Secondhand smoke exposure inside the house and low birth weight in Indonesia: Evidence from a demographic and health survey

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KEYWORDS
secondhand smoke, tobacco control, low birth weight, Indonesia

Received: 27 April 2023, Revised: 20 June 2023, Accepted: 23 June 2023

Popul. Med. 2023;5(June):17

https://doi.org/10.18332/popmed/168620

ABSTRACT

INTRODUCTION Secondhand smoke (SHS) exposure during pregnancy among non-smoking women is associated with mortality and morbidity risks in infants. However, little is known about SHS inside the house and low birth weight in newborns. This study aims to assess the prevalence, level, and frequency of SHS exposure inside the house and investigate their associations with low birth weight.

METHODS We used the Indonesian Demographic and Health Survey (IDHS) 2017, a large-scale, nationally representative survey. Women aged 15–49 years who had given birth in the last five years before the study and their husbands were interviewed (n=19935). Two dependent variables included low birth weight (LBW) and birth weight.

RESULTS In all, 78.4% of mothers were exposed to SHS inside the home, of whom 7.2% had LBW children. Compared to non-exposed to SHS mothers, those exposed to SHS were younger, had their first birth before the age of 20 years, were married, lower educated, non-workers, lived in rural areas, were grand multipara, had pollution from cooking fuel, cooked in a separate building, and had a higher risk of delivering a lower birth weight (AOR=1.16; 95% CI: 1.02–1.33).

CONCLUSIONS Exposure to SHS inside the home was significantly associated with LBW. Given the high prevalence of smoking, relevant policies and health promotion are needed.

INTRODUCTION

Globally, about 0.6 million deaths are attributable to secondhand smoke (SHS) each year. More than 33% of the population is often actively or passively exposed to cigarette smoke, and about 35% of all female non-smokers are exposed to SHS[1]. Tobacco smoke exposure and the resulting inhalation of SHS are among the most widespread forms of micro-environmental exposure (i.e. indoor). Women and children aged <5 years are most vulnerable to indoor air pollution. A retrospective study from 192 countries reported that 40% of children were exposed to SHS, higher than non-smoking men and women, who were only 33% and 35%, respectively. In contrast, 47% of deaths related to SHS occurred in women, almost twice as many as in children and men[2]. In addition, 36% of children have been exposed since they were in the womb[3]. At least 40% of children have become passive smokers because of SHS in their homes, and 31% of them die from the cigarette smoke they breathe every day[2].

SHS during pregnancy among non-smoking women is associated with mortality and morbidity risks in their infants, including stillbirth, prematurity, miscarriage, and low birth weight (LBW)[4]. SHS is also associated with an increased risk of stunting, wasting, underweight among children, a smaller head circumference, and the susceptibility of being overweight simultaneously, in accordance with the country's Gross National Income[5]. Evidence in Indonesia showed that compared to non-exposed pregnant women, the risk of having low birth weight infants was around three times higher in exposed ones. A similar risk was also drawn based on the number of active smokers at home, the number of cigarettes consumed, and the exposure duration on a daily basis[6].

Based on Demographic and Health Survey data collected between 2008 and 2013, from 30 low- and middle-income countries (LMICs), daily SHS exposure accounted for a more significant population-attributable fraction of stillbirths than active smoking, which was 14% in Indonesia. This number is the highest among the other 30 LMICs[7]. Indonesia has compiled various regulations governing public protection from the dangers of exposure to cigarette smoke. One of them is the adoption of no-smoking zones in various public places and workplaces, especially in schools and hospitals. However, the World Health Organization (WHO) notes that regulations regarding smoke-free areas in public areas in Indonesia are still relatively low compared to other South-East Asian countries, and in accordance with the geographical distribution as well as socioeconomic disparity, in urban settings, the wealthier and more educated population were more likely to adopt a smoke-free policy[8].

Given the implications for child mortality, a significant reduction in the prevalence of LBW is necessary to achieve the Sustainable Development Goals, and there is a similar need to strengthen the implementation of the Framework Convention on Tobacco Control (FCTC) of the WHO in all countries[9]. Only a few robust studies examined a clear association between exposure to SHS inside the house and birth outcomes, especially in Indonesia[10,11]. This study contributes to filling the knowledge gap in SHS exposure inside the house and low birth weight in Indonesia by using the evidence of large-scale population-based data and taking into account SHS frequency and LBW, neither of which have been presented in previous studies. This study assesses the prevalence, level, and frequency of SHS exposure inside the house and their associations with birth outcomes.

