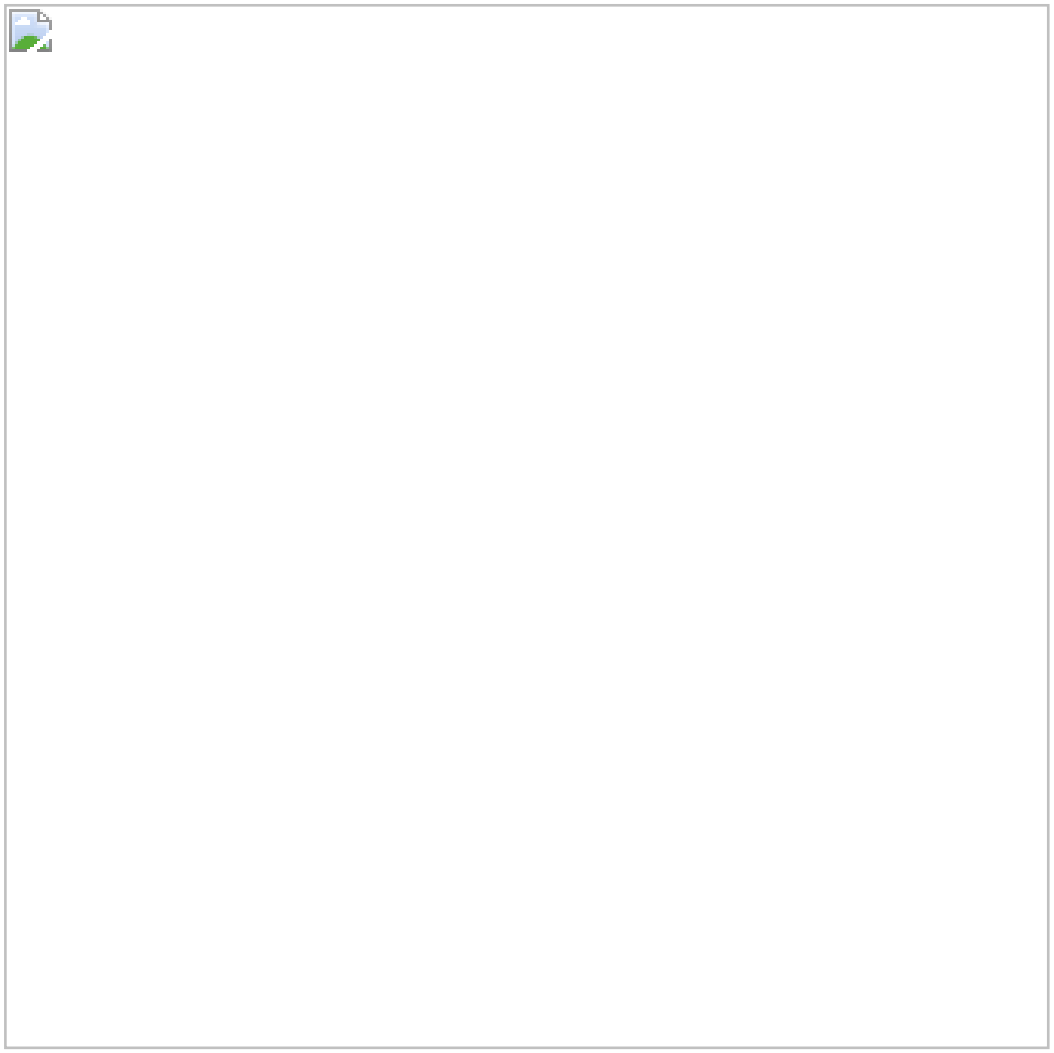

Re-examining the Nexus Between Maternal Smoking Behavior and Under-Five Children's ARI in India: A Comprehensive Study

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Source: Environmental Health Insights, 17(1)

Published By: SAGE Publishing

URL: https://doi.org/10.1177/11786302231200997

Re-examining the Nexus Between Maternal Smoking Behavior and Under-Five Children's ARI in India: A Comprehensive Study

Environmental Health Insights
Volume 17: 1–9
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DOI: 10.1177/11786302231200997

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ABSTRACT

BACKGROUND: The burden of acute respiratory infections (ARIs) among children under-five is a serious concern in lower and middle-income countries (LMICs), including India, where it is positively associated with indoor smoking exposures. This study re-examines the impact of maternal smoking on ARIs among children under 5 in India, considering other indoor air pollutant factors and covariates. The aim is to establish existing findings and capture any differentials in results using comprehensive analytical approaches.

METHODS: Data from the National Family Health Survey (NFHS-5), 2019 - 21, was used. Descriptive statistics, bivariate analysis, multivariable logistic regression models, and interaction analysis were applied to accomplish the study objective.

RESULTS: The adjusted likelihood of ARI was 1.24 (95% CI: 1.04-1.48) times higher in under-five children with smoking mothers than those with non-smoking mothers. The result was also observed to be almost similar across all seasons. Moreover, the combined effect of maternal smoking with other household members smoking and using unclean cooking fuel without a separate ventilated kitchen escalated the risk (AOR: 2.01; 95% CI: 1.98-2.67). Breastfeeding was found to be a preventive measure for reducing the risk of indoor smoking exposure. The children who were never breastfed and were born large or small were more susceptible to maternal smoking.

