

# UCSF

## WHO Tobacco Control Papers

**Title**

Tobacco and stunting

**Permalink**

<https://escholarship.org/uc/item/9sx5h2b7>

**Author**

World Health Organization

**Publication Date**

2025-09-02

# Tobacco and stunting

- Tobacco smoking is one of the critical factors associated with stunting in children. Other correlates include low socioeconomic status, low parental education level, young maternal age and poor maternal health status, poor nutrition and repeated respiratory infections.
- For postnatal growth, it remains unclear whether the observed associations are causal or non-causal, whereas for fetal growth, there is stronger evidence supporting a causal relationship.
- A higher incidence of stunting has been found among children whose parents both smoke tobacco, and the risk increases with greater exposure to smoke.
- Tobacco smoking during pregnancy is associated with preterm birth, fetal growth reduction and other complications. Birth length and weight are the most robust predictors of linear growth status and stunting at 2 years of age.
- Heavy maternal tobacco smoking (smoking one or more packs of cigarettes per day) is associated with a graded effect on fetal growth; residual effects are seen later in life as well.
- Sufficient evidence is available to suggest that tobacco cessation during pregnancy has a positive effect on child growth.

## What is stunting?

Stunting is impaired growth and development that children experience as a result of poor nutrition, repeated infection and inadequate psychosocial stimulation. Children are considered stunted if their height-for-age is more than two standard deviations below the WHO Child Growth Standards median (1). Of the approximately 148 million stunted children in the world in 2022, 52% lived in Asia and 43% in Africa (2–4). Stunting is associated with increased morbidity and mortality in children. Under the Global Nutrition Targets 2025, WHO has envisaged a 40% reduction in the number of stunted children under 5 by 2025 (5).

Fetal growth restriction (FGR), low maternal socioeconomic status, low maternal education level, poor maternal health, inadequate sanitation, the sex of the child, poor nutrition and repeated infections are some of the risk factors associated with stunting (2,3,6). Meta-analysis has found strong evidence of a link between maternal active smoking and FGR (7). Smoking during pregnancy is still a prevalent behaviour in many countries (8,9). Exposure to environmental tobacco smoke is also associated with FGR (10). For postnatal growth, it remains unclear whether the observed associations are causal or non-causal, whereas for fetal growth, there is stronger evidence supporting a causal relationship.

## Tobacco definitions

**Smoked tobacco products:** any product made or derived from tobacco that generates smoke. Examples include manufactured cigarettes, roll-your-own tobacco, cigars, shisha (also known as waterpipe), kreteks and bidis.

**Second-hand smoke (SHS):** the smoke emitted from the burning end of a cigarette or other tobacco products, usually in combination with the smoke exhaled by the smoker.

**Smokeless tobacco:** any product that consists of cut, ground, powdered or other tobacco intended to be placed in the oral or nasal cavity. Examples include snuff, chewing tobacco, gutka, mishri and snus.

**Heated tobacco product (HTP):** tobacco product that produces aerosols containing nicotine and toxic chemicals when tobacco is heated or when a device containing tobacco is activated. Users inhale these aerosols during a process of sucking or smoking involving a device. They contain the highly addictive substance nicotine, as well as non-tobacco additives, and are often flavoured.

**Electronic nicotine delivery system (ENDS) (also known as e-cigarette):** a device that heats a liquid to create an aerosol that the user inhales. The aerosol typically contains nicotine and toxic substances that are harmful to users and non-users who are exposed to the aerosols second-hand; the liquid is often flavoured.

## Health impact of tobacco smoking

Tobacco smoke has been found to contain more than 7000 chemicals, of which at least 69 are known to cause cancers in adults, while others can reduce the ability of the immune system to fight these cancers (11). Tobacco smoke is also known to cause cardiovascular and respiratory diseases. There is an association between smoking during pregnancy and FGR, even when the pregnancy is full term. Maternal smoking can also lead to premature delivery. Children born prematurely can have a range of health problems. Both active tobacco smoking and exposure to second-hand smoke are harmful to pregnant women and their babies.

Exposure to tobacco smoke is dangerous to children. In utero exposure to tobacco smoke is associated with congenital anomalies, overweight and obesity in childhood and adolescence and neuropsychiatric sequelae, and has also been linked to certain childhood malignancies (12). Active smoking exposure in pregnant women is associated with neurodevelopmental disorders in children (13), which lead to increased health expenditures for sick children. In the long term, the result is lower productivity and higher rates of chronic disease in adulthood (3,14).

