Second-Hand Smoke Exposure inside the House and Adverse Birth Outcomes in Indonesia: Evidence from Demographic and Health Survey 2017

Helen Andriani1*, Nurul Dina Rahmawati2, Abdillah Ahsan3, Dian Kusuma4

1Department of Health Policy and Administration, Faculty of Public Health, Universitas Indonesia, Depok, Indonesia
2Department of Nutrition, Faculty of Public Health, Universitas Indonesia, Depok, Indonesia
3Faculty of Economics and Business, Universitas Indonesia, Depok, Indonesia
4Centre for Health Economics & Policy Innovation, Imperial College Business School, London, UK

Address: Kampus Baru UI Depok, Depok 16424, Indonesia, Department of Health Policy and Administration, Faculty of Public Health, Universitas Indonesia, Depok, Indonesia

*Corresponding author: Helen Andriani, Ph.D
Phone: (62)-21-7864975
Fax: (62)-21-7864975
e-mail: helenandriani@ui.ac.id

Declaration

Funding: This study was supported by the 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.

Conflicts of interest/Competing interests: The authors have no conflicts of interest associated with the material presented in this paper.

Ethics approval: 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 IDHS to use the dataset, the IRB of Universitas Indonesia provided further ethical review approval (598/UN2.F10.D11/PPM.00.02/2020).

Consent to participate: Not applicable

Consent for publication: Not applicable

Availability of data and material: Not applicable

Code availability: Not applicable

Authors' contributions: Conceptualization: HA and NDR; Data acquisition and curation: HA; Methodology: HA, NDR, DK; Software: HA; Formal analysis: HA; Interpretation: HA, NDR, AA, DK; Writing original draft: HA and NDR; Writing critical review: HA, NDR, AA, DK. All authors read and approved the final manuscript.

Acknowledgments

The authors would like to acknowledge the Indonesian Demographic and Health Surveys (IDHS) Program for the access to the data used in this study. This study was supported by the
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 and collection, analysis, and interpretation of data and in writing the manuscript.

ABSTRACT

Objectives: Second-hand Smoke (SHS) during pregnancy among non-smoking women associates with mortality and morbidity risks in their infants. However, little is known about the SHS inside the house and the adverse birth outcomes. This study aims to assess the prevalence, level, and frequency of SHS exposure inside the house and investigate their associations with birth outcomes.

Methods: We use the Indonesian Demographic and Health Survey (IDHS) 2017, a large-scale nationally representative survey. Women aged 15 to 49 years who had given birth in the last five years before the study and their husbands were interviewed (n=19,935). Three dependent variables included Low Birth Weight (LBW), size at birth, and birth weight.

Results: Seventy-eight percent of mothers exposed to SHS inside home, of whom 7.2% had LBW children. Compared to non-SHS exposure mothers, those exposed to SHS were younger, had first birth before 20 years old, married, lower educated, non-worker, lived in rural, grand multipara, had pollution from cooking fuel, cook in a separate building, had higher risk of delivering lower birth weight (aOR=1.16, 95% CI: 1.02, 1.33), and smaller baby (aOR=1.51, 95%CI: 1.35, 1.69), even after the controlling for the covariates. We identified the inverted U-shaped association for SHS exposure frequency. Similar risk was also observed among mothers exposed with SHS on a daily basis compared to those who are not exposed.

Conclusion for Practice: Exposure to SHS inside home was significantly associated with LBW and size at birth. Given the high smoking prevalence, relevant policy and health promotion are needed.

Significance Statement

Adverse birth outcomes, such as low birth weight and smaller size at birth, may not be clearly explained by the second-hand smoke (SHS) exposure from a smoking husband alone. Our findings show that the prevalence of SHS inside the house in Indonesia is 78.4%. Pregnant women exposed to anyone who smokes in the household may be linked to poor birth quality, including low birth weight and smaller size at birth in their babies, after adjustment for risk.
factors. The effects of SHS exposure on birth outcomes are further exacerbated by daily SHS exposure.

**Keywords**: Second-hand smoke, tobacco control, low birth weight, birth size, Indonesia

**Introduction**

Globally 600,000 deaths are attributable to Second-hand Smoke (SHS) in each year (Oberg et al., 2011) and 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 (Data). Tobacco smoke exposure and the resulting inhalation of SHS is among the most widespread forms of micro-environmental exposure (i.e., indoor) is among the most widespread forms of micro-environmental exposure (i.e., indoor). Women and children under five years of age are most vulnerable in the houses or 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, that were only 33% and 35%, respectively, while 47% of death contributed to SHS occurred in women, almost twice higher than in children and men (Oberg et al., 2011). In addition, 36% of children even got exposed since they were in the womb (Cheng et al., 2017). At least 40% of children had become passive smokers because of SHS in their homes, and 31% of them die due to the cigarette smoke they breathe every day (Oberg et al., 2011).

