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Passive Smoking and Its Correlation with Stunting in Children: A Systematic Review

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Abstract

Passive smoking is a significant risk factor for stunting in children, highlighting the urgent need for effective public health measures. This study aimed to investigate the association between passive smoking and stunting in children aged 0 months-7 years. Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, a comprehensive literature search was conducted across multiple online databases, including PubMed, ProQuest, Science Direct, Willey Online Library, Sage Journal, Cambridge University Press, and Oxford Academic. The quality of included articles reporting observational studies was assessed using the Critical Appraisal Skill Programme (CASP) checklist, presenting data through narrative synthesis. Findings suggested that passive smoking significantly contributed to the risk of stunting in children. Most reviewed articles were from low-income countries and reported studies with various age groups, demographic characteristics, and self-reported measures. Establishing a causal relationship remains challenging, with 99% of these studies using a cross-sectional design. Based on these findings, further study into this relationship using more comprehensive study designs is necessary. Interventions for mothers and children experiencing stunting should also be prioritized to reduce risk factors and strengthen protective factors.

Keywords: child stunting, passive smoking, public health, systematic review

Introduction

Child growth is an important metric for assessing nutritional health. However, child growth is vulnerable to a variety of influences, including chronic malnutrition, which can lead to stunting, a condition in which children are significantly shorter than their age. This condition not only marks a gap in human development but also significantly increases the risk of death, which limits the children's ability to reach their full intellectual and physical potential. As recognized by the World Health Organization (WHO) as an important nutrition target, stunting reflects broader dietary, health, and socioeconomic challenges that interfere with healthy growth.[1-4]

The WHO Global Nutrition Targets 2025 identifies stunting as impaired growth resulting from inadequate nutrition and repeated infections in the first 1,000 days of life, affecting between 171 and 314 million children under the age of five worldwide.[5,6] Indonesia, in particular, shows a high prevalence of stunting, second only to Southeast Asia, with a very high figure of 43.8% among the under-five, according to the 2018 Indonesian Basic Health Research data.[7] Stunting occurs due to complex factors, including fetal growth retardation, maternal and child nutrition and infections, and environmental influences, such as exposure to cigarette smoke.[6] Stunted growth in early childhood has serious impacts on mental health, intellectual intelligence (IQ), cognitive, psychomotor, and motor development, and increases susceptibility to fatal infections.[8]

Although the causes of stunting are diverse, a significant gap is found in awareness among Indonesian mothers regarding its determinants, leading to misunderstandings and maladaptive behaviors. A previous study shows that exposure to cigarette smoke can cause an increased risk of stunting.[8] Most studies have focused on nutritional aspects, but the potential role of environmental factors, especially exposure to passive smoke, remains to be explored.[9-11] This analysis aimed to investigate the correlation between exposure to passive smoke and the incidence of stunting in

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children, using a systematic review to answer the question: "Is exposure to passive smoke correlated with increased incidence of stunting in children?" According to this study, passive smoking significantly contributes to the risk of stunting in children in terms of diverse age groups and demographic characteristics.

Method

Search strategy

Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 10 guidelines, this systematic review refined its search strategy by leveraging the Population, Intervention, Comparison, and Outcome (PICO) framework to optimize the study plan.[12,13] This study was conducted through a comprehensive search of several electronic databases, including PubMed, ProQuest, Science Direct, Willey Online Library, Sage Journal, Cambridge University Press, and Oxford Academic, from September 1-December 13, 2023. The search terms were refined through initial searches and testing of truncations "*" and wildcards "?," ultimately focusing on "passive smoking" AND "stunting" OR passive smoking AND stunting.

Inclusion and exclusion criteria

This study included open-access and full-text articles published between 2018-2023, which reported the association between passive smoking and child stunting. The last five years of research were selected because the study used the most recent primary research articles. Exclusions applied to studies that did not focus on stunting involved non-child samples, did not have full-text accessibility, were ongoing studies, or were not written in Indonesian or English. However, studies with abstracts in both languages were accepted without imposing language restrictions on the full text.

Screening procedures

To ensure the integrity of reviews, duplicate articles were removed, and independent article selection was performed based on title and abstract by a third primary reviewer. The discrepancies were resolved through discussion and thorough full-text review based on criteria applied in this study.

Data analysis and quality assessment

Data extraction included study identification, objectives, location (world), participant demographics, methodology (PICO and PRISMA Flow Diagram), and anticipated outcomes. Article quality assessment used the Critical Appraisal Skill Programme (CASP) Checklist for Observational Studies without using global quality ratings.[14] A narrative synthesis approach for data analysis was adopted as recommended by systematic review guidelines.