CONCLUSION: The study highlights the association between maternal smoking and ARIs in Indian under-five children. Interventions include reducing maternal smoking, promoting breastfeeding, and improving respiratory health in fuel-exposed households.

KEYWORDS: Maternal smoking behavior, under-five ARIs, indoor air pollution, India

RECEIVED: May 3, 2023. **ACCEPTED:** August 28, 2023.

TYPE: Original Research

FUNDING: The author received no financial support for the research, authorship, and/or publication of this article.

DECLARATION OF CONFLICTING INTERESTS: The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Introduction

Acute respiratory infections (ARIs) are more likely to trigger severe morbidity and premature death in children under 5 .[1] Although ARIs are susceptible to any individual, children under-five are especially vulnerable because of their developing immune systems and susceptibility to infection.[2] However, the prevalence of ARIs significantly varied with several demographic and biological factors such as age, sex, size at birth, breastfeeding status, and other underlying maternal and child health backgrounds.[3,4] ARIs are considered a significant public health problem among children under-five worldwide, and global risk patterns vary widely between regions and countries.[1] According to the World Health Organization (WHO), about 20% of deaths in the under-five age group are caused by ARIs, primarily concentrated in low- and middle-income countries (LMICs).[5] Sub-Saharan Africa and South Asia have the highest burden of ARIs, with mortality rates of almost 101 and 56 deaths per 100 000 children, respectively.[6,7] In contrast, the mortality rate in high-income countries is less than ten deaths per 100 000 children.[7] These regional differences can be attributed to various factors, including behavioral factors, socioeconomic poverty, poor living standards, inadequate maternal and child healthcare awareness, healthcare infrastructure, accessibility, and affordability.[7]

Like regional variation, household-level variation in the prevalence of ARIs among children under-five is also significant in LMICs.[8,9] In particular, household-level factors such as using cooking fuel, having a separate kitchen, ventilation, WASH (water, sanitation, and hand washing) practices, household wealth quintile, and tuberculosis among household members are significant predictors of ARIs.[10,11] Household wealth-based inequality in ARIs among under-five children is also noteworthy in highly focused ARI-prone regions like sub-Saharan African and South Asian countries.[12] In particular, the risk of ARIs among under-five children is significantly higher among poor households than their wealthier counterparts. Household-level poverty increases the risk of livelihood

vulnerability, which is positively linked to indoor smoking exposures, poor dietary practices, and poor reproductive and child healthcare utilization. Further, this multidimensional household-level poverty increases the risk of ARIs among under-five children.[12,13] In the multifaceted household-level poverty, household smoking exposure received much attention in environmental health and epidemiology.

Previous studies found that the likelihood of ARIs among under-five children is higher in households using unclean cooking fuel without separate kitchens and ventilation than in their counterparts.[3,11] Similarly, household having passive smoking exposures like maternal smoking or other family member smoking increased the risk of developing ARIs among under-five children.[9] Existing studies suggested maternal smoking may significantly affect ARIs more than other indoor exposures due to prolonged proximity.[14] The literature on the association between maternal smoking behavior and the risk of ARIs among under-five children is substantial in India and elsewhere.[11,14-16] However, comprehensive research on the linkage between maternal smoking and ARIs in under-five children, particularly in India, is currently limited. As a result, the current study aims to re-examine the association between maternal smoking and ARIs in under-five children, considering other indoor smoking exposures and relevant factors in the Indian context. Existing studies have highlighted that the association between indoor smoking exposure and ARIs among under-five children can vary significantly depending on various factors, including the population, spatial considerations, and specific circumstances.[11,14-16] For example, using unclean cooking fuel has been shown to negatively impact under-five children's health. However, this impact can be modified by factors such as the location of the kitchen, the presence of a separate kitchen facility, the cooking duration, and the availability of eligible household members to care for the children while the mother is engaged in cooking activities.[11,14-16] Additionally, under-five children tend to spend significantly less time with other household members than their mothers, resulting in lower exposure to smoking from other household members.[3] However, the close connection between mothers and their children during early childhood further amplifies the impact of maternal smoking on children's health compared to other sources of exposure. Furthermore, in patriarchal societies, where mothers may smoke, there is a higher likelihood of other household members engaging in indoor tobacco smoking.[3,14] This situation may indirectly influence the results through dual tobacco smoking exposures in the household. Given these considerations, the present study primarily examines the relationship between maternal smoking and ARIs among under-five children in India. By concentrating on this specific aspect, the study aims to provide a more precise and focused understanding of the implications of maternal smoking on the health of young children, considering the various contextual factors that can play a role in shaping this association.