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) (Jaddoe et al., 2008). SHS also increased risk of stunting (length for age), wasting (weight for age), and underweight (weight for length) among children as well as smaller head circumference resulting smaller babies, on the other hand increased susceptibility of being overweight at the same time, in accordance to the Gross National Income of the country (Nadhiroh et al., 2020). Evidence in Indonesia showed that compared to non-exposed pregnant women, the risk of having low birth weight infants were around three times higher in exposed ones. Similar risk was also drawn based on the number of active smokers at home, number of cigarettes consumed, and exposure duration in a daily basis (Ardelia et al., 2019).

Based on Demographic and Health Survey data collected between 2008 and 2013 from 30 Low-income and Middle-income Countries (LMICs), daily SHS exposure accounted for a greater population attributable fraction of stillbirths than active smoking was 14% in
Indonesia. This number is the highest among other 30 LMICs (S. Reece et al., 2019). Indonesia has compiled various regulations governing public protection from the dangers of exposure to cigarette smoke. One of them is through the adoption of no-smoking zones in various public places and workplaces, especially in schools and hospitals. However, World Health Organization (WHO) notes that regulations regarding smoke-free areas in public areas in Indonesia are still relatively low compared to other Southeast Asia countries and in accordance with the geographic distribution as well as socio-economic disparity, where urban settings, wealthier and more educated population were more likely adopt smoke-free policy (Wahidin et al., 2020).

Given the implications for child mortality, a significant reduction in prevalence of LBW is necessary in order to achieve Sustainable Development Goals (SDGs) and a similar need to strengthen the implementation of the Framework Convention on Tobacco Control (FCTC) of the WHO in all countries (Organization, 2015a). Only few robust studies examined clear association between the exposure to SHS inside the house and birth outcomes, especially in Indonesia (Noriani et al., 2015; Sian Reece et al., 2019; Soesanti et al., 2019). This study contributes to fill knowledge gap in SHS exposure inside the house and adverse birth outcomes in Indonesia, using the latest and quantitative evidence of a large-scale population-based data and taking into account SHS frequency, LBW, and size at birth, neither of which have been presented in previous studies. This study aims to assess the prevalence, level, and frequency of SHS exposure inside the house and investigate the association between SHS exposure inside the house and birth outcomes.

Methods

Data sources

We use data from the latest survey of Indonesia Demographic and Health Survey (IDHS) 2017, a nationally representative, large-scale, and repeated cross-sectional household survey collecting population, health, and nutrition data. All ever married women between 15 to 49 years of age who had given birth in the last five years prior to the survey in sampled households are eligible for an interview using a standard self-reported questionnaire (Population et al., 2018). The reason women were chosen to give birth during the last five years prior to the survey was to prevent bias in memory recall from mother. A written, informed consent was given to all participants. The total sample size in the study was 19,935.
Ethical oversight

The 2017 IDHS program collects data periodically for policy development and program planning, monitoring and evaluation. Respondents read an informed consent statement before each interview. The statements include voluntary participation, refusal to answer questions or termination of participation at any time and confidentiality of identity and information. 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 IDHS to use the dataset, the IRB of Universitas Indonesia provided further ethical review approval (598/UN2.F10.D11/PPM.00.02/2020).

Measurement

Two main independent variables were the exposure to SHS inside the house and SHS exposure frequency. A binary variable (not exposed vs exposed) was created to measure exposure to SHS inside the house, where one or more adult smoke commercial cigarettes, cigars, and other country-specific smoking products. SHS smoking frequency was classified as: not exposed, less than once a month, monthly, weekly, and daily.

Three outcomes variable related to the self-reported birth outcomes are: 1. LBW, 2. Size at birth, and 3. Birth weight. We treated LBW (<2,500; >2500 grams) and size at birth (mothers’ perception of their newborns’ size at birth: smaller than average; average; and larger than average) as categorical variables. We note that there are mixed results in the literature on the validity of using mother’s perceptions on size (Channon, 2011; Nigatu et al., 2019), but for our data we found significant positive association of the perceived size and birth weight (see Table S1). Birth weight (in grams) was treated as continuous variable. Control variables included demographic and socioeconomic characteristics such as maternal age, age at first birth, marital status, maternal education, family size, mother’s occupation, husband’s education, residence (urban; rural), parity, birth interval, birth order, wealth index (a composite measure of a household’s cumulative living standard or ownership of selected assets), cooking fuel, and kitchen location.

