 (85.6)	1083 (14.4)	
Junior college	4797	4422 (92.2)	375 (7.8)	
College and above	3852	3689 (95.8)	163 (4.2)	
Parents' employment status				
Father employed	18053	16 007 (88.7)	2045 (11.3)	<0.0001
Father not employed	610	503 (82.5)	107 (17.5)	
Mother employed	11 475	10 337 (90.1)	1137 (9.9)	<0.0001
Mother not employed	7262	6240 (85.9)	1022 (14.1)	
Parents' smoking status				<0.0001
Only father smokes	8854	7404 (83.6)	1450 (16.4)	
Only mother smokes	87	75 (86.2)	12 (13.8)	
Both parents smoke	923	638 (69.1)	285 (30.9)	
None of them smoke	8760	8364 (95.5)	396 (4.5)	
Heavy smoker				
Father	4506	3351 (74.4)	1155 (25.6)	<0.0001
Mother	162	80 (49.4)	82 (50.6)	<0.0001
<b>Children's characteristics</b>				
Gender				0.189
Boy	9912	8733 (88.1)	1177 (11.9)	
Girl	8932	7926 (88.7)	1006 (11.3)	
Birth order				<0.0001
First-born child	9468	8491 (89.7)	976 (10.3)	
Non-first-born child	9365	8158 (87.1)	1207 (12.9)	
<b>Household characteristics</b>				
Family income (NTD)				<0.0001
<30 000	2195	1781 (81.1)	414 (18.9)	

Continued

Table 2 Continued

Characteristics	Total (n)	Non-heavy SHS	Heavy SHS	p Value
30 000–100 000	14 332	12 694 (88.6)	1 637 (11.4)	
>100 000	2 249	2 132 (94.8)	1 17 (5.2)	
Any smoker present in the household				<0.0001
No	7 130	6 968 (97.7)	1 62 (2.3)	
Yes	11 651	9 632 (82.7)	2 019 (17.3)	
No of smokers in the family				<0.0001
0	7 790	7 472 (95.9)	3 16 (4.1)	
1	7 309	6 463 (88.4)	8 46 (11.6)	
2	2 513	1 927 (76.7)	5 86 (23.3)	
≥3	1 209	7 78 (64.4)	4 31 (35.6)	

40 New Taiwan Dollars (NTD)=£1; 30 NTD=1 US\$.

SHS, secondhand smoke.

household have father being the only smoker, and 14% have other family member and 0.7% have mother being the only smoker.<sup>7 21</sup> These results indicate the urgent need to keep homes smoke-free to protect children from SHS exposure. Indeed, banning smoking in the home is found to be associated with a significant reduction in urinary cotinine to creatinine ratio in infants.<sup>22–25</sup> However, smoking restrictions in homes are not mandated by legal regulations, and the voluntary restriction of smoking is usually rare. Efforts are needed to encourage Taiwanese families to adopt their own policy of restricting smoking in the home setting.

Taiwan is similar to many other Asian countries in that the familial values are deeply influenced by Confucianism, with an expectation of respecting the elderly and males to maintain the patriarchal family. This philosophy of Confucianism and patriarchy embedded in Chinese familial values may cause married women and children to be hesitant to change the smoking behaviour of their male household members or to ask male smokers to smoke outside of the home.<sup>26 27</sup> Therefore, in addition to providing women with advice and information about the harms of SHS exposure, their husbands, partners and other household members should be informed with the risks of such exposure on pregnant women as well as children. Most importantly, smoking cessation support should be provided to increase the quit rates, which ultimately would reduce SHS exposure.<sup>28</sup>

Previous studies have indicated that smoke-free legislation in public places can spill over to the home setting through creating a norm of not smoking around non-smokers.<sup>16 29–32</sup> Indeed, a few studies found that the comprehensive smoke-free laws enacted in 2009 in Taiwan reduced adult non-smokers' SHS exposure in the home and even increased smoking cessation.<sup>11 14</sup> The enforcement of smoke-free environments in many public places may further reduce women and children's SHS exposure at home. In our study, we found that the

SHS exposure declined significantly from 12.1% when the children were 36 months old in 2008 to 9.5% when the children were 66 months old in 2010–2011. The decreasing patterns were similar when the sample was divided into those who live in smoker versus non-smoker households. Part of the decrease may result from the implementation of comprehensive smoke-free laws in 2009. Future studies may use the TBCS data to investigate the effect of comprehensive smoke-free laws on children's SHS exposure by comparing the exposure between precomprehensive and postcomprehensive smoke-free laws, controlling for environmental factors and household characteristics.