Results

The search yielded 1,375 articles, with 25 duplicates subsequently excluded. Of the remaining 1,350 articles, title and abstract screening led to the exclusion of 845 articles. A total of 505 articles were comprehensively reviewed, with 12 meeting the inclusion criteria. These studies, conducted in Indonesia, China, Japan, and India between 2018 and 2023, were predominantly cross-sectional observational designs with one case-control study. The total number of participants in these studies was 257,590, with sample sizes ranging from 57 to 206,898. The stunting assessment included measurements of height-for-age, weight-for-age, weight-for-height, and body mass index (BMI), supplemented with WHO Z-scores and questionnaires to assess the sociodemographic factors and the impact of passive smoke on stunting. The PRISMA flowchart reflects the selection, as shown in Figure 1.

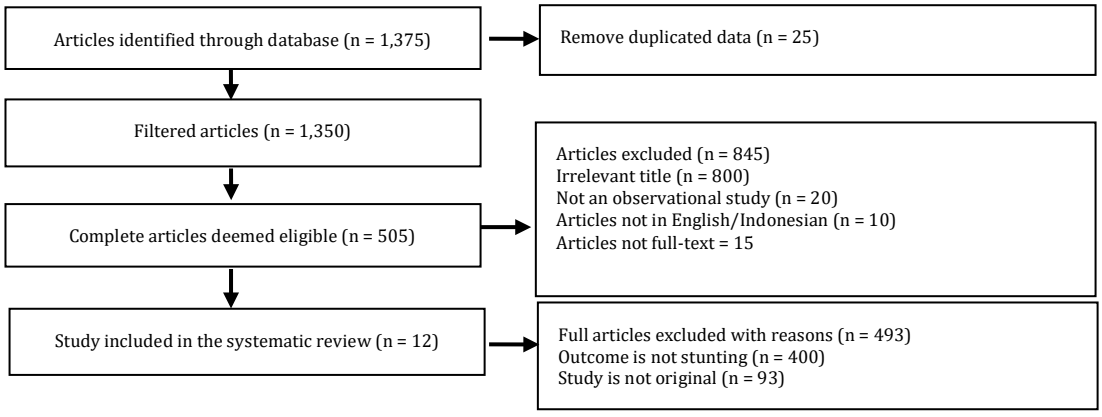

Figure 1. Review Process PRISMA Flow Diagram

Table 1. Characteristics of Included Articles

Author (Year)	Country	Design	Sample Characteristic	Sample Size	Finding
Hasnita *et al.* (2022)[4]	Indonesia	Cross-Sectional	The regional data sample from the 1-PPGBM application selected is Padang Pariaman District.	574 respondents were selected as samples, and 316 people experienced stunting.	Correlation of the stunting incidence with cigarette exposure (26.6%). There is a significant relationship between the stunting incidence and cigarette smoke (p-value = 0.001).
Widyawati *et al.* (2021)[8]	Indonesia	Cross-Sectional	Children in the age group of under 5.	The number of samples was 128 respondents. Data collection used questionnaires and anthropometric measurements (weight, body length, and baby head circumference).	Analysis of factors related to stunting obtained p-values for the last education factor of parents (0.161), exclusive breastfeeding record (0.794), LBW (1.000), exposure to cigarette smoke during pregnancy (0.303), and after birth (1.000). The test results showed no relationship between record of cigarette exposure during pregnancy and stunting, but the group exposed during pregnancy was more likely to have stunted children compared to those not exposed.
Astuti *et al.* (2020)[11]	Indonesia	Cross-Sectional	Children in the age group of 25–59 months old.	123 children aged 25-59 months. Cigarette exposure was assessed based on duration using a cigarette smoke exposure scale questionnaire.	Bivariate statistical tests using Chi-square and Fisher's exact test showed a correlation between stunting and the length of exposure to cigarettes (p-value <0.001; or 10.316).
Shinsugi *et al*. (2022)[15]	Japan	Cross-Sectional	Children in the age group of 12-59 months.	900 of 3,000 survey areas were randomly selected, and 900 children aged two years and older prior to elementary school were selected.	Smoker fathers or mothers during pregnancy and childbirth can increase the incidence of stunting (aOR: 5.78, 95%CI: [3.48–9.60], p-value <0.001) and wasted (aOR: 7.02, 95%CI: [3.30−15.0], p-value <0.001).
Li *et al*. (2022)[16]	China	Cross-Sectional	The physical growth indexes of children are height-for-age, weight-for-age, weight-for-height, and BMI-for-age. BMI is generally measured by the comparison of a child's weight (kg) and height (kg/m2): BMI = weight (kg)/height (m2). The physical growth of children is assessed by the WHO z-score (Z-score = (analyzed index - median of reference standard)).	5,529 children aged 0 to 71 months and their caregivers were randomly selected using multistage stratified cluster sampling from 72 villages in rural Hunan, spread across 24 cities in 12 countries.	There is no correlation between passive smoking and stunted child growth (p-value = 0.953).