Statistical analyses
Data were analyzed using SPSS version 25. The proportions and chi-squared tests were used to test for differences between SHS exposure inside the house, demographic and socioeconomic characteristics. Logistic regression analyses were conducted to measure relative odds of associations of SHS exposure and frequency inside the house with LBW and size at birth. Using General Linear Model, we assessed the relationships of SHS exposure and frequency inside the house with birth weight. All multivariable models were used to control for background characteristics. In addition to significant covariates, backward elimination was performed as the variable selection procedure to retain important confounding variables, resulting potentially in a slightly richer model. The overall model is also evaluated using the goodness of fit test by likelihood ratio test.

Results

The characteristics of the participants are presented in Table 1. Seventy-eight percent of the mothers in our study were exposed to SHS in the household, with 7.2% of those who had LBW being exposed SHS. Compared with non-SHS exposure mothers, mothers exposed to SHS were aged 15-24 years, had first birth before 20 years of age, married, had a lower education, non-worker, lived in a rural area, grand multipara, had pollution from cooking fuel, and cook in a separate building. All the indicators were statistically significant at p<0.05, except for husband’s occupation and birth interval, which were not different in exposure to SHS.

Table 2 shows the association between SHS exposure inside house and birth weight and LBW. 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<0.001) lower than that of mothers who did not exposed to SHS. SHS exposure significantly raised the odds of having LBW children (OR=1.21, p<0.05). After adjusting for the covariates, compared to non-SHS exposure, mothers who exposed to SHS showed a significant 1.16-fold increase in the odds for having LBW children (adjusted OR=1.16, 95% CI [1.02, 1.33], p<0.050). For SHS exposure frequency, mothers exposed to SHS daily had children with a mean birth weight of 63.4 g (p<0.001) lower than that of mothers who did not exposed to SHS. SHS exposure weekly and daily significantly raised the odds of having LBW children (OR=1.37, p<0.050 and OR=1.21, p<0.050, respectively). After adjusting for the covariates, compared to non-SHS exposure, mothers who exposed to SHS weekly and daily showed a significant 1.33-fold and 1.18-fold increase in the odds for
having LBW children (adjusted OR=1.33, 95% CI [1.03, 1.71], p<0.050 and adjusted
OR=1.18, 95% CI [1.01, 1.38], p<0.050). We have identified the inverted U-shaped
association between SHS exposure frequency and birth weight or LBW. Daily exposure
group showed a statistically significant lower adjusted mean of birth weight than non-
exposed group and lower odds of LBW than weekly exposure group, but still showed a
higher adjusted mean of birth weight when compared with weekly or other categories of SHS
and a higher odd of LBW when compared with non-exposed or other categories of SHS.

Table 3 shows the association between SHS exposure size at birth, using multinomial
logistic model. Mothers who exposed to SHS significantly raised the odds of having larger
than average size at birth of their children (OR: 1.09, p<0.05) and having smaller than
average size at birth of their children (OR: 1.41, p<0.001). After adjusting for the covariates,
compared to those who did not expose to SHS, mothers who exposed to SHS showed a
significant 1.10-fold increase in the odds for having larger than average size at birth of their
children (adjusted OR (95% CI): 1.10 (1.01 – 1.20), p<0.05) and having smaller than average
size at birth of their children (adjusted OR (95% CI): 1.51 (1.35 – 1.69), p<0.001). Mothers
who exposed to SHS daily significantly raised the odds of having larger than average size at
birth of their children (OR: 1.10, p<0.05) and having smaller than average size at birth of
their children (OR: 1.43, p<0.001). After adjusting for the covariates, compared to those who
did not expose to SHS, mothers who exposed to SHS daily showed a significant 1.11-fold
increase in the odds for having larger than average size at birth of their children (adjusted OR
(95% CI): 1.11 (1.02 – 1.201), p<0.05) and having smaller than average size at birth of their
children (adjusted OR (95% CI): 1.54 (1.37 – 1.73), p<0.001).

Discussion

Our findings show that 78.4% of study sample were exposed to SHS inside the house, which
is remarkably higher than the prevalence of SHS exposure at home from other countries such as
China (48.3%), Bangladesh (46.7%), and Thailand (46.8%) (Fischer et al., 2015;
Phetphum & Noosorn, 2020; Wang et al., 2009). SHS is a major source of indoor pollution of
particulate matter and is further enhances 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 gasses and particles that
are hazardous to not only the smokers but also to those around them (Nafees et al., 2012).

