Secondhand Smoke Exposure during Pregnancy and its Effect on Birth Outcomes: Evidence from a Retrospective Cohort Study in a Tertiary Care Hospital in Bengaluru

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Abstract

Context: The effect of maternal smoking on birth outcomes is well-established, but the effect of maternal secondhand smoke (SHS) exposure is less clear, especially among Indian women. Aim: To evaluate the effect of SHS exposure during pregnancy on birth outcomes such as gestational age at birth, neonatal anthropometry, and Apgar score. Setting and Design: Retrospective cohort study at a tertiary hospital in Bengaluru. Methods: 208 postnatal mothers: 104 each in “exposed” and “nonexposed” group, based on the history of SHS exposure during pregnancy. Sociodemographic and obstetric details were obtained by interview schedule and birth outcomes were obtained from patient charts. Statistical Analysis: Association of SHS exposure with birth outcomes was analyzed using inferential statistics such as Chi-square, t-test, and Mann–Whitney U-test, whereas the strength of association was expressed as relative risk with 95% confidence intervals. P < 0.05 was considered statistically significant. Results: SHS exposed and nonexposed groups were comparable with regard to potentially confounding socioeconomic and obstetric covariates. Babies born to SHS-exposed mothers had significantly lower mean birth weight, mean birth length, and mean birth head circumference by 172.5 g (P = 0.027), 1.6 cm (P = 0.001), and 1.1 cm (P = 0.001), respectively. Conclusion: Mothers exposed to SHS during pregnancy were twice likely to deliver low birth weight babies (relative risk [RR] = 1.9 [1.0–3.6], P = 0.02) and babies of low birth length (RR = 2.64 [1.4–4.6], P = 0.001) than unexposed mothers. With a significant risk of adverse birth outcomes found among mothers exposed to SHS during pregnancy, it is important that a “no tobacco smoke” environment at home should be recommended for pregnant women and their families.

Keywords: Birth outcomes, low birth length, low birth weight, neonatal anthropometry, passive smoking, secondhand smoke

INTRODUCTION

India is the second largest consumer of tobacco in the world,[1] where one in every ten adults smokes tobacco.[2] Secondhand smoke (SHS) is smoke from burning tobacco products, such as cigarettes and beedis, as well as the smoke exhaled by the person smoking.[3] Tobacco smoke contains more than 7000 toxic chemicals, some carcinogenic.[4] Persons breathing in SHS are exposed to the same toxins as the person smoking tobacco products.[3]

Although since 2008, smoking in public places is prohibited throughout India,[6] nearly 40% of adults are still exposed to SHS at home.[1] In the absence of tests for biological markers and environmental monitoring, questionnaires can be a simple and cost-effective method for assessing SHS exposure.[7] While adverse birth outcomes as a result of maternal smoking during pregnancy have been proven conclusively in numerous studies,[8-9] results have also emerged from various research done on the effect of SHS exposure during pregnancy, in terms of low birth weight (LBW) and preterm birth.[10-12] However, there is a paucity of data, more so in India, on the effect of SHS exposure during pregnancy on other birth outcomes such as birth length, head circumference at birth, and APGAR score (an indicator of health status in the early neonatal period).[13] There is also a dearth of scientifically

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robust studies with study designs better suited to establishing the effect of SHS exposure in pregnancy on birth outcomes. This study was therefore conducted with the aim of determining the effect of SHS exposure during pregnancy, on birth outcomes including neonatal anthropometry (birth weight, length, and head circumference), gestational age at birth, and APGAR scores in a tertiary care teaching hospital in Bengaluru city.

**Methods**

**Study design and setting**
A retrospective cohort study was conducted in a large medical college teaching hospital in Bengaluru city in 2018. This study received ethics approval from the institutional ethics committee.

**Study population**
Women who delivered in the hospital and were admitted in the postnatal ward were included in the study.

**Sampling**
With reference to a study by Gupta et al., which found 20% LBW among mothers unexposed to SHS and an estimated odds ratio of 2.2, with power of 90% and alpha error of 5%, we estimated that the minimum sample size to test a two-sided hypothesis was 104 postnatal women exposed to SHS during pregnancy and 104 postnatal women not exposed to SHS during pregnancy. Women were consecutively enrolled until the sample size was achieved in each group.

**Inclusion criteria**
Women with live singleton birth.

**Exclusion criteria**
Women who had smoked during pregnancy, had diabetes in pregnancy, or were seriously ill.

**Data collection**
Women were approached on second or third postnatal day, and after obtaining written informed consent, they were assigned to either exposed or nonexposed group, based on the reported SHS exposure during pregnancy.