## Health impact of stunting

Environmental exposure to toxins and infections leading to inflammation can cause stunting in the post-natal period (15,16). Children with stunting experience higher mortality and morbidity and suboptimal motor and cognitive development (17). A meta-analysis of five studies found a positive association between linear growth in early childhood and cognitive development later in life (18). Another study indicates that 21% of global deaths and disability-adjusted life years (DALYs) among children under 5 years of age are attributable to stunting, severe wasting, and intrauterine growth restriction and low birthweight, largely because of their synergistic relationship with infectious diseases (19). In the long term, stunting has also been found to have negative impacts on cognitive

development, school achievement, economic productivity in adulthood and, among girls, later maternal reproductive outcomes (20).

## Maternal tobacco smoking and stunting

The literature indicates that birth weight is a significant predictor of growth trajectory during infancy (21–23). Prenatal tobacco exposure from maternal smoking during pregnancy has been extensively reported to be associated with FGR and smallness for gestational age (SGA) (24,25). Numerous studies have reported that smoking during pregnancy can lead to reduced birth length in infants and shorter stature in children (24,26–31). The literature also indicates a dose-response relationship between smoking during pregnancy and all adverse growth outcomes, including stunting, in children: the impact is greater if the number of cigarettes smoked is more than 10 a day (29,32,33).

Maternal tobacco smoking during pregnancy has been found to be one of the strongest behavioural risk factors for stunting (34). The pathophysiology behind maternal smoking during pregnancy and adverse growth outcomes in children has been well studied in the literature. Active maternal smoking can cause stunting prenatally through various mechanisms. One is oxidative stress, which can impair growth and development (35). Prenatal exposure to maternal smoking can also cause epigenetic modifications that can alter the expression of genes involved in growth and development, potentially leading to long-term growth deficits (36–39). A recent systematic review found statistically significant associations between waterpipe tobacco smoking and various pregnancy outcomes, including low birth weight (40,41).

Maternal tobacco use during pregnancy is similarly associated with adverse growth outcomes in children under 5 years of age (42). For example, one study found that prenatal exposure to tobacco smoke, even from additive-free cigarettes and cigarettes with reduced tar and nicotine content, can interfere with osteogenic differentiation and inhibit growth in children (43).

# Tobacco and stunting

## Smokeless tobacco products and stunting

Use of smokeless tobacco products during pregnancy is a known risk for placental damage due to hypoxia and oxidative stress, which can lead to FGR (44). While no substantial association between smokeless tobacco use and stunting has been identified, a number of studies have found the use of such products during pregnancy to be associated with low birth weight and preterm birth (25,45–49).

## Second-hand tobacco smoke and stunting

Numerous studies have reported an association between exposure to second-hand smoke and stunting in children (50–59). There is ample evidence of the impact of maternal tobacco smoking on stunting, but relatively few studies have mentioned the effect of smoking by fathers on stunting (54,60,61), although some studies have reported a dose-response relationship between paternal smoking and stunting (54,56). Second-hand smoke exposure lasting more than three hours daily has been found to be significantly associated with stunting. Second-hand smoke exposure at any stage of pregnancy is dangerous to the growth of children. A higher incidence of preterm birth and FGR has been reported among such children (24,62). In an Asian birth cohort, high maternal plasma cotinine concentrations due to active smoking and exposure to second-hand smoke in pregnant women was associated with persistent short stature in children between birth and 5 years of age (28).

Although there is a dearth of literature on how tobacco smoke may exacerbate stunting complications, the literature does report complications of exposure to second-hand smoke, to which children are particularly vulnerable. These complications may include worsening respiratory symptoms, learning difficulties and behavioural problems (30,57). The most influential variable associated with second-hand smoke exposure and stunting is

recurrent respiratory infections (56). A systematic review found that exposure to second-hand smoke is likely associated with negative growth outcomes in children, including stunting. The review also examines potential mechanisms behind this effect, such as the increased incidence of health problems linked to second-hand smoke exposure, highlighting the critical importance of minimizing tobacco smoke in environments where children live, learn, and play (58).

Many studies have reported that exposure to second-hand smoke during pregnancy is associated with FGR and low birth weight (59–70). A few studies have also reported an association with reduced anthropometric measurements in infants born to women who were exposed to second-hand smoke (65,68). The underlying mechanisms by which FGR and low birth weight occur are maternal inflammation and lower placental weight. The second-hand smoke releases tumour necrosis factor alpha (TNF- $\alpha$ ) and interleukins, leading to lower placental weight (69,70).