It is made available under a CC-BY-NC 4.0 International license.
We also found significant associations between SHS exposure and birth weight, LBW, and size at birth. SHS exposure in the house during pregnancy raised the risk of LBW, which was 7.2% more likely in household for babies whose mothers were exposed to SHS compared to babies whose mothers were not. The frequency of exposure has also contributed significantly to LBW risk. As the prevalence of smoking is rising in some Asian countries due to a change in tobacco markets from high to low-income countries (Organization, 2015b), adverse birth outcomes such as LBW and size at birth may be unavoidable. Our research showed that mothers exposed to SHS in Indonesia were 1.16 times more likely to have LBW newborns and 1.51 times more likely to have smaller infants. In terms of 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 is positively correlated with LBW risk (Jaddoe et al., 2008; La Merrill et al., 2011; Vardavas et al., 2010).

Previous retrospective and prospective cohort studies confirmed that the exposure of domestic cigarette smoke throughout the pregnancy was significantly related to the lower adjusted mean birth weight as well as doubling the risk of having smaller baby (Kobayashi et al., 2019; Norsa'adah & Salinah, 2014). Voigt et al. also reported that the mean birth weight of exposed group was significantly lower no matter the Body Mass Index (BMI) of the mothers is (Voigt, Jorch, et al., 2011). It was suggested that there was 12.9 g reduction of birth weight related to exposure of each additional cigarette smoke and prevalence of LBW was twice higher in exposed compared to non-exposed women (Norsa'adah & Salinah, 2014). The plausible mechanism for the increased risk of LBW can be explained by two pathways, namely: 1) the elevation of Tumor Necrosis Factor alpha triggered by SHS exposure which is transmitted across placenta and might directly increase the risk of LBW, and 2) significant reduction of placental weight by almost 4 times lower compared to un-exposed mothers due to the increased secretion of TNF-α and Vascular Cell Adhesion Molecule-1 as inflammatory markers. These factors can be directly associated with LBW since the abundant level of inflammatory markers in pregnant women lead to the damage of placenta and thus nutrient and oxygen cannot be optimally delivered to the fetus, resulting suboptimal growth and LBW (Niu et al., 2016).

The inverted U-shaped association were likely attributable to the age of mother, education, occupation, parity, and wealth index. Compared with non-daily exposure, mothers exposed to daily SHS were aged 15-24 years, had first birth before 20 years of age, had a
lower education, non-worker, grand multipara, and were from lower wealth index. There were 58% of women in our sample had daily exposure; these women were younger maternal age (the proportion of women maternal age 15–24 was 12.7% vs 19.9% with non-daily vs daily (or 1.6 times)), which may drive the higher birth rates among daily. One study in China showed that birth weight increased 16.204 g per year when maternal age was less than 24 years old, and increased 12.051 g per year when maternal age ranged from 24 to 34 years old, then decreased 0.824 g per year from 34+ years (Wang et al., 2020). In our study, although it has been controlled for maternal age in regression, it still shows U-shaped for daily, so that the potential explanation could be maternal age. Smoking prevalence in men will raise the risk of SHS exposure among young women who have never smoked (Lim et al., 2018). 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 (Sun et al., 2016). Also, because younger maternal age may tend to be lower education, employability, income, and higher parity. The self-administration of nicotine (positive re-enforcing effect) need optimum doses near the top of the inverted U that may enhance growth, longevity, etc., but at higher doses, aversive effects dominated (Heishman et al., 2010). These findings reinforced the social inequality associated with smoking, backed up the need for further research on the subject, and emphasized the need for more approaches to control the issue.

In terms of birth size, the exposure of SHS attenuated the risk of delivering macrosomia baby (weighted ≥4,000 g) by almost 2 times among obese women (Body Mass Index of ≥30 kg/m²) and on the other hand increasing the risk of delivering LBW infants among underweight women (BMI of <18 kg/m²) to almost 3-fold (Wahabi et al., 2013). The nicotine exposure during pregnancy impaired the differentiation and proliferation of placenta cell named cytotrophoblast (CTB) that reduce the blood flow and create pathological hypoxic environment in the womb (Zdravkovic et al., 2005). Voigt et al. in another study suggested that the prevalence of Small Gestational Age (SGA) defined by birth weight, length, and head circumference is elevating in accordance with the increasing of cigarette smoke exposure up to 8% for each seven additional cigarettes daily (Voigt, Zels, et al., 2011).