Saeni *et al.* (2020)[17]	Indonesia	Case Control	57 people	All mothers with stunted children, while controls were mothers with children with normal height. Inclusion criteria include: 1. Willing to be involved in the study; and 2. Having a KMS card.	Exposure to cigarette smoke was not statistically associated with stunting (p-value = 0.090; OR = 0.31).
Qamarya *et al.* (2022)[18]	Indonesia	Cross-Sectional	Mothers who have children	100 mothers	Children exposed to cigarette smoke and stunting were 13.3%, and those not at 0%. The Chi-square test showed a p-value of 0.007, meaning that there is a relationship between cigarette smoke exposure and stunting, with OR 95%CI = 0.867. This shows that the children exposed have a 0.867 times greater likelihood of experiencing stunting compared to those not exposed.
Islam *et al.* (2020)[19]	India	Cross-Sectional	Children under the age of five and have child stunting status from the latest national family.	206,898 children aged >5 from the most recent national families.	Not being exposed to cigarette smoke can reduce the prevalence of stunting by 4%, 1%, and 1% of the current prevalence at 38%.
Chao *et al.* (2022)[20]	China	Cross-Sectional	Children in the age group 6-17 years old.	41,439 children aged 6–17 included from 30 provinces in mainland China.	Exposure to passive smoke in households inhibits children's growth, and it is recommended to support smoke-free homes.
Kadir *et al*. (2021)[21]	Indonesia	Cross-Sectional	57 people	66 parents with children aged >5 in the Kintamani I Primary Health Care working	The study showed a p-value = 0.011 (<0.05); hence, there is a relationship between parental smoking behavior and stunting in children aged 2-5 years, with a correlation strength value of 0.33 so that the variable of

				area.	parental smoking behavior with stunting in children aged 2-5 years has a low correlation relationship. In conclusion, parental smoking behavior has direct and indirect effects on child growth and development.
Muchlis *et al*. (2023)[22]	Indonesia	Cross-Sectional	221 children	Children aged 0 to 59 months from poor areas in Indonesia.	Predictors of stunting in children aged >5 years are smoker fathers (aOR 1.8; 95%CI=1.281-4.641), smoker parents increase the risk of stunting (COR 3.591; 95%CI = 1.67-3.77), longer exposure to cigarette smoke. Exposure to cigarette smoke for three hours a day increases the risk of stunting in children (COR 2.05; 95%CI 1.214-3.629), and the use of conventional cigarettes increases the risk (aOR 3.19; 95%CI 1.139-67.785). This study indicates the negative impact of smoker parents on their child growth. It is pivotal to reduce the prevalence of smokers by implementing a smoke-free home policy to prevent stunting.

Notes: aOR = adjusted odd ratio, OR = odd ratio, COR = crude odd ratio; CI = confidence interval, LBW = low birth weight, BMI = body mass index, KMS = Health Card/*Kartu Menuju Sehat*, PPGBM = Community-based Nutrition Reporting Recording/*Pencatatan Pelaporan Gizi Berbasis Masyarakat*.

After adjusting for confounding factors, multiple logistic regression analysis showed that boys with low birth weight (LBW) for gestational age tended to experience stunting (aOR: 5.78, 95%CI: [3.48-9.60], p-value <0.001), while those with high birth weight for gestational age had a lower probability (aOR: 0.26, 95%CI: [0.11-0.60], p-value <0.01). In contrast, girls with LBW for gestational age tended to experience stunting (aOR: 4.04, 95%CI: [2.43−6.73], p-value <0.001) compared to others. Exposure to passive smoke for more than three hours a day increases the risk of stunted growth in children.