To the best of our knowledge, the present study is the first to address several crucial aspects: the potentially higher detrimental effect of maternal smoking on ARIs in under-five children compared to other indoor exposures, the combined effect of maternal smoking and other indoor smoking exposures on ARIs in under-five children, potential variations in the association between maternal smoking and ARIs based on the children's age group and breastfeeding status, and the potential impact of seasonal variability in the link between maternal smoking and ARIs among under-five children. The insights derived from this study are expected to play a pivotal role in comprehending the relationship between maternal smoking and ARIs in young children. Consequently, this information will be invaluable for shaping targeted interventions to enhance respiratory health among children in India.

Materials and Methods

Data

The present study used data from the most recent fifth round of the National Family Health Survey (NFHS-5), 2019 - 21. The NFHS provides reliable data on various demographic, socioeconomic, sexual, reproductive, and child health and healthcare utilization, chronic diseases, and behavioral aspects (like smoking, alcohol, and other substance use).[17] The NFHS is an Indian version of the Demographic and Health Survey (DHS), a cross-sectional survey. The NFHS-5 interviewed 724 115 women aged 15 to 49 years, including 225 641 under-five children.[17] The analysis is based on a 134 916 weighted sample of under-five children, excluding missing samples related to acute respiratory infections (ARIs), cooking fuel, mothers, and other household members' smoking behavior. All estimations are based on the latest live under-five children to restrict the effect of dual reporting.

Measures

Outcome variable. The outcome variable of this study is acute respiratory infections (ARIs) among under-five children. As consistent with previous literature, the ARIs were a composite outcome of cough-related illness accompanied by short, rapid, or difficult chest-related breathing in the past 2 weeks from the survey.[11,17,18] A set of questions asked mothers whether their children had any symptoms of ARIs within the reference time.[17] The responses were yes and no. Therefore, the outcome variable is dichotomous (had no ARI symptoms = 0, had ARI symptoms = 1).

Explanatory variables. Mother's smoking (non-smoker and smoker) was considered a key explanatory variable.[18,19] In line with the previous study, the present study also included other indoor smoking exposures, including other household members' smoking, using unclean cooking fuel, and a separate kitchen facility with ventilation. The study also included a range of covariates to ensure the reliability of the association between mothers' smoking behavior and ARIs among under-five children.[3,9,11] The covariates were improved toilet facility, improved

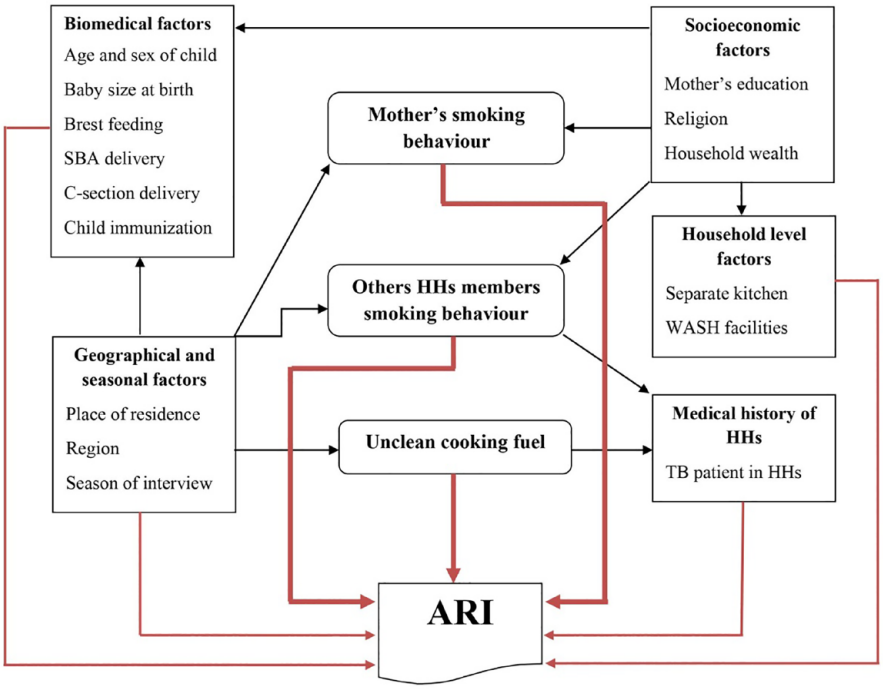

Figure 1. Conceptual framework of the study.

water facility, hand wash facility, children's age, and sex, size at birth, children's breastfeeding and immunization status, skilled birth attendant delivery, and C-section delivery.[11,14-16] Similarly, the present study also included several socioeconomic and geographical factors as covariates, including the mother's education, religion, household wealth quintile, seasonal variability, place of residence, and region.[11,14] The conceptual framework of the study variables is presented in Figure 1. The size at birth and skilled birth delivery variables were measured based on the NFHS-5 report.[17] The household wealth quintile was a composite outcome of a set of household amenities; the details of these amenities are available in the NFHS-5 report.[17] The regional division was also based on the NFHS-5 classification.[17] Further details of the study variables are presented in Supplemental Appendix Table 1.