Policymakers should align tobacco control initiatives with maternal, newborn, and child health care services with continued evidence of the health effects of the SHS. Indonesia’s cultural norms have also attributed to exposure to SHS in houses, as older people...
are not required to avoid smoking in homes. The limited awareness and knowledge about the health risks of SHS among active and passive smokers is also a key factor. Passive smoking seems to be a neglected public health problem in Indonesia. Cigarette smokers should be forced to stop indoor smoking, and smoking cessation campaign services should also be strengthened. To reduce exposure to SHS, enforcing strict tobacco control laws and promoting smoke-free environments is also crucial, as is encouraging mothers to take precautionary action to avoid exposure to SHS during pregnancy. The attitude of parents and health-related behaviors that control SHS exposure to non-smokers, can be influenced by electronic and social media. Moreover, it can be used to raise awareness and provide information on the hazards of SHS and passive smoking. Preventing family members from smoking inside the houses and creating smoke-free homes can also act as a powerful strategy of tobacco control for adolescents (Song et al., 2009).

There were many limitations in our study. A self-reported questionnaire of SHS exposure and frequency without measurement of the duration of maternal or pregnancy exposure and cotinine levels in the household may have been 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, our 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. Self-reported variables may lead to misclassifications due to recall and reporting bias (i.e., size at birth reported by the mother may prone to subjectivity). Only crude categories (exposed vs not exposed) were selected for the multivariable analysis to prevent any false exposure categories precision. 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, which may clarify our results because for general national policy purposes, the data was collected and is therefore limited. Nonetheless, our research contributes to the body of knowledge on the birth effects of SHS with regards to birth weight and size at birth. With a wide range of representative populations in Indonesia, this is the first study of its kind, thereby raising the generalizability of our results to the Indonesian population, the largest cigarette consumer in the Asia Pacific region.

In conclusion, household exposure to SHS remains a relevant risk factor and is significantly associated with lower birth weight, LBW, and smaller size at birth at population level in Indonesia. For the implementation of strategies to minimize SHS exposure, the home
of non-smokers living with smokers must be taken into account through smoke-free homes policy (Trisnowati et al., 2019). 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 plausibility. Public health promotions that disseminate general recommendations for action are likely to have a positive impact on the health of mothers, newborns, and children.

References

Ardelia, K. I. A., Hardianto, G., & Nuswantoro, D. (2019). Passive smoker during pregnancy is a risk factor of low birth weight. Majalah Obstetri & Ginekologi (Vol 27, No 1 (2019): April), 12-16. https://e-journal.unair.ac.id/ MOG/article/view/13082

Channon, A. A. R. (2011). CAN MOTHERS JUDGE THE SIZE OF THEIR NEWBORN? ASSESSING THE DETERMINANTS OF A MOTHER’S PERCEPTION OF A BABY’S SIZE AT BIRTH. Journal of Biosocial Science, 43(5), 555-573. https://doi.org/10.1017/S0021932011000198

Cheng, K. W., Chiang, W. L., & Chiang, T. L. (2017). In utero and early childhood exposure to second hand smoke in Taiwan: a population-based birth cohort study. BMJ Open, 7(6), e014016. https://doi.org/10.1136/bmjopen-2016-014016

Data, G. H. O. G. Second-Hand Smoke. Retrieved February 17 from https://www.who.int/gho/phe/secondhand_smoke/en/

Fischer, F., Minnwegen, M., Kaneider, U., Kraemer, A., & Khan, M. M. H. (2015). Prevalence and determinants of second hand smoke exposure among women in Bangladesh, 2011. Nicotine & tobacco research: official journal of the Society for Research on Nicotine and Tobacco, 17(1), 58-65. https://doi.org/10.1093/ntr/ntu129

Heishman, S. J., Kleykamp, B. A., & Singleton, E. G. (2010). Meta-analysis of the acute effects of nicotine and smoking on human performance. Psychopharmacology (Berl), 210(4), 453-469. https://doi.org/10.1007/s00213-010-1848-1

Jaddoe, V. W., Troe, E. J., Hofman, A., Mackenbach, J. P., Moll, H. A., Steegers, E. A., & Witteman, J. C. (2008). Active and passive maternal smoking during pregnancy and the risks of low birthweight and preterm birth: the Generation R Study. Paediatr Perinat Epidemiol, 22(2), 162-171. https://doi.org/10.1111/j.1365-3016.2007.00916.x

Kobayashi, S., Sata, F., Hanoaka, T., Braimoh, T. S., Ito, K., Tamura, N., Araki, A., Itoh, S., Miyashita, C., & Kishi, R. (2019). Association between maternal passive smoking and increased risk of delivering small-for-gestational-age infants at full-term using plasma cotinine levels from The Hokkaido Study: a prospective birth cohort. BMJ Open, 9(2), e023200. https://doi.org/10.1136/bmjopen-2018-023200

La Merrill, M., Stein, C. R., Landigan, P., Engel, S. M., & Savitz, D. A. (2011). Prepregnancy body mass index, smoking during pregnancy, and infant birth weight. Ann Epidemiol, 21(6), 413-420. https://doi.org/10.1016/j.annepidem.2010.11.012