**Assessment of exposure**
Global Adult Tobacco Survey questions were used in research studies to determine SHS exposure among adults. SHS exposure at home was taken to be present if the response to the question, “How often does anyone smoke inside your home?,” was “at least once in a month” or if the subject answered “Yes” to the question, “During the past 30 days, did anyone smoke in indoor areas where you work?”

**Study tool**
A pretested, face-validated, structured interview schedule was used to capture sociodemographic and obstetric details. Socioeconomic status was determined using the Modified BG Prasad classification. Patient’s antenatal records and hospital charts were the source of data for maternal complications in pregnancy, maternal hemoglobin levels (earliest hemoglobin reading during pregnancy), mode of delivery, gestational age at birth, and neonatal anthropometry (birth weight, birth length, head circumference at birth, and APGAR score at 1 and 5 min).

**Measuring outcome variables**

**Low birth weight**
Low birth weight: Birth weight <2500 g irrespective of gestational age. Low birth length: Birth length <3rd percentile for newborn (<46.1 cm for boys and <45.4 cm for girls) based on the WHO Child Growth Standards. Low head circumference: Head circumference <3rd percentile for newborn (<31.9 cm for boys and <31.5 cm for girls). Preterm: Gestational age at birth of 37 completed weeks. Low APGAR score: <7 at 1 min and at 5 min after birth.

**Statistical analysis**
The IBM SPSS Statistics for Windows, version 17 (IBM Corp., Armonk, N.Y., USA). The data were checked for normality using Shapiro–Wilk test and normality probability plot. The study variables were described using frequencies, proportion, mean, standard deviation, median, and interquartile range. The exposed and nonexposed groups were compared with regard to confounding covariates, using Chi-square test, independent sample t-test, and Mann–Whitney U test as applicable. The strength of association between exposure to SHS and birth outcomes was expressed as relative risk with 95% confidence intervals. $P < 0.05$ was considered statistically significant for all analyses.

**Results**
A total of 208 subjects were included in this study, 104 exposed to SHS during pregnancy and 104 not exposed. The mean age of participants was 24.7 ± 4.1 years, and the mean years of education attained was 12.8 ± 2.8 years. Majority of subjects (80%) belonged to middle class. Most were homemakers (79.8%), residing in urban areas (68.8%), and had median per capita monthly income of Rs. 3333 (2000, 5000). At least one complication in pregnancy was experienced by 122 (58%) of the subjects, the most common being anemia, hypothyroidism, hypertension, and genitourinary infection. All the participants had tested negative for hepatitis B, HIV, and syphilis. None had consumed alcohol or drugs and smoked or chewed tobacco during pregnancy. There was no difference between the SHS-exposed and SHS nonexposed groups with regard to possibly confounding covariates such as age, education, occupation, income, gravidity, and maternal complications in pregnancy [Table 1]. Of the 104 women exposed to SHS, 91 (87.5%) were exposed to SHS at home.

Regarding birth outcomes, nearly equal number of girls (49.5%) and boys (50.5%) were born to mothers in both exposed and unexposed groups. None of the babies had any congenital defects. 26.4% were LBW, 19.7% were preterm births, and 37% were born by cesarean section.
SHS exposure was significantly associated with LBW ($P=0.041$) and low birth length ($P=0.001$) [Table 2]. Among babies born to mothers exposed to SHS, the mean birth weight, mean birth length, and mean birth head circumference were significantly lower by 172.5 g ($P=0.027$), 1.6 cm ($P=0.001$), and 1.1 cm ($P=0.001$), respectively. SHS exposure was not associated with mode of delivery, preterm birth, or low APGAR scores at 1 min and 5 min. Mothers exposed to SHS had double the risk of giving birth to an LBW baby (RR = 1.9 [1.0–3.6], $P=0.02$) and two and a half times higher risk of giving birth to a low length baby (RR = 2.64 [1.4–4.6], $P=0.001$) as compared to mothers without SHS exposure [Table 3].