Statistical analysis

The present study performed a range of statistical analyses to accomplish its objective. Descriptive statistics were applied to present the sample background, including a weighted frequency distribution with a 95% confidence interval (CI). Bivariate analysis was used to demonstrate the weighted distribution of acute respiratory infections (ARIs) among under-five children with background characteristics. A set of multivariable binary logistic regression models were applied to assess the adjusted association between mothers' smoking and ARIs among under-five children. Further, a set of interaction analyses were performed to examine the changing patterns of association between mothers smoking and ARIs, considering potential confounding variables. The regression results were presented in the form of odds ratio (OR) and adjusted odds ratios (AOR) with 95% confidence interval (CI). Prior to conducting the multivariable analysis, the study assessed the potential multicollinearity among the explanatory variables using the variance inflation factor (VIF) and found no indications of a multicollinearity issue. All the statistical analyses were performed using Stata version 17.0 (StataCorp LP, College Station, TX, USA).

Table 1. Descriptive statistics of the key study variables.

	N	PERCENTAGE	95% CI
Outcome variable			
ARIs			
No	130 827	97.0	96.9-97.1
Yes	4089	3.0	2.9-3.1
Key explanatory variable			
Mother's smoking status			
No	131 381	97.4	97.3-97.5
Yes	3535	2.6	2.5-3.0

Results

Background characteristics of the study sample

Approximately 3% (95% CI: 2.5-3.0) of mothers were smokers (Table 1). The prevalence of smoking among other household members was 43% (95% CI: 42.7-43.2). Nearly 40% of respondents reported using unclean cooking fuel (40%; 95% CI:

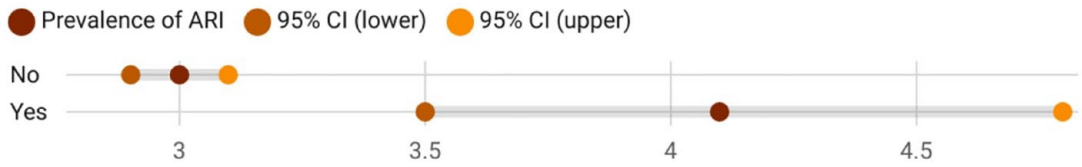

Figure 2. Prevalence of ARIs (%) by mothers smoking status.

39.8-40.3) and lacked a separate kitchen facility with ventilation (37.4%; 95% CI: 37.2-37.7). About one-fourth of the respondents had no improved toilet facilities. The majority of the selected children belonged to the age group of 23 months and below. Almost 60% of the under-five children were currently breastfeeding during the survey. Only 30% of the selected children had completed full vaccination. Regarding socioeconomic background, the majority of the mothers had completed secondary education or above (71%), followed the Hindu religion (80%), lived in households with a poor wealth quintile (40%), and resided in rural areas (68%). Further details of other background characteristics are presented in Supplemental Appendix Table 2.

Prevalence of acute respiratory infections (ARIs) by maternal smoking and other covariates

The prevalence of ARIs was considerably higher among children with smoking mothers (4.1%; 95% CI: 3.5-4.8) than among children with non-smoking mothers (3.0%; 95% CI: 2.9-3.1) (Figure 2). The prevalence also varied significantly with other indoor smoking exposures. There was a fair difference in ARIs between children from households with household members who smoked indoors (3.5%; 95% CI: 3.4-3.7) and children from households with no indoor smoking (2.7%; 95% CI: 2.6-2.8). Similarly, the prevalence of ARIs was slightly higher in households using unclean cooking fuel (3.3%; 95% CI: 3.1-3.4) than in households using clean fuel (2.9%; 95% CI: 2.7-3.0). Likewise, there was a difference in the prevalence of ARIs between households with separate, ventilated kitchens (2.6%; 95% CI: 2.5-2.7) and households without separate, ventilated kitchens (3.7%; 95% CI: 3.5-3.9). The prevalence of ARIs also significantly varied with other background characteristics (Supplemental Appendix Table 3). The state-level spatial patterns display the prevalence of ARIs was high in Delhi, Meghalaya, Uttar Pradesh, Bihar, and Maharashtra (Figure 3).

Association between maternal smoking and ARIs

The multivariable binary logistic regression examined both adjusted and unadjusted associations between maternal smoking and ARIs among under-five children. The unadjusted analysis revealed that children whose mothers smoked had a 31% higher likelihood of ARIs (unadjusted OR: 1.31; 95% CI: 1.16-1.49) than children with non-smoking mothers. Even after considering other indoor smoking exposures, biomedical,