METHODS

Data sources

We used data from the latest 2017 Indonesia Demographic and Health Survey (IDHS) survey, a nationally representative, large-scale, and repeated cross-sectional household survey collecting population, health, and nutrition data. All ever-married women aged 15–49 years who had given birth in the last five years before the survey in sampled households are eligible for an interview using a standard self-reported questionnaire[12]. Women were chosen to give birth during the last five years before the survey to prevent bias in memory recall from mothers. The total sample size in the study was 19935. Respondents in the 2017 IDHS read a written informed consent statement before each interview. The statement also included voluntary participation, refusal to answer questions or termination of participation at any time, and confidentiality of identity and information.

Measurement

Two main independent variables were the exposure to SHS inside the house and the frequency of SHS exposure. The information about SHS inside the house is obtained from two types of 2017 IDHS questionnaires: the household questionnaire and the women's questionnaire. The information regarding SHS exposure at home was derived from the question at the household questionnaire: 'How often does anyone smoke inside your house? (daily, weekly, monthly, less than monthly, never)?'. To ascertain whether the mother in the household smoked or not, we linked smoking data from the household questionnaire to the women's questionnaire through their unique identifier codes. In the women's questionnaire, there are two questions related to smoking habits: 1) 'Do you currently smoke?' (every day, sometimes, not at all); 2) 'In the past, have you ever smoked?'. (every day, sometimes, not at all.) All household members and mothers who answered 'never' or 'not at all' were included in the 'non-exposed' SHS group. Meanwhile, the SHS 'exposed' group consists of: 1) household members who do not smoke, but the mother smokes; 2) household members who smoke, but the mother does not smoke; and 3) all household members and mothers who answered 'daily, weekly, monthly, less than monthly, every day, sometimes'. Then, a binary variable (not exposed vs exposed) was created to measure exposure to SHS inside the house, where one or more adults smoke commercial cigarettes, cigars (including kretek cigarettes or unfiltered cigarettes of Indonesian origin), and other country-specific smoking products (including pipes, cigars, shisha, chewing tobacco, and chewing betel nut with tobacco). The information regarding SHS exposure frequency at home was derived from the question on the household questionnaire in the 2017 IDHS: 'How often does anyone smoke inside your house?' (daily, weekly, monthly, less than monthly, never). SHS frequency was then classified as: not exposed, less than once a month, monthly, weekly, and daily. Two outcome variables related to the self-reported birth outcomes are LBW and birth weight. We treated LBW (<2500 g; compared to ≥2500 g) as a categorical variable. Birth weight (g) was treated as a continuous variable.

Potential covariates

Demographic and socioeconomic characteristics included maternal age, age at first birth, marital status, maternal education level, family size, mother's occupation, husband's education level, residence (urban or rural), parity, birth interval, birth order, wealth index, cooking fuel, and kitchen location. The wealth index is a composite measure of a household's cumulative living standard or ownership of selected assets. The resulting combined wealth index has a mean of zero and a standard deviation of one. Once it is obtained, national-level wealth quintiles are obtained by assigning the household score to each de jure household member, ranking each person in the population by their score, and then dividing the ranking into five equal parts, from quintile one (lowest=poorest) to quintile five (highest=wealthiest), each having approximately 20%

of the population. Cooking fuel consists of electricity or gas, kerosene, coal or lignite, charcoal, and wood or straw (including grass, shrubs, and plant residues). Clean cooking fuels include electricity or gas, while pollutant cooking fuels include kerosene, coal or lignite, charcoal, and wood or straw (including grass, shrubs, and plant residues).

Statistical analysis

The data were analyzed using SPSS version 25. The proportions and chi-squared tested the differences between SHS exposure and demographic and socioeconomic characteristics inside the house. Logistic regression analyses measured the relative odds of associations between SHS exposure and frequency inside the house and LBW. The general linear model assessed the relationships between SHS exposure and frequency inside the house and birth weight. All multivariable models were used to control for covariates. Backward elimination as the variable selection procedure retained critical confounding variables, resulting in a slightly richer model. The overall model was also evaluated using the goodness-of-fit test and the likelihood ratio test.

RESULTS

The characteristics of the participants are presented in Table 1. In all, 78.4% of the mothers were exposed to SHS in the household, with 7.2% of those with LBW being exposed to SHS. Compared with non-SHS exposure mothers, mothers exposed to SHS were aged 15–24 years, had their first birth before 20 years of age, were married, had a lower education, were non-workers, lived in a rural area, had grand multiparas, had pollution from cooking fuel, and cooked in a separate building. All the indicators were statistically significant at p<0.05, except for the husband's occupation and birth interval, which were not different in exposure to SHS.