This study revealed that boys were more at risk of stunting with parents who had positive smoking status compared to girls. A significant correlation was found between stunting and cigarette smoke (p-value = 0.001). This is because nicotine has the potential to interfere with oxygen delivery by 30-40%, as well as the absorption of calcium, minerals, and vitamin C, which are very important for growth. This study found a relationship between stunting and the duration of exposure to cigarette smoke (p-value <0.001; OR 10.316). The exposure to cigarette smoke increased the risk of stunting by up to 10 times.

Passive smoking and stunting occurred because environment and nutrition played an essential important role in stunting prevention efforts. Short mothers with a good environment and nutrition were less likely to have stunted children. Therefore, the first 1000 days of life are a crucial variable that requires great attention. The Chi-square test produced a p-value of 0.007, indicating a correlation between cigarette smoke exposure and stunting with OR 95%CI = 0.867. Based on the results of this study, children exposed to cigarette smoke had a 0.867 times greater likelihood of experiencing stunting compared to those not exposed.

In addition, this study also revealed that passive smoking raised the condition risk [OR =1.520, 95%CI: 1.318, 1.753]. A similar relationship was reported between the variables, particularly among children aged two to five years (p-value = 0.011), with a correlation strength value of 0.33. This indicated that parental smoking behavior with stunting had a low relationship. In conclusion, parental smoking behavior has direct and indirect effects on child growth.

The prevalence of stunting was 145 people, or 65.6% of the population. In addition, children living with smoker parents were 157 people (71%), and the most exposure could be attributed to fathers among 147 participants (67.4%). Predictors of stunting in children aged more than five years were fathers who smoke (AOR = 1.8; 95%CI = 1.281-4.641), and both parents who smoke further increase the risk (COR = 3.591; 95%CI = 1.67-3.77). Other influential factors were exposure to cigarette smoke for more than three hours daily (COR = 2.05; 95%CI = 1.214-3.629) and using conventional cigarettes (AOR = 3.19; 95%CI = 1.139-67.785). High smoking prevalence can increase stunting because cigarettes contribute to household expenses in low-income families.

There was no relationship between passive smoking and stunting for several reasons. First, economic conditions, culture, religion, life, and living habits differ between ethnic groups. Second, the samples, index definitions, and report data vary. The association test did not show any relationship between records of exposure to cigarette smoke during pregnancy and stunting. However, there was a possibility of stunting in the group exposed to cigarette smoke during pregnancy compared to the group not exposed (p-value = 0.100).

Discussion

This study highlighted a significant association between passive smoke and stunting in children, corroborating findings from several studies. Most studies emphasized an association between passive smoke and stunting, with maternal sociodemographic and psychological factors also playing an important role. Passive smoke emerges as an important risk factor for stunting, highlighting the detrimental impact of passive smoke exposure on child development. Passive smoking is one of the known risk factors for stunting in children, and most studies have shown a significant association. This analysis is not only limited to passive smoking habits but also includes maternal sociodemographic and psychological factors, in line with previous reports that collectively affect the incidence of stunting.

There were twelve articles analyzing the association of passive smoking with stunting.[4,8,11,15-22] Mixed results were described, with eleven articles[4,11,15-22] reporting that cigarette smoke exposure contributed to stunting disease, while one article[8] reported the absence of a relationship. Bivariate analysis showed that children, the passive smokers, have a higher risk of stunting in adolescence. In this context, participants have fathers, mothers, and/or other family members in the same household who actively smoke.[3] This is consistent with previous reports in Indonesia showing that paternal smoking is associated with severe malnutrition.[3] Handriani *et al.* revealed that exposure to cigarette smoke increased weight gain risk in LBW infants by 2.19 times more than others.[23]

An increase in tobacco expenditure proportions from 3.6% in 1993 to 5.6% in 2014, accompanied by a decrease in important expenditures, such as carbohydrates and protein, had created long-run impacts on stunted children. Children with smoker parents had a weight growth of 1.5 kg and a height growth of 0.34 cm, which was lower compared to others with non-smoker parents. In addition, children with smoker parents had a probability of experiencing stunting 5.5% (percentage point from average) higher compared to those with non-smoker parents. This had been controlled with genetic, environmental, and nutrition variables. In terms of household welfare, higher smoking expenditure increased the probability of households being continuously poor.[24,25]