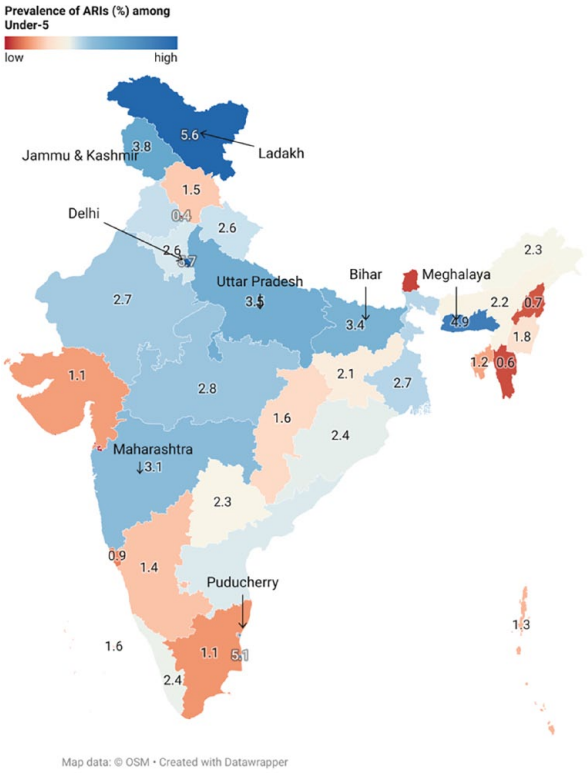

Figure 3. State level prevalence of acute respiratory infections (ARIs) among under-5 children, India, National Family Health Survey, 2019 - 21.

Table 2. Adjusted and unadjusted associations between mother's smoking status and ARIs among under-5 children, India, 2019-21.

MOTHER'S SMOKING STATUS	UOR (95% CI)	AOR (95% CI)
No (Ref.)	1.00	1.00
Yes	1.31*** (1.16-1.49)	1.24** (1.04-1.48)

Abbreviations: UOR, unadjusted odds ratio; AOR, adjusted odds ratio; Ref., reference category.
The result of adjusted odds ratio (AOR) estimated based on adding all explanatory variables.
Significance level: **≤.01. ***≤0.001.

socioeconomic, seasonal, and spatial factors, the impact of maternal smoking on children's ARI symptoms remained significant and robust. The adjusted odds ratio (AOR) of ARI was 1.24 (95% CI: 1.04-1.48) times higher among under-five children whose mothers smoked compared to their counterparts, that is, children of non-smoking mothers (Table 2). The study further examined the association between maternal smoking and ARIs among under-five children in each age

Table 3. Adjusted and unadjusted odds ratio of under-5 children ARIs by multiple indoor smoking factors (maternal smoking status, other household smoking status, type of cooking fuel and, type of kitchen), India 2019-21.

	ARI	
	UOR (95% CI)	AOR (95% CI)
NSM#NHM#CCF#SKV (Ref.)	1.00	1.00
NSM#NHM#CCF#NSKV	1.16*** (1.13-1.72)	1.19*** (1.14-1.80)
NSM#NHM#UCF#SKV	1.04 (0.91-1.20)	0.98 (0.85-1.14)
NSM#NHM#UCF#NSKV	1.41*** (1.25-1.60)	1.19** (1.03-1.38)
NSM#SHM#CCF#SKV	1.41*** (1.27-1.58)	1.34*** (1.20-1.50)
NSM#SHM#CCF#NSKV	1.58*** (1.38-1.81)	1.54*** (1.34-1.77)
NSM#SHM#UCF#SKV	1.37*** (1.22-1.54)	1.11 (0.97-1.28)
NSM#SHM#UCF#NSKV	1.5*** (1.34-1.68)	1.27*** (1.10-1.46)
SM#NHM#CCF#SKV	1.11* (1.09-1.21)	1.12** (1.11-1.96)
SM#NHM#CCF#NSKV	1.17** (1.05-1.28)	1.15** (1.14-1.29)
SM#NHM#UCF#SKV	1.02 (0.83-2.43)	1.36 (0.68-2.72)
SM#NHM#UCF#NSKV	1.83*** (1.24-2.86)	1.04 (0.58-1.85)
SM#SHM#CCF#SKV	1.09** (1.04-1.18)	1.17* (1.14-1.54)
SM#SHM#CCF#NSKV	1.13*** (1.09-1.27)	1.71** (1.04-2.81)
SM#SHM#UCF#SKV	2.46*** (1.94-3.11)	1.45*** (1.39-2.22)
SM#SHM#UCF#NSKV	1.89*** (1.42-2.35)	1.98*** (1.47-2.67)

Abbreviations: NSM, non smoking mothers; NHM, non smoking household members; CCF, clean cooking fuel; SKV, separate kitchen with ventilation; SM, smoking mothers; SHM, smoking household members; UCF, unclean cooking fuel; NSKV, no separate kitchen with ventilation; UOR, unadjusted odds ratio; AOR, adjusted odds ratio; Ref., reference category.
The result of adjusted odds ratio (AOR) estimated based on adding all explanatory variables.
Significance level: *⩽.05. **⩽.01. ***⩽.001.

group. The results indicated that except for the age groups 36 to 47 months and 48 to 59 months, the association between maternal smoking and ARIs among under-five children was significant. However, there was considerable variation in odds ratios across the age groups. For instance, in the age group of 24 to 35 months, the adjusted likelihood of ARIs was 40% higher (AOR: 1.40; 95% CI: 1.14-1.57) among children with smoking mothers compared to their counterparts. In contrast, in the age group of 11 months or below, the likelihood of ARIs was only 6% (AOR: 1.06; 95% CI: 1.03-1.09) higher among children with smoking mothers than their counterparts (Supplemental Appendix Table 4).