Table 2 shows that the mean birth weight was significantly associated with SHS exposure inside the house. After adjusting for the covariates, mothers exposed to SHS had children with a mean birth weight of 71.6 g (p<0.01) lower than that of mothers who were not exposed to SHS. Compared to non-SHS exposure, mothers who were exposed to SHS showed a 1.16-fold increase in the odds of having LBW children (AOR=1.16; 95% CI: 1.02–1.33, p<0.05). For SHS exposure frequency, mothers exposed to SHS daily had children with a mean birth weight of 63.4 g (p<0.01) lower than that of mothers who were not exposed to SHS. Compared to non-SHS exposure, mothers who were exposed to SHS weekly and daily showed an increase in the odds of having LBW children (AOR=1.33; 95% CI: 1.03–1.71, p<0.05 and AOR=1.18; 95% CI: 1.01–1.38, p<0.05, respectively).

Table 1. Characteristics of participants by exposure to SHS inside the house based on secondary data analysis from the 2017 Indonesia Demographic Health Survey (N=19935)

Characteristics	All (n=19935) n (%)*	SHS exposure		p[a]
		Not exposed (n=4305) n (%)*	Exposed[b] (n=15627) n (%)*	
Birth weight (g)				0.007
Normal (≥2500)	16287 (93.0)	3529 (94.0)	12758 (92.8)	
Low (<2500)	1225 (7.0)	225 (6.0)	997 (7.2)	
Birth weight (g), mean (SD)		3165.1 (506.6)	3066.1 (551.7)	<0.001
Maternal age (years)				<0.001
15–24	3370 (16.9)	470 (10.9)	2899 (18.6)	
25–34	10342 (51.9)	2328 (54.1)	8013 (51.3)	
>34	6223 (31.2)	1507 (35.0)	4715 (30.2)	
Maternal age at first birth (years)				<0.001
<20	5712 (28.7)	880 (20.4)	4830 (30.9)	
20–29	12950 (65.0)	3067 (71.2)	9882 (63.2)	
>29	1273 (6.4)	358 (8.3)	915 (5.9)	
Marital status				<0.001
Unmarried	31 (0.2)	7 (0.2)	24 (0.2)	
Married	19297 (96.8)	4101 (95.3)	15193 (97.2)	
Divorced/widowed/ separated	607 (3.0)	197 (4.6)	410 (2.6)	

Continued

Table 1. Continued

Characteristics	All (n=19935) n (%)*	SHS exposure		p[a]
		Not exposed (n=4305) n (%)*	Exposed[b] (n=15627) n (%)*	
Maternal education level				<0.001
None	295 (1.5)	47 (1.1)	248 (1.6)	
Primary	5109 (25.6)	778 (18.1)	4330 (27.7)	
Secondary	11035 (55.4)	2291 (53.2)	8742 (55.9)	
Higher	3496 (17.5)	1189 (27.6)	2307 (14.8)	
Family size, mean (SD)		5.1 (1.8)	5.7 (2.2)	
Mother's occupation				<0.001
Not working	9263 (46.5)	1811 (42.1)	7451 (47.7)	
Working	10672 (53.5)	2494 (57.9)	8176 (52.3)	
Husband's occupation				0.821
Not working	151 (0.8)	33 (0.8)	118 (0.8)	
Working	18976 (99.2)	4003 (99.2)	14970 (99.2)	
Residence				<0.001
Rural	9918 (49.8)	1532 (35.6)	8484 (54.3)	
Urban	10017 (50.2)	2773 (64.4)	7143 (45.7)	
Parity				<0.001
≥5	1427 (7.2)	240 (5.6)	1186 (7.6)	
3–4	5968 (30.1)	1351 (31.5)	4616 (29.7)	
1–2	12456 (62.7)	2698 (62.9)	9757 (62.7)	
Birth interval				0.163
Short (<33 months)	2845 (21.4)	592 (20.5)	2253 (21.7)	
Recommended (≥33 months)	10435 (78.6)	2298 (79.5)	8135 (78.3)	
Birth order, mean (SD)		2.3 (1.3)	2.4 (1.5)	<0.001
Wealth index				<0.001
Q1 (poorest)	5466 (27.4)	692 (16.1)	4773 (30.5)	
Q2	3901 (19.6)	611 (14.2)	3290 (21.1)	
Q3	3635 (18.2)	735 (17.1)	2899 (18.6)	
Q4	3532 (17.7)	944 (21.9)	2587 (16.6)	
Q5 (richest)	3401 (17.1)	1223 (30.7)	2078 (13.3)	
Cooking fuel				<0.001
Clean	13597 (68.2)	3333 (77.5)	10236 (65.7)	
Pollutant	6334 (31.8)	970 (22.5)	5362 (34.3)	
Kitchen location				<0.001
Separate building	1482 (7.4)	257 (6.0)	1225 (7.8)	
In-house	17930 (90.1)	3929 (91.5)	13998 (89.7)	
Outdoor	496 (2.5)	106 (2.5)	390 (2.5)	