Our results indicated that the first-born children are significantly less likely to be exposed to heavy SHS than later-born children are. This finding confirms previous studies indicating that first-born children tend to receive higher quality care in social, affectionate and caretaking activities during early childhood than later borns do.<sup>33–35</sup> In addition, the finding of the high in utero SHS exposure indicates a serious lack of knowledge on and social protection from the harms of SHS exposure during pregnancy, leading pregnant women continually being exposed to SHS.<sup>36–38</sup>

Our results indicated that several factors are significantly associated with heavy early childhood SHS exposure, which allows the specific groups to be targeted by interventions to be identified, for example households with smokers, households with more than one smoker, both parents smoke, parents with lower educational attainment, mothers of younger age and non-first-born children. More educational interventions and resources need to be aimed at these target groups to reduce early childhood SHS exposure from their household smokers through education about the health risks from SHS exposure.

A potential limitation this study has is that parents or primary caregivers may under-report infant's SHS due to lack of awareness or social desirability bias.

**Table 3** Risk factors for heavy SHS exposure for children in all, smoker and non-smoker households

Characteristics	All households	Smoker households	Non-smoker households
<b>Total</b>			
<b>Parent's characteristics</b>			
Father's age (years) (ref: <25)			
25–29	0.82 (0.63–1.07)	0.81 (0.62–1.06)	1.54 (0.19–12.45)
30–34	0.86 (0.66–1.13)	0.85 (0.65–1.12)	1.46 (0.18–11.86)
≥35	0.87 (0.66–1.14)	0.88 (0.67–1.16)	1.24 (0.15–10.15)
Mother's age (years) (ref: <25)			
25–29	0.96 (0.84–1.11)	0.98 (0.85–1.13)	0.99 (0.46–2.13)
30–34	0.84 (0.71–0.99)*	0.84 (0.71–1.00)*	0.93 (0.41–2.09)
≥35	0.76 (0.62–0.92)**	0.75 (0.60–0.92)**	0.97 (0.40–2.32)
Father's education level (ref: ≤junior high)			
Senior high	0.77 (0.67–0.87)***	0.75 (0.66–0.85)***	2.04 (0.85–4.89)
Junior college	0.58 (0.48–0.69)***	0.56 (0.47–0.67)***	1.35 (0.54–3.41)
College and above	0.37 (0.29–0.48)***	0.33 (0.25–0.43)***	1.10 (0.42–2.86)
Mother's education level (ref: ≤junior high)			
Senior high	0.80 (0.70–0.92)***	0.80 (0.69–0.91)**	1.02 (0.48–2.14)
Junior college	0.72 (0.61–0.86)***	0.67 (0.55–0.81)***	1.40 (0.64–3.06)
College and above	0.80 (0.62–1.02)	0.84 (0.65–1.10)	0.83 (0.35–1.99)
Parents' employment status			
Father employed (ref: yes)	1.00 (0.78–1.29)	0.99 (0.76–1.29)	1.21 (0.42–3.49)
Mother employed (ref: yes)	1.10 (0.99–1.21)	1.18 (1.06–1.32)**	0.46 (0.31–0.68)***
Parents' smoking status (ref: none of them smoke)			
Only father smoke		0.87 (0.74–1.01)	
Only mother smoke		0.63 (0.32–1.22)	
Both parents smoke		1.62 (1.30–2.00)***	
<b>Children's characteristics</b>			
Child being a boy (Ref: girl)	1.07 (0.97–1.18)	1.07 (0.96–1.18)	1.04 (0.76–1.43)
First-born child (Ref: no)	0.73 (0.66–0.81)***	0.74 (0.67–0.83)***	0.62 (0.44–0.87)**
<b>Household characteristics</b>			
Family income (NTD) (ref: <30000)			
30000–100000	0.97 (0.83–1.12)	0.98 (0.84–1.13)	0.88 (0.43–1.82)
>100000	0.88 (0.68–1.13)	0.88 (0.67–1.16)	0.77 (0.32–1.82)
Any smoker present in the household (ref: no)	3.79 (3.03–4.73)***		
No of smokers in the family	1.45 (1.38–1.53)***	1.45 (1.38–1.53)***	

\*p&lt;0.05; \*\*p&lt;0.01; \*\*\*p&lt;0.001.

40 New Taiwan Dollars (NTD)≈£1; 30 NTD≈1 US\$.

SHS, secondhand smoke.

Nevertheless, in our sample, 55.2% of primary caregivers indicated that their children were exposed to SHS, and this prevalence is higher than previously found in Taiwan.<sup>10 13</sup> Another concern regarding systematic bias in childhood SHS exposure may arise if under-reporting occurs in a certain demographic or socioeconomic subgroup and not others. However, a study using multiple SHS exposure measures, both self-reporting and serum cotinine level, indicated that

exposure patterns by demographic characteristics were similar among those two measures.<sup>39</sup>

## CONCLUSIONS

This study investigated the early childhood SHS exposure among 18-month-old infants, a subgroup of young children spending most of their time at home and most likely to be exposed to household SHS through



their household members. The results indicate that most early childhood SHS comes from the father and other household members, whereas the smoking rate for women in this study setting is very low. Encouraging families to maintain a smoke-free home environment, empowering women to ensure their perspectives and rights are embedded into tobacco control efforts, and educating families about the health risks from childhood SHS exposure, especially among children living in households with smokers, will protect non-smoking women and their children from SHS exposure.

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