High smoking contributed to a rise in stunting prevalence.[22] A previous study of children aged 16-24 months stated there is an association between smoker parents and child stunting, with a p-value = 0.601 and OR = 1.15. This indicated that smoker parents were 1.15 times more at risk of having stunted children compared to non-smoker parents. Parental smoking could affect stunted children by two methods.[22,26,27] Children exposed to passive smoke potentially experience the same effects as active smokers. A 2018 report was carried out by the Universitas Indonesia Center for Social Security Studies according to data exploration of the Indonesian Family Life Survey. The results showed that the likelihood of having stunted children for the smoker parents was >5.5% compared to the non-smoker parents.[28] Tobacco smoke affects the absorption of nutrients in children, affecting their growth and development. The use of Javanese conventional cigarettes, well-known as *Kretek*, increased the risk of stunted growth.[22,29] The exposure to smoke for three hours more a day increased the risk of stunting, which applies to the use of *Kretek* as well.[22]

A safe environment is usually free from pollution caused by the smoker members of the family. Some reports show that cigarettes contain around 4,000 types of dangerous compounds. Lead toxins in cigarettes include nicotine, carbon monoxide, and tar. The content of cigarette smoke affects gene mutations. Smoking exposes children to dangerous chemicals that inhibit their growth. The cost of cigarettes also reduces the cost of meeting household needs so that nutritional intake is reduced.[21,30,31] Exposure to cigarette smoke, both during pregnancy and during child development, is correlated with the risk of stunting. In low- and middle-income countries, cadmium in cigarette smoke disrupts the balance of calcium, zinc, and cadmium in the body, causing impaired bone formation and slow growth.[30]

A study found that those exposed to cigarette smoke were shorter than those not exposed [β = -2.897, 95%CI): -3.090, -2.703] and had a greater likelihood of stunting [OR = 1.520, 95%CI: 1.318, 1.753]. The impact of cigarette smoke exposure was the same for all sexes but correlated with age, especially at the age of six to eight years (OR = 3.708, 95%CI: 2.572, 5.346). The risk of stunting increased with the duration of smoke exposure, with risk levels of 1.246 (CI: 1.053,1.474), 1.904 (CI: 1.572–2.305), and 3.263 (CI: 2.203,4.833) for those exposed for 1–10, 11–55, and 56 minutes/day, respectively, which recommends a dose-response correlation.[20] This analysis shows that exposure to smoke inhibits the growth of school-age children. A previous study in China showed that the prevalence of girls (43%) was higher than that of boys (40%), and a positive correlation with age was observed. Based on region, the prevalence of children in South and Southwest China was higher, at 47%, while 33% was obtained in Northeast China.[20]

Exposure to passive smoke is common in low-income families, especially those with low education levels. Children with smoker parents had higher serum thyroglobulin and thiocyanate concentrations at birth and aged one year than others. These results suggest that the passive transfer effect of smoking (thiocyanate) stimulates thyroglobulin secretion.

Some reports have also revealed that smoking during pregnancy causes neonatal thyroid dilatation.[20,22] Cigarette smoke could cause clogged blood vessels, leading to substance inhibition needed by the body. Therefore, the body's vulnerability could happen because of an imbalance, causing the development of various diseases. The same impact was also felt by children exposed to cigarette smoke. This exposure caused people in the environment to be passive smokers, thereby increasing the risk of stunting.[17,32,33] Apart from the direct effect of stunting, smoking also had the potential to cause health problems indirectly. This occurred because family income was predominantly spent on cigarettes rather than nutritional needs, particularly children.[34]

Based on previous reports, three toxic compounds are carcinogenic (benzo(a)pyrene, 4-aminobutylene, and acrylonitrile) and can poison mothers and babies. In addition, cigarette smoke contains 400 chemicals, and 200 of them are reported to be very toxic. CO is a toxic substance that can cause blood vessels to cramp, increase blood pressure, and tear blood vessel walls. CO gas can cause hemoglobin desaturation, reducing oxygen circulation to tissues and causing myocardium. This gas is reported to have the potential to replace O_2 bound to hemoglobin.[35,36] Exposure duration to cigarette smoke was significantly correlated with stunting in children aged 25-59 months. Exposure for three hours more a day raised the risk by 10.316 times. Most stunted children had fathers with a record of smoking for more than three years and three times more a day.[11] Previous analysis in Indonesia has shown that paternal smoking is strongly associated with stunting due to the chronic effects of low-quality diets in households where fathers are smokers.[11] A correlation might also occur with a decrease in the proportion of weekly household expenditure on quality food (eggs, fish, fruits, and vegetables).[37]