a Chi-squared measure for the group difference of categorical variables, while continuous variables used generalized linear regression. b SHS exposure frequency: never (n=4305; 21.6%), less than once a month (n=2417; 12.1%), monthly (n=313; 1.6%), weekly (n=1274; 6.4%), and daily (n=11623; 58.3%). SHS: secondhand smoke. SD: standard deviation. *Weighted percentage.

Table 2. Association between SHS exposure and frequency inside the house, birth weight, and low birth weight, based on secondary data analysis from the 2017 Indonesia Demographic Health Survey (N=17400)

SHS exposure	n	Birth weight (g)	Low birth weight	
		Adjusted mean ± SE[a]	OR (95% CI)	AOR (95% CI)[b]
Inside the house				
Not exposed	3724	3176.6 ± 11.11	1	1
Exposed	13676	3105.0 ± 5.76**	1.21 (1.04–1.40)*	1.16 (1.02–1.33)*
Frequency				
Not exposed	3724	3140.8 ± 9.06	1	1
Less than once a month	2119	3074.6 ± 11.70	1.11 (0.90–1.38)	1.10 (0.88–1.36)
Monthly	281	3054.3 ± 32.03	1.19 (0.74–1.90)	1.16 (0.72–1.86)
Weekly	1124	3061.2 ± 16.02	1.37 (1.07–1.76)*	1.33 (1.03–1.71)*
Daily	10152	3077.4 ± 5.41**	1.21 (1.04–1.41)*	1.18 (1.01–1.38)*

SE: standard error. a Adjusted for maternal age, maternal education level, residence, parity, birth interval, wealth index, cooking fuel, and kitchen location. b AOR: adjusted odds ratio; adjusted for maternal age, maternal education level, mother's occupation, husband's occupation, residence, and parity. *p<0.05, **p<0.010.

DISCUSSION

Our findings show that 78.4% of the study sample were exposed to SHS inside the house, which is remarkably higher than the prevalence of SHS exposure at home in other countries such as China (48.3%), Bangladesh (46.7%), and Thailand (46.8%)[13-15]. SHS is a significant source of indoor particulate matter pollution, which is further enhanced inside the houses by cigarette smoking. Cigarette smoke contains toxic substances and has detrimental effects on almost every organ in the body. Besides, tobacco smoke contains a large variety of poisonous gases and particles that are hazardous to smokers and those around them[16].

SHS exposure in the house during pregnancy raised the risk of LBW, which was 7.2% more likely in households for babies whose mothers were exposed to SHS compared to babies whose mothers were not. As the prevalence of smoking is rising in some Asian countries due to a change in tobacco markets from high- to low-income countries[17], LBW may be unavoidable. Regarding SHS exposure frequency, mothers who were exposed to SHS at a daily rate were at an increased risk of having LBW newborns and smaller infants. The results of other studies in different populations, such as the Netherlands, USA, and Greece, have also shown that exposure to SHS positively correlates with LBW risk levels[4,18,19].

Previous retrospective and prospective cohort studies confirmed that the exposure to domestic cigarette smoke throughout pregnancy was significantly related to the lower adjusted mean birth weight and doubled the risk of having a smaller baby[20]. Voigt et al.[21] also reported that the mean birth weight of the exposed group was significantly lower irrespective of the body mass index (BMI) of the mother. It was suggested that there was a 12.9 g reduction in birth weight related to exposure to each additional cigarette smoked, and the prevalence of LBW was twice higher in exposed women compared to non-exposed women[20]. Two pathways can explain the plausible mechanism for the increased risk of LBW, namely: 1) the elevation of Tumor Necrosis Factor-alpha triggered by SHS exposure, which is transmitted across the placenta; and 2) the increased secretion of TNF- and Vascular Cell Adhesion Molecule-1 as inflammatory markers. The abundant level of inflammatory markers in pregnant women leads to the damage of the placenta, and thus nutrients and oxygen cannot be optimally delivered to the fetus, resulting in suboptimal growth and LBW[22].