Association between other indoor smoking exposures and ARIs

The adjusted odds of ARIs based on other indoor smoking exposures are presented in Supplemental Appendix Table 5. The likelihood of ARIs was considerably higher among children living with household members smoking within the household than among their counterparts. Similarly, the likelihood of ARIs was slightly higher in those households using unclean cooking fuel than those using clean cooking fuel. Regardless of the type of cooking fuel used, households without separate ventilated kitchen facilities showed a 27% higher likelihood of ARIs than households with ventilated kitchen facilities. Furthermore, among households using unclean cooking fuel, the absence of a separate and ventilated kitchen increased the likelihood of ARIs among under-five children (Table 3).

Interaction result of maternal smoking and other indoor smoking exposures with ARIs

The interaction analysis between maternal smoking and other indoor smoking exposures (such as other household members smoking, using unclean cooking fuel, and cooking without a separate ventilated kitchen) with ARIs revealed significant variations in the association with changing patterns of indoor smoking exposures (Table 3). The result indicates that the combined effect of maternal smoking with other multiple household smoking exposures (including maternal smoking, other household members smoking, unclean cooking fuel, and lack of a separate ventilated kitchen) had the most severe

Table 4. Interaction effects of maternal smoking and breastfeeding status of children on ARIs.

	AOR	95% CI
NSM#CBF (Ref.)		
NSM#EBF	0.98	0.89-1.06
NSM#NBF	1.36***	1.18-1.57
SM#CBF	1.2	0.96-1.49
SM#EBF	1.23	0.89-1.72
SM#NBF	2.11**	1.17-3.64

Abbreviations: NSM, non smoking mothers; SM, smoking mothers; CBF, currently breast feeding; EBF, ever breastfed; NBF, never breastfed; AOR, adjusted odds ratio; Ref., reference category.
The result of adjusted odds ratio (AOR) estimated based on adding all explanatory variables.
Significance level: **⩽.01. ***⩽.001.

Table 5. Interaction effects of maternal smoking and seasonal variability on ARIs.

	AOR	95% CI
NSM#Winter (Ref.)		
NSM#Summer	0.75***	0.67-0.83
NSM#Rainy	1.13**	1.01-1.27
NSM#Autumn	1.23***	1.09-1.39
SM#Winter	1.28**	1.01-1.63
SM#Summer	1.09***	1.04-1.16
SM#Rainy	1.19***	1.14-1.74
SM#Autumn	1.88***	1.50-1.94

Abbreviations: NSM, non smoking mothers; SM, smoking mothers; AOR, adjusted odds ratio; Ref., reference category.
The result of adjusted odds ratio (AOR) estimated based on adding all explanatory variables.
Significance level: **⩽.01. ***⩽.001.

detrimental effect on under-five children's risk of ARIs (AOR:2.01; 95% CI: 1.98-2.67).

Interaction effects of maternal smoking and breastfeeding status of children on ARIs

The adjusted interaction effect between maternal smoking, breastfeeding status, and ARIs demonstrated that children who never breastfed faced an increased risk of ARIs, especially when their mothers smoked (Table 4). In particular, the adjusted likelihood of ARIs was 2.11 (95% CI: 1.17-3.64) times higher among under-five children who were never breastfed and had smoking mothers than the reference group, which consisted of currently breastfeeding children with non-smoking mothers. However, the adjusted likelihood of ARIs was relatively lower among under-five children who were never breastfed and had non-smoking mothers (AOR 1.36; 95% CI: 1.18-1.57).

Interaction effects of maternal smoking and seasonal variability on ARIs

Irrespective of maternal smoking, the adjusted likelihood of ARIs was higher among children of those mothers interviewed during the autumn (AOR: 1.23; 95% CI: 1.09-1.39) than in the reference category, that is, the winter season (Supplemental Appendix Table 5). Considering seasonal variability, children with smoking mothers had a significantly higher adjusted odds ratio of ARIs (AOR: 1.88; 95% CI: 1.50-1.94) in autumn compared to the reference category of non-smoking mothers during the winter season. Almost similar results were also observed across the other seasons (Table 5).

Association between other covariates and ARIs

The study identified several significant predictors of ARIs among under-five children, including age, sex, mode of delivery (cesarean vs vaginal), size at birth, and breastfeeding status (Supplemental Appendix Table 5). Female children were found to be less vulnerable to ARIs compared to their male counterparts. The likelihood of ARIs was considerably higher among children who were born underweight (very small) or overweight (very large) than among their normal-weight peers, and this risk was further increased in the presence of maternal smoking. Furthermore, the adjusted odds of ARIs were significantly higher among under-five children delivered through cesarean section than those delivered vaginally. Children who were never breastfed showed a 37% higher likelihood of ARIs compared to children who were currently breastfeeding.

Additionally, several socioeconomic and geographical factors were associated with an increased risk of ARIs. Children with lower-educated mothers, those living in rural areas, interviewed during autumn, and those residing in the northern region were more likely to experience ARIs. Moreover, the presence of household tuberculosis (TB) patients also significantly increased the likelihood of ARIs among under-five children.