**Discussion**

This study has elicited findings that point out to increased risk of adverse birth outcomes among women exposed to SHS during pregnancy. Both the exposed and nonexposed groups were found to be similar with respect to age, education, income, parity, and hemoglobin levels. Each of these variables is known to have an independent relationship with the birth outcomes we studied, either directly, for example, low hemoglobin is linked to low neonatal anthropometry,[20] or indirectly, for example, low per capita income leads to poor maternal nutrition levels, which in turn leads to LBW.[21] A study by Goel et al. in North India found that women exposed to SHS tend to be

**Table 1: Comparison of secondhand smoke exposed and secondhand smoke nonexposed groups with regard to possibly confounding covariates ($n=208$)**

| Variable                      | Category          | Total             | SHS exposed (%) | SHS nonexposed (%) | $P$       |
|-------------------------------|-------------------|-------------------|-----------------|-------------------|-----------|
| Per capita income (Rs.)       | Median (IQR)      | 3333 (000-5000)   | 3000 (2000-5000) | 3333.3 (2055-5000) | 0.311*    |
| Gravida                       | Primi             | 132 (63.5)        | 67 (50.8)       | 65 (49.2)         | 0.581b    |
|                               | Multi             | 76 (36.5)         | 37 (48.7)       | 39 (51.3)         |           |
| Maternal pregnancy complication | Yes               | 122 (58.7)        | 62 (50.8)       | 60 (49.2)         | 0.778c    |
|                               | No                | 86 (41.3)         | 42 (48.8)       | 44 (51.2)         |           |
| Hemoglobin (%)                | Mean±SD           | 11.1±1.5          | 11.0±1.6        | 11.1±1.5          | 0.632c    |

*Mann-Whitney U-test, *Chi-square test, *Independent sample t-test. SHS: Secondhand smoke, IQR: Interquartile range, SD: Standard deviation

**Table 2: Comparison of various birth outcomes among the exposed and nonexposed groups ($n=208$)**

| Variable                               | Category       | Total       | SHS exposed (%) | SHS nonexposed (%) | $P$       |
|----------------------------------------|----------------|-------------|-----------------|-------------------|-----------|
| Gestational age at birth               |                |             |                 |                   |           |
|                                        | Preterm        | 41 (19.7)   | 23 (22.1)       | 18 (77.9)         | 0.385     |
|                                        | Term           | 167 (80.3)  | 81 (77.9)       | 86 (22.1)         |           |
| Birth weight (g)                       | <2500          | 55 (26.4)   | 34 (61.8)       | 21 (38.2)         | 0.041*    |
|                                        | ≥2500          | 153 (73.6)  | 70 (45.8)       | 83 (54.2)         |           |
| Birth length                           | <3rd percentile| 86 (41.3)   | 55 (64.0)       | 31 (36.0)         | 0.001*    |
|                                        | ≥3rd percentile| 122 (58.7)  | 49 (40.2)       | 73 (49.8)         |           |
| Head circumference at birth            | <3rd percentile| 19 (9.1)    | 10 (52.6)       | 9 (47.4)          | 0.809     |
|                                        | ≥3rd percentile| 189 (90.9)  | 94 (49.7)       | 95 (50.3)         |           |
| Apgar at 5 min                         | <7             | 3 (1.4)     | 2 (66.7)        | 1 (33.3)          | 0.561     |
|                                        | ≥7             | 205 (98.6)  | 102 (49.7)      | 103 (50.3)        |           |

*Chi-square test, *Statistically significant with $P<0.05$. SHS: Secondhand smoke

**Table 3: Relative Risk for various birth outcomes among mothers exposed to SHS ($n=208$)**

| Outcome                     | Category       | Exposed to SHS $N=104$ | Not Exposed to SHS $N=104$ | Relative Risk (95% CI) | $P$ value |
|-----------------------------|----------------|------------------------|-----------------------------|------------------------|-----------|
| Birth Weight                | < 2500gm       | 34(32.7)               | 21(20.2)                    | 1.9 (1.02-3.60)        | 0.041*    |
|                             | ≥2500gm        | 70(67.3)               | 83(79.8)                    |                        |           |
| Birth Length                | <3rd percentile| 55(52.9)               | 31(29.8)                    | 2.6 (1.49-4.67)        | 0.001*    |
|                             | ≥3rd percentile| 49(47.1)               | 73(70.2)                    |                        |           |
| Head Circumference at birth | <3rd percentile| 10(9.6)                | 9(8.7)                      | 1.1 (0.43-2.88)        | 0.809     |
|                             | ≥3rd percentile| 94(90.4)               | 95(91.3)                    |                        |           |
| Gestational age at birth    | Preterm        | 23(22.1)               | 18(17.5)                    | 1.3 (0.68-2.69)        | 0.385     |
|                             | Term           | 81(77.9)               | 86(82.7)                    |                        |           |
| Apgar Score at 1 min        | <7             | 14(13.5)               | 9(8.7)                      | 1.6(0.67-3.98)         | 0.269     |
|                             | ≥7             | 90(86.5)               | 95(91.3)                    |                        |           |
| Apgar Score at 5 min        | <7             | 2(1.9)                 | 1(1)                        | 2.0 (0.18-22.62)       | 0.561     |
|                             | ≥7             | 102(98)                | 103(99)                     |                        |           |