Lim, K. H., Lim, H. L., Teh, C. H., Kee, C. C., Heng, P. P., Cheah, Y. K., & Ghazali, S. M. (2018). Secondhand smoke (SHS) exposure at home and at the workplace among non-smokers in Malaysia: Findings from the Global Adult Tobacco Survey 2011. Tob Induc Dis, 16, 49-49. https://doi.org/10.18332/tid/95188

Nadhir, S. R., Djokosujojo, K., & Utari, D. M. (2020). The association between secondhand smoke exposure and growth outcomes of children: A systematic literature review. Tob Induc Dis, 18, 12. https://doi.org/10.18332/tid/117958

Nafees, A. A., Taj, T., Kadir, M. M., Fatmi, Z., Lee, K., & Sathia Kumar, N. (2012). Indoor air pollution (PM2.5) due to secondhand smoke in selected hospitality and entertainment venues of Karachi, Pakistan. Tob Control, 21(5), 460-464. https://doi.org/10.1136/tc.2011.043190

Nigatu, D., Haile, D., Gebremichael, B., & Y, M. T. (2019). Predictive accuracy of perceived baby birth size for birth weight: a cross-sectional study from the 2016 Ethiopian Demographic and Health Survey. BMJ Open, 9(12), e031986. https://doi.org/10.1136/bmjopen-2019-031986
Niu, Z., Xie, C., Wen, X., Tian, F., Yuan, S., Jia, D., & Chen, W. Q. (2016). Potential pathways by which maternal second-hand smoke exposure during pregnancy causes full-term low birth weight. Sci Rep, 6, 24987. https://doi.org/10.1038/srep24987

Noriani, N., Aratwan Eka Putra, I. W. G., & Karmaya, I. (2015). Paparan Asap Rokok dalam Rumah Terhadap Risiko Peningkatan Kelahiran Bayi Prematur di Kota Denpasar. Public Health and Preventive Medicine Archive, 3, 55. https://doi.org/10.15562/pha.2015.88

Norsaadah, B., & Salinah, O. (2014). The Effect of Second-Hand Smoke Exposure during Pregnancy on the Newborn Weight in Malaysia. Malays J Med Sci, 21(2), 44-53.

Oberg, M., Jaakkola, M. S., Woodward, A., Peruga, A., & Prüss-Ustün, A. (2011). Worldwide burden of disease from exposure to second-hand smoke: a retrospective analysis of data from 192 countries. Lancet, 377(9760), 139-146. https://doi.org/10.1016/s0140-6736(10)61388-8

Organization, W. H. (2015a). Health in 2015: from MDGs, Millennium Development Goals to SDGs, Sustainable Development Goals.

Organization, W. H. (2015b). WHO Report on the Global Tobacco Epidemic, 2015: Raising Taxes on Tobacco.

Phetphum, C., & Noosorn, N. (2020). Prevalence of second hand smoke exposure at home and associated factors among middle school students in Northern Thailand. Tob Induc Dis, 18. https://doi.org/10.18332/jid.117733

Population, N., Family Planning Board, Statistical Indonesia, Ministry of Health – Kemenkes, & ICF. (2018). Indonesia Demographic and Health Survey 2017. http://dhsprogram.com/pubs/pdf/FR342/FR342.pdf

Reece, S., Morgan, C., Parascandola, M., & Siddiqi, K. (2019). Second hand smoke exposure during pregnancy: a cross-sectional analysis of data from Demographic and Health Survey from 30 low-income and middle-income countries. Tob Control, 28(4), 420-426. https://doi.org/10.1136/tobaccocontrol-2018-054288

Reece, S., Morgan, C., Parascandola, M., & Siddiqi, K. (2019). Second hand smoke exposure during pregnancy: a cross-sectional analysis of data from Demographic and Health Survey from 30 low-income and middle-income countries. Tob Control, 28(4), 420. https://doi.org/10.1136/tobaccocontrol-2018-054288

Soesanti, F., Uiterwaal, C., Grobbee, D., Hendarto, A., Dalmeijer, G., & Idris, N. (2019). Antenatal exposure to second hand smoke of non-smoking mothers and growth rate of their infants. PLOS ONE, 14, e0218577. https://doi.org/10.1371/journal.pone.0218577

Song, A. V., Glantz, S. A., & Halpern-Felsher, B. L. (2009). Perceptions of second-hand smoke risks predict future adolescent smoking initiation. J Adolesc Health, 45(6), 618-625. https://doi.org/10.1016/j.jadohealth.2009.04.022