There were 58% of women with daily exposure; these women were younger in maternal age (the proportion of women maternal age 15–24 year was 12.7% versus 19.9% with non-daily versus daily, or 1.6 times, which may drive the higher birth rates among daily). One study in China showed that birth weight increased by 16.204 g per year when maternal age was <24 years, increased by 12.051 g per year when maternal age ranged 24–34 years, and decreased by 0.824 g per year for those aged ≥34 years[23]. Smoking prevalence in men will raise the risk of SHS exposure among young women who have never smoked[24]. Since many women spend the majority of their time at home, the home is the most common source of SHS exposure for unemployed women. Well-educated and higher income women may have a greater understanding of the hazards of SHS exposure and may have more positive attitudes toward SHS exposure in the home, resulting in them becoming more conscious of avoiding SHS[25]. Also, because younger maternal age may tend to have lower education level, employability, income, and parity,

In terms of birth size, the exposure to SHS attenuated the risk of delivering a macrosomia baby (weight >4000 g) by almost 2 times among obese women (BMI of 30 kg/m^2) and, on the other hand, increased the risk of delivering LBW infants among underweight women (BMI of 18 kg/m^2) by almost 3-fold[26]. The nicotine exposure during pregnancy impaired the differentiation and proliferation of placenta cells named cytotrophoblasts (CTB), which reduced blood flow and created a pathological hypoxic environment in the womb[27]. Voigt et al.[28] suggested that the prevalence of small gestational age, defined by birth weight, length, and head circumference, rises in accordance with the increasing exposure to cigarette smoke, up to 8% for each 7 additional cigarettes consumed daily.

Limitations

A self-reported questionnaire of SHS without measurement of the duration of maternal or pregnancy exposure and cotinine levels in the household may have underestimated the true impact of SHS in Indonesia. Also, we are unable to match the period of smoking experience (by anyone) and the period of pregnancy. Secondly, since we used a cross-sectional dataset and worked under the presumption that SHS was even over time, the results should be interpreted with caution, and thus causality could not be determined. With reliable measurement of exposure to SHS toxins, a prospective cohort study would be suitable. Finally, we were unable to account for a variety of unmeasured confounders, such as biological influences, including food intake and nutritional status of pregnant women. Future studies may assess the associations between SHS smoke inside the house, the number of cigarettes exposed to per day, birth length, and head circumference, in addition to birth weight. Nonetheless, our research contributes to the body of knowledge on the effects of SHS with regard to birth weight. With a wide range of representative populations in Indonesia, this is the first study of its kind, thereby raising its generalizability to the Indonesian population, the largest cigarette consumer in the Asia Pacific region.

CONCLUSIONS

The homes of non-smokers living with smokers must be taken into account through the smoke-free homes policy. Therefore, it is not only important to enact regulations, but also to consider more public health strategies to raise awareness of the adverse health effects caused by SHS exposure. It is important to do further research to investigate the duration of SHS exposure and other biological parameters. Public health promotions that disseminate general recommendations for action are likely to have a positive impact on the health of mothers, newborns, and children.

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ACKNOWLEDGEMENTS
The authors would like to acknowledge the Indonesian Demographic and Health Survey (IDHS) Program for the access to the data used in this study.

CONFLICT OF INTEREST
The authors have each completed and submitted an ICMJE form for disclosure of potential conflicts of interest. The authors declare that they have no competing interests, financial or otherwise, related to the current work. H. Andriani reports that since the initial planning of the work she received payments from a research grant from Indonesian Tobacco Control Research Network (ITCRN) 2020, in collaboration with the Center of Islamic Economics and Business, Faculty of Economics and Business, Universitas Indonesia and the Johns Hopkins Bloomberg School of Public Health.

FUNDING
This work was supported by a research grant from Indonesian Tobacco Control Research Network (ITCRN) 2020, in collaboration with the Center of Islamic Economics and Business, Faculty of Economics and Business, Universitas Indonesia and the Johns Hopkins Bloomberg School of Public Health. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

ETHICAL APPROVAL AND INFORMED CONSENT
The Institutional Review Board (IRB) of the Inner City Fund International Inc., Fairfax, VA, USA, reviewed and approved the study procedures and survey protocols. After obtaining authorization from the Indonesian Demographic and Health Survey to use the dataset, the IRB of Universitas Indonesia provided further ethical approval (Approval number: 598/UN2.F10.D11/PPM.00.02/2020; Date: 31 August 2020). Participants provided informed consent.

DATA AVAILABILITY
Data sharing is not applicable to this article as no new data were created.

AUTHORS' CONTRIBUTIONS
HA and NDR: conceptualized the study, interpreted the results, and drafted the manuscript. HA: collected the data and performed the analysis. All authors: revised the manuscript critically for important intellectual content, read, and approved the final version of the manuscript.

PROVENANCE AND PEER REVIEW
Not commissioned; externally peer reviewed.