*statistically significant at $P<0.05$. SHS= Second hand smoke, CI= Confidence Interval
less educated and of lower socioeconomic class than women not exposed to SHS. However, in our study, the two exposure groups were comparable with respect to these confounding covariates. This was probably because the mothers in our study came from a uniform socioeconomic background, with majority belonging to middle class. The overall rates of LBW, preterm deliveries, and cesarean sections were comparable to tertiary hospitals elsewhere in India.\[22\]

In our study, SHS exposure was significantly associated with LBW (\(P = 0.041\)) and low birth length (\(P = 0.001\)). This was also found in a study conducted in Malaysia with a similar study design to ours,\[23\] as well as a cross-sectional study in Saudi Arabia, where exposure to SHS was associated with lower anthropometric measurements at birth.\[11\] In our study, mothers exposed to SHS had twice the risk of delivering an LBW baby. Goel et al. similarly found double the risk of LBW among SHS-exposed mothers.\[10\] There are several potential pathways by which maternal SHS exposure affects birth weight and birth length: one is that SHS triggers maternal inflammation with rising cytokine levels causing placental damage and the other is that carbon monoxide and nicotine inhaled through SHS reduce placental blood flow. These biologically plausible theories were expounded in a study by Niu et al. in China, which found that not only birth weight but also placental weight was significantly lower among those exposed to SHS in pregnancy.\[24\]

Our study found a significant difference in anthropometric measurements at birth between the exposed and nonexposed groups. Mothers exposed to SHS delivered babies who were on an average 172.5 g lighter than those born of nonexposed mothers. Similarly, in studies in North India, by Goel et al. and Gupta et al., the mean birth weight among babies born to mothers exposed to SHS was 138 g and 282 g lower, respectively, than babies in the unexposed group.\[10,12\] These findings have implications for public health policy and practice, as this crucial additional birth weight gained by prevention of SHS exposure could help babies cross the 2500g cutoff, from LBW category to normal weight category.

While the difference in mean length (1.6 cm) and mean head circumference (1.1 cm) among the two groups was small, it was, nevertheless, significant. A similar small, but statistically significant mean difference of 0.26 cm in birth length and 1.1 mm in head circumference was noted in studies in Saudi Arabia\[11\] and Indonesia.\[25\] In our study, we also found that mothers exposed to SHS had 2.6 times higher risk of a low length baby. This has far-reaching public health implications, as short length at birth is a known risk factor for stunting among young children.\[26\] Avoiding SHS in pregnancy therefore becomes one way of addressing childhood stunting in the long run.

We did not find any association between SHS and low APGAR scores, unlike Gupta et al.,\[12\] who found that SHS exposure increased the risk of low APGAR scores at 5 min. However, the total number of babies with low APGAR scores at 5 min was only 3 (1.4%) in our study, a number too low to draw necessary statistical conclusion, as compared to 26 (9%) in theirs.

Considering that we found a significant risk of LBW and low birth length among women exposed to SHS during pregnancy, and the fact that an overwhelming majority of women who were exposed to SHS in our study reported SHS exposure at home, rather than the workplace, it is important that a “no tobacco smoke” environment at home be recommended for pregnant women. Doctors may utilize the opportunity afforded by regular antenatal visits (or home visits as in the case of grassroot-level health workers), to enquire about SHS exposure and advise pregnant women, their spouses and families regarding consequences of SHS exposure in terms of adverse birth outcomes, and the need to create a “no tobacco smoke” environment at home.

Conclusion

In the present study, we found that babies born to mothers exposed to SHS during pregnancy had significantly lower mean birth weight, lower mean birth length, and lower mean birth head circumference, as compared to babies born to mothers not exposed to SHS. Mothers exposed to SHS during pregnancy were twice likely to deliver LBW babies and babies of low birth length than unexposed mothers. Considering that we found a significant risk of adverse birth outcomes among women exposed to SHS during pregnancy, and the fact that SHS exposure occurred at home, rather than the workplace, it is important that a “no tobacco smoke” environment at home be recommended for pregnant women and their families.

Limitations of the study

Like most other research studies on SHS, we used self-reporting to assess exposure to SHS in our study, with a possible recall bias. Furthermore, as SHS exposure was not quantified in our study, a dose–response relationship could not be estimated. This, however, opens up further avenue for research in this area.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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