Sun, L. Y., Cheong, H. K., Lee, E. W., Kang, K. J., & Park, J. H. (2016). Affecting Factors of Second-hand Smoke Exposure in Korea: Focused on Different Exposure Locations. Journal of Korean medical science, 31(9), 1361-1372. https://doi.org/10.3346/jkms.2016.31.9.1362

Trisnowati, H., Kusuma, D., Ahsan, A., Kurniash, D. E., & Padmawati, R. S. (2019). Smoke-free home initiative in Bantul, Indonesia: Development and preliminary evaluation [journal article]. Tobacco Prevention & Cessation, 5(November). https://doi.org/10.18332/tpc/113357

Vardavas, C. I., Chatzi, L., Patelarou, E., Plana, E., Sarri, K., Kafatos, A., Koutis, A. D., & Kogevas, M. (2010). Smoking and smoking cessation during early pregnancy and its effect on adverse pregnancy outcomes and fetal growth. Eur J Pediatr, 169(6), 741-748. https://doi.org/10.1007/s00431-009-1107-9

Voigt, M., Jorch, G., Briese, V., Kwool, G., Borchardt, U., & Straube, S. (2011). The combined effect of maternal body mass index and smoking status on perinatal outcomes – an analysis of the german perinatal survey. Zeitschrift fur Geburtshilfe und Neonatologie, 215(1), 23-28. https://doi.org/10.1055/s-0030-1254142

Voigt, M., Zels, K., Guthmann, F., Hesse, V., Görllich, Y., & Straube, S. (2011). Somatic classification of neonates based on birth weight, length, and head circumference: quantification of the effects of maternal BMI and smoking. J Perinat Med, 39(3), 291-297. https://doi.org/10.1515/jpm.2011.017

Wahab, H. A., Mandil, A. A., Alzeidhan, R. A., Bahnassy, A. A., & Fayed, A. A. (2013). The independent effects of second hand smoke exposure and maternal body mass index on the anthropometric measurements of the newborn. BMC Public Health, 13, 1058. https://doi.org/10.1186/1471-2458-13-1058

Wahidin, M., Hidayat, M. S., Arasy, R. A., Amir, V., & Kusuma, D. (2020). Geographic distribution, socioeconomic disparity and policy determinants of smoke-free policy adoption in Indonesia. Int J Tuberc Lung Dis, 24(4), 383-389. https://doi.org/10.5588/ijtld.19.0468
Wang, C.-P., Ma, S. J., Xu, X. F., Wang, J.-F., Mei, C. Z., & Yang, G.-H. (2009). The prevalence of household second-hand smoke exposure and its correlated factors in six counties of China. *Tob Control, 18*(2), 121-126. https://doi.org/10.1136/tc.2008.024836

Wang, S., Yang, L., Shang, L., Yang, W., Qi, C., Huang, L., Xie, G., Wang, R., & Chung, M. C. (2020). Changing trends of birth weight with maternal age: a cross-sectional study in Xi’an city of Northwestern China. *BMC Pregnancy and Childbirth, 20*(1), 744. https://doi.org/10.1186/s12884-020-03445-2

Zdravkovic, T., Genbach, O., McMaster, M. T., & Fisher, S. J. (2005). The adverse effects of maternal smoking on the human placenta: a review. *Placenta, 26 Suppl A*, S81-S86. https://doi.org/10.1016/j.placenta.2005.02.003
Table 1 Characteristics of participants by exposure to SHS inside the house

|                          | All (n = 19935) | SHS exposure | p<sup>a</sup> |
|--------------------------|----------------|--------------|---------------|
|                          | n (%)          | Not Exposed (n = 4305) | Exposed<sup>b</sup> (n = 15627) | |
| Birth weight             |                |              |               | 0.007 |
| Normal (≥2500 g)         | 16287 (93.0)   | 3529 (94.0)  | 12758 (92.8)  | |
| Low birth weight (<2,500 g) | 1225 (7.0)    | 225 (6.0)    | 997 (7.2)     | |
| Birth weight (g), M (SD) | 17512 (87.8)   | 3165.1 (506.6) | 3066.1 (551.7) | <0.001 |
| Size of child at birth   |                |              |               | <0.001 |
| Larger than average      | 5687 (32.5)    | 1233 (32.8)  | 4451 (32.4)   | |
| Average                  | 9549 (54.5)    | 1923 (51.2)  | 7626 (55.6)   | |
| Smaller than average     | 2276 (13.0)    | 598 (15.9)   | 1678 (12.2)   | |
| Maternal Age             |                |              |               | <0.001 |
| 15 – 24 years            | 3370 (16.9)    | 470 (10.9)   | 2899 (18.6)   | |
| 25 – 34 years            | 10342 (51.9)   | 2328 (54.1)  | 8013 (51.3)   | |
| >34 years                | 6223 (31.2)    | 1507 (35.0)  | 4715 (30.2)   | |
| Age at first birth       |                |              |               | <0.001 |
| < 20 years               | 5712 (28.7)    | 880 (20.4)   | 4830 (30.9)   | |
| 20 – 29 years            | 12950 (65.0)   | 3067 (71.2)  | 9882 (63.2)   | |
| >29 years                | 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)     | |
| Maternal Education       |                |              |               | <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, M (SD)      | 19935 (100)    | 5.1 (1.8)    | 5.7 (2.2)     | <0.001 |
| 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 or more                | 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)   | |
Chi-Square was used to measure the group difference of categorical variables while continuous variables used generalized linear regression; 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 \((n = 11,623 \ (58.3\%))\); SHS, second hand smoke; \(M\), mean; \(SD\), standard deviation; \(n\), number; \%wt, weighted percentage.