According to some studies, there was no correlation between passive smoking and stunting.[27,16] Bella *et al.* revealed that children whose fathers had moderate/high smoking intensity tended to be skinnier and stunted by 2.93 and 3.47 percentage points.[28] While the intensity of the father's smoking did not have a significant effect on overweight. This analysis observed the effect of the father's smoking status on child malnutrition, which was insignificant because the amount of nicotine smoked by parents was not measured; thus, the threshold value that could trigger inflammation was unknown. In this report, this was not proven, possibly because the levels of TNF, interleukin 1, and interleukin 6 were not measured. This condition could also be caused by low levels of these mediators due to various factors. Therefore, the hypothesis in this study was not proven, possibly because low levels of mediators were not enough to trigger an increase in leptin hormone production. This study's results indicated that the statistical significance of cigarette consumption may be reduced by the influence of external variables, such as maternal height, which has the potential to have a stronger effect. An alternative interpretation may indicate that varying nicotine content in each type of cigarette makes direct comparisons unreliable.[26]

This systematic review has carefully examined the association between passive smoke and stunting in children, revealing a strong correlation. Evidence suggests that children exposed to passive smoke, especially from parents, are at higher risk of stunting. This finding is consistent across studies, highlighting the detrimental impact of environmental tobacco smoke on child growth and development.

The complexity of stunting, influenced by multiple elements, including socioeconomic status, nutritional intake, and environmental factors, underscores the challenges in addressing this public health problem. However, the consistent association between passive smoke and stunting highlights the need for targeted interventions to protect children from exposure to passive smoke. Efforts to reduce the impact of passive smoke should include public health campaigns aimed at reducing smoking in the presence of children, implementing smoke-free home policies, and educating parents about the risks associated with tobacco smoke exposure. Furthermore, broader strategies to combat stunting should address malnutrition, improve maternal health, and improve living conditions to promote optimal child growth.

The findings suggest an influence of passive smoke on stunting, suggesting increased awareness among policymakers and mothers. Despite the inability to establish causality due to the largely cross-sectional study design, evidence suggests a significant impact of passive smoke on child growth. Future studies should expand the scope to include other potential stunting factors and use longitudinal designs to better understand causal pathways.

Strengths and Limitations

All included articles were of strong/moderate quality. In addition, the sample population consisted of children aged 0 months-7 years. During the selection process, there was no age limit on the samples made, thus increasing the breadth and sensitivity of the review. The articles included were carried out in various countries, with various educational institutions and households, so the review is representative. However, the majority was conducted in middle- to low-

income countries (77.7%), which might increase the risk of applying the results only to low-income countries. The articles did not use the same measurement tools and questionnaires, and standards for instruments were not established in several articles. All articles in this review relied on self-reported data, which could be affected by individual dishonesty, social desirability, self-evaluative capacity, and interpretation, thus introducing self-reported bias.

Furthermore, as 99% had a cross-sectional design, it is inconclusive. Although eight databases were often used to search for eligible articles, there might be articles in other databases that were not previously considered. The reasons are that the study does not focus on stunting, involves non-child samples, lacks accessibility of full text, is ongoing research, or is not written in Indonesian or English. Given the limitations of predominantly cross-sectional studies in this review, there is an urgent need for longitudinal studies to establish causality between passive smoke and stunting. Such studies will provide a deeper understanding of temporal relationships and potential mechanisms underlying these associations, informing more effective prevention and intervention strategies.

Conclusion

This review shows the significant relationship between passive smoking and stunting in children, calling for concerted efforts from policymakers, healthcare providers, and communities to reduce children's exposure to tobacco smoke and address the broader determinants of stunting.

Abbreviations

WHO: World Health Organization; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analysis; PICO: Population, Intervention, Comparison, Outcome; BMI: body mass index; aOR: adjusted odd ratio; OR: odd ratio; COR: crude odd ratio; CI: confident interval; LBW: low birth weight.

Ethics Approval and Consent to Participate

Not applicable.

Competing Interest

The authors declare no substantial competing financial, professional, or personal interests that could have influenced how the work described in this publication was performed or presented.

Availability of Data and Materials

The data is publicly available from PubMed, ProQuest, Science Direct, Willey Online Library, Sage Journal, Cambridge University Press, and Oxford Academic databases published from 2018-2023. For more information, the reader can contact the corresponding author.

Authors' Contribution

AR contributed to the manuscript's conceptualization, data screening, supervision, and writing. The manuscript was conceived and written with the help of K, HH, and F.

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