Discussion

The present study aimed to comprehensively analyze the association between maternal smoking and acute respiratory infections (ARIs) among children under-five in India. To achieve this, the research employed adjusted interaction analyses and considered several confounding variables, such as child age, breastfeeding status, other household smoking exposures, and seasonal variability. By capturing the differentials in this association by employing interaction analyses, the study's findings offer crucial insights that can inform interventions to enhance respiratory health in India's under-five children in India.

In line with previous research,[11,14-16] the present study established a positive association between maternal smoking

and ARIs in children under-five throughout the entire season. Interestingly, the adjusted effect of maternal smoking was significantly higher compared to other indoor smoking exposures, including other household members smoking and exposure to unclean cooking fuel. This consistent finding echoes a previous study conducted in Nepal and elsewhere,[14,15] which suggested that the impact of tobacco smoking on respiratory illnesses in children may be more pronounced when mothers smoke. The study proposed that this could be due to under-five children spending more time with their mothers than other household members.[14,15] Similarly, exposure to unclean cooking fuel is limited due to several background circumstances, such as limited time spent on household cooking, distance from the kitchen, availability of separate kitchen facilities, or even cooking in open spaces, all of which can affect the results.[11,20] Furthermore, during cooking time, children are generally cared for by other household members because the structure of Indian families is commonly extended in nature.[21] Finally, when a mother smokes, there is a high possibility of other household members engaging in indoor tobacco smoking, which may indirectly affect the results through dual tobacco smoking exposures. To support this possibility, we conducted an additional analysis, which showed that 76% of other members reported indoor tobacco smoking in households with maternal smoking exposure. In contrast, households with non-smoking mothers showed a significantly lower rate, with only 47% of other members practicing indoor tobacco smoking (Supplemental Appendix Table 6). These findings highlight the importance of understanding the various factors and interactions within households that can impact respiratory health in children under-five in India. By considering these factors, interventions can be better tailored to address the specific challenges and improve the respiratory well-being of children in such environments.

However, when examining specific age cohorts, the study found that the association between maternal smoking and ARIs was insignificant among children aged 36 months and above (Table 3). This observation may be attributed to the decrease in time spent by children with their mothers as they age, which could influence the study results. Additionally, infants are particularly vulnerable to respiratory infections due to their weak immune systems and underdeveloped lungs, making them more susceptible to the adverse effects of maternal smoking.[20] While unclean cooking fuels were identified as risk factors for ARIs, the presence of a separate kitchen facility emerged as a significant mediator in the association between unclean cooking fuel and ARIs. Similar to a study in Afghanistan,[20] the combined effects of unclean cooking fuels and households without separate ventilated kitchen facilities demonstrated a higher likelihood of children's ARIs compared to households using unclean cooking fuel in separate ventilated kitchen facilities and other counterparts in India. Previous research suggests that children are more susceptible to particulate matter exposure when there is no separate kitchen for cooking,[11,20] highlighting the importance of proper ventilation in reducing ARI risk. Moreover, the study highlighted that multiple indoor smoking exposures increased the likelihood of ARIs, supporting previous research[15] and providing additional evidence that maternal smoking combined with other indoor smoking exposures can exacerbate the risk of acute respiratory infections. This underscores the need for targeted interventions to reduce indoor smoking exposures and promote smoke-free environments for children. The government of India has launched essential programs to promote a healthy household environment, such as Pradhan Mantri Awas Yojana (Housing for all with separate kitchen facilities) and Pradhan Mantri Ujjwala Yojana (providing subsidized clean cooking fuel), which are expected to positively impact the burden of ARIs in India in the near future. Alongside structural interventions at the household level, India should focus on awareness campaigns, local media coverage, and the engagement of community-level health workers to raise awareness against passive tobacco smoking practices. Minimizing indoor tobacco passive smoking could significantly reduce the burden of ARIs among children under-five.

Regarding breastfeeding, the study observed that children who were never breastfed were 1.37 times more likely to be vulnerable to ARIs compared to those who were currently breastfeeding. This finding highlights the importance of breastfeeding as a preventive factor against ARIs among children under-five. Previous research in Nepal has also supported this, suggesting that breastfeeding promotes good health and immunity among under-five children.[22] Furthermore, the interaction analysis revealed that maternal smoking exacerbates the risk of ARIs among children who were never breastfed. This emphasizes the need for special attention to smoking mothers, particularly those who encounter breastfeeding difficulties. Providing counseling and support to these mothers to avoid smoking can significantly reduce the risk of ARIs in their children.