|                          | Birth order, \(M\) (SD) | Wealth index | SHS exposure frequency |
|--------------------------|--------------------------|--------------|------------------------|
|                          | 19935 (100)              |              |                        |
|                          | 2.3 (1.3)                |              |                        |
|                          | 2.4 (1.5)                |              |                        |
|                          | <0.001                   | <0.001       |                        |
| Wealth index             |                          |              |                        |
| 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             |                          |              |                        |
| Clean                    | 13597 (68.2)             | 3333 (77.5)  | 10236 (65.7)            |
| Pollutant                | 6334 (31.8)              | 970 (22.5)   | 5362 (34.3)             |
| Kitchen location         |                          |              |                        |
| 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)               |
Table 2 Association between SHS exposure inside the house and birth weight and low birth weight

| SHS exposure inside the house | Linear regression | Logistic regression |
|------------------------------|-------------------|---------------------|
|                              | Birth weight | Low birth weight |
|                              | n | Adjusted mean | cOR (95% CI) | aOR (95% CI) |
| 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)* |
| SHS exposure 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)* |

Note. SE = standard error; cOR = crude odds ratio; aOR = adjusted odds ratio; CI = confidence interval
*p<0.050, **p<0.010, ***p<0.001

a adjusted for maternal age, maternal education, residence, parity, birth interval, wealth index, cooking fuel, and kitchen location

b adjusted for maternal age, maternal education, mother’s occupation, husband’s occupation, residence, and parity
| SHS exposure inside the house<sup>a</sup> | n       | Larger than average<sup>†</sup><sup>a</sup> | Smaller than average<sup>†</sup><sup>a</sup> |
|--------------------------------------|---------|---------------------------------------|---------------------------------------|
| Not exposed                         | 3708    | 1                                     | 1                                     |
| Exposed                             | 13656   | 1.09<sup>*</sup>                        | 1.10 (1.01-1.20)<sup>*</sup>           |
|                                     |         |                                         | 1.41<sup>***</sup>                    |
|                                     |         |                                         | 1.51 (1.35-1.69)<sup>***</sup>        |

| SHS exposure frequency<sup>b</sup> | n       | Larger than average<sup>†</sup><sup>a</sup> | Smaller than average<sup>†</sup><sup>a</sup> |
|-----------------------------------|---------|---------------------------------------|---------------------------------------|
| Not exposed                       | 3708    | 1                                     | 1                                     |
| Less than once a month            | 2122    | 0.97                                  | 0.97 (0.84-1.11)                      |
|                                   |         | 1.07                                  | 1.08 (0.90-1.31)                      |
| Monthly                           | 281     | 0.89                                  | 0.88 (0.67-1.16)                      |
|                                   |         | 1.19                                  | 1.25 (0.88-1.77)                      |
| Weekly                            | 1116    | 1.06                                  | 1.07 (0.96-1.18)                      |
|                                   |         | 1.00                                  | 1.04 (0.89-1.21)                      |
| Daily                             | 10137   | 1.10<sup>*</sup>                      | 1.11 (1.02-1.21)<sup>*</sup>         |
|                                   |         |                                         | 1.43<sup>***</sup>                    |
|                                   |         |                                         | 1.54 (1.37-1.73)<sup>***</sup>       |

Note: cOR = Crude Odds Ratio; aOR = Adjusted Odds Ratio; CI = Confidence Interval
<sup>†</sup>Average is the reference category
<sup>*</sup>p<0.05, <sup>**</sup>p<0.01, <sup>***</sup>p<0.001
<sup>a</sup>adjusted for maternal age, age at first birth, maternal education, family size, mother’s occupation, residence, parity, birth order, wealth index, cooking fuel