The study also examined individual-level factors that contribute to the risk of ARIs. Children's age, sex, and size at birth were identified as significant predictors of ARIs, which is consistent with many previous studies.[11,14-16] Consistent with earlier studies in India, Philippines, and elsewhere,[11,15,16,20] female children were less susceptible to ARIs than males, possibly due to boys facing both indoor and outdoor pollution exposures in patriarchal societies,[11,20] increasing the risk of lung infections. Furthermore, male toddlers' heightened activity levels might contribute to a higher risk of respiratory virus exposure from surfaces (fomites), potentially explaining the elevated incidence of ARIs among them. However, the underlying reasons for this discrepancy remain unclear and require further research. Understanding the biological aspects contributing to these gender-based differences could provide valuable insights into preventing and managing ARIs among male children.[23]

Additionally, abnormal birth size (small or large size births) was recognized as a risk factor for severe respiratory infections. Low birth weight may affect the risk of ARIs through abnormalities in lung structure and function and impaired immune competence resulting from intra-uterine growth restriction.[24] The study further suggests counseling mothers who experience abnormal births to protect their children from passive smoking exposures.

Healthcare utilization was also found to significantly shape the risk of ARIs. Children delivered through cesarean or by unskilled birth attendants were more vulnerable to ARIs than their counterparts. This finding is consistent with a previous study conducted by Begum et al,[25] which revealed that cesarean-born children have a persistent health difficulty and obesity trajectory that increases the risk of ARIs and cardiovascular diseases during childhood.[25] Improving the quality of maternal care during childbirth and ensuring adequate immunization coverage could reduce the risk of ARIs among children. The study also unveiled a significant regional disparity in the incidence of ARIs in India, with a clear gap between the north and south regions. The southern region has reported improved environmental quality and quality of life, contributing to the lower risk of ARIs. In contrast, the north, particularly Delhi, has shown the highest prevalence of ARIs, mainly due to severe air pollution negatively impacting overall health.

Similar to regional variations in ARIs likelihood among children under-five, this study highlights the significance of seasonal variability. Confirming previous findings,[14,26] a higher likelihood of ARIs in children under-five was observed during autumn compared to summer. Earlier research suggests that viruses thrive in colder, humid conditions (autumn to winter season), potentially heightening the risk of childhood infections like pneumonia and influenza. Smaller-scale surveys noted a higher risk of respiratory issues, particularly cough, cold, and fever, in children under-five during autumn in India.[26] Pneumonia and influenza significantly and positively contribute to the occurrence of severe acute respiratory illness.[27] Autumn acts as a transition between the monsoon and winter in India,[28] marked by frequent weather disturbances like rainfall, temperature fluctuations, and cyclones, escalating the risk of child morbidities.[26] Despite varying degrees of association between maternal smoking and ARIs among children under-five depending on the season, the positive connection persists across all seasons as observed in the current study. Even though the likelihood of ARIs among children under-five is lower during the summer [Supplemental Appendix Table 5], the current study also found that children with smoking mothers were 9% more likely to experience ARIs than those with non-smoking mothers during this season. This finding underscores a robust and significant link between maternal smoking and ARIs among children under-five in India. Therefore, it becomes imperative to offer comprehensive counseling during antenatal check-ups, primarily focusing on raising awareness among smoking mothers regarding the adverse repercussions of tobacco consumption on their children's health. Promoting smoking cessation for the betterment of both the mother and the child emerges as a pivotal and compassionate facet of these efforts.

Limitations of the Study

However, it is essential to acknowledge that the present study has certain limitations. Firstly, due to its cross-sectional design, we could not establish a cause-effect relationship between maternal smoking and ARIs in children. To establish causality, longitudinal datasets would be required. Secondly, the study relies on secondary data, which is self-reported and retrospective, leading to potential recall bias. Thirdly, several important covariates, such as the complete health history of the children, the respiratory infection history of the mothers, their tuberculosis history, the children's immunity, dietary practices, and the status of environmental pollutant particles, were not included in the analysis due to data limitations. These unaccounted factors could influence the study's results. Fourthly, in this study, we used proxies like cooking fuels, a separate kitchen, and smoking behavior to measure children's exposure to indoor air pollution instead of directly measuring the concentration of particulate matter. Direct indoor air pollution measures would be more appropriate for validating the association. Despite these limitations, this study contributes valuable insights for designing effective policy interventions to address the issue of respiratory infections among children in developing countries like India, where a significant number of households are vulnerable to indoor pollution exposures.

Conclusion

In conclusion, the present study sheds light on the positive association between maternal smoking and ARIs among children under-five across all seasons in India. The findings underscore the importance of interventions to reduce maternal smoking, promote breastfeeding, and improve respiratory health in households exposed to unclean cooking fuels and indoor smoking. Additionally, efforts to improve healthcare utilization and control air pollution in the northern regions are crucial in reducing the burden of ARIs among children. By implementing targeted strategies and policies, India can take significant steps toward improving respiratory health and enhancing the overall well-being of its young population.

Acknowledgements

The authors are grateful to the Demographic and Health Surveys (DHS) for providing approval to use the dataset in this study. We would also like to thank anonymous reviewers for their critical input in the manuscript.

Ethics Approval and Consent to Participate

This study is based on secondary data that is available in the public domain. Therefore, ethical approval is not required to conduct this study.

Consent for Publication

Not applicable

Availability of Data and Material

The datasets analyzed during the current study are available in the Demographic and Health Surveys (DHS) repository, https://dhsprogram.com/data/available-datasets.cfm.

Supplemental Material

Supplemental material for this article is available online.

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