## New and emerging nicotine products and stunting

While no direct link has been found between stunting and the use of e-cigarettes and other novel products, a recent study in Japan reported an association between the use of heated tobacco products and FGR (71). Another study found an association between the use of electronic nicotine delivery systems (ENDS), or e-cigarettes, and preterm birth and low birth weight (72). In pregnant mice exposed to e-cigarette vapour, it was found that nicotine directly binds and inhibits the Kcnj2 (potassium inwardly-rectifying channel, subfamily J, member 2) channel, which is essential for bone development, resulting in disruption of embryonic lung and skeletal development (73). Another recent study of pregnant mice exposed to e-cigarette vapour revealed decreased placental weight, increased blood pressure and increased proteinuria, which leads to maternal inflammation and, thus, to FGR (74).



Overall, the research suggests that stunting is a consequence of a variety of situations and that parental tobacco smoking, especially maternal smoking during pregnancy, has an impact that is more dangerous with a higher dose and duration of exposure.

## Population-level and health systems interventions

WHO offers tools for implementing the main demand reduction provisions of the WHO Framework Convention on Tobacco Control (WHO FCTC) through the MPOWER measures (75,76). WHO tracks the status of the MPOWER demand reduction measures in the biennial WHO report on the global tobacco epidemic (77). In 2017, the World Health Assembly also endorsed a set of WHO “best buys” and other recommended interventions for governments to implement to prevent and control noncommunicable diseases. These “best buys” have recently been updated and include seven tobacco control interventions (78). The implementation of effective tobacco control measures has been proven to reduce tobacco use and tobacco use-related morbidity and mortality (75).

Robust evidence is available indicating that cessation or reduction of tobacco use during pregnancy has a positive effect on maternal and child undernutrition and reduces the risk of stunting (79,80). The Cochrane database contains numerous studies of various interventions for the prevention of tobacco exposure, such as education of carers and families and workplace or school-based strategies to reduce tobacco use (81–84). No systematic review has reported the impact of selected interventions on stunting per se. However, there is ample evidence that preventing tobacco use and exposure to second-hand smoke during pregnancy can prevent FGR and SGA (85). It is known that use of tobacco in any form is harmful. Whether tobacco is smoked during pregnancy or after, any exposure of children to tobacco smoke is detrimental to their health.

## Emerging concerns and future directions

There is substantial research indicating that both prenatal and postnatal tobacco smoke exposure—whether from the mother, the father or other household members—can negatively affect a child’s growth. While stunting is not solely caused by exposure to tobacco smoke, tobacco use is a significant contributing factor to poor growth outcomes. The literature also indicates a dose-response relationship, meaning that higher levels of exposure lead to greater risks. Several mechanisms have been proposed to explain how tobacco smoke contributes to stunting. However, a critical gap remains in understanding how tobacco exposure is linked to the birth of infants with fetal growth restriction and infants who are small for gestational age and how this connection may lead to stunting later in life. Addressing this gap requires targeted research efforts. There is also a notable absence of systematic reviews evaluating the impact of tobacco use reduction or tobacco cessation interventions on stunting specifically. This represents another significant gap in the existing literature, highlighting the need for further research.

## Contributors

Kajal F,<sup>1</sup> Prasad V,<sup>2</sup> Ashorn P,<sup>3</sup> St Claire S,<sup>2</sup> Schotte K.<sup>2</sup>

<sup>1</sup> Ministry of Commerce and Industry, Government of India

<sup>2</sup> World Health Organization, Department of Health Promotion, No Tobacco Unit

<sup>3</sup> World Health Organization, Department of Maternal, Newborn, Child and Adolescent and Ageing, Newborn and Child Health and Development Unit

# Tobacco and stunting

## References

1. Stunting in a nutshell. In: World Health Organization [website]. Geneva: World Health Organization; 2015. (<https://www.who.int/news/item/19-11-2015-stunting-in-a-nutshell>).
2. Danaei G, Andrews KG, Sudfeld CR, Fink G, McCoy DC, Peet E, et al. Risk factors for childhood stunting in 137 developing countries: a comparative risk assessment analysis at global, regional, and country levels. *PLoS Med.* 2016;13(11): e1002164. (doi: 10.1371/journal.pmed.1002164).
3. Childhood stunting: context, causes and consequences, In: World Health Organization [website]. Geneva: World Health Organization; 2017. (<https://www.who.int/publications/m/item/childhood-stunting-context-causes-and-consequences-framework>).
4. World Health Organization, United Nations Children's Fund (UNICEF), International Bank for Reconstruction and Development/The World Bank. The Joint Child Malnutrition Estimates (JME). Levels and trends in child malnutrition: UNICEF/WHO/World Bank Group Joint Child Malnutrition Estimates: Key Findings of the 2023 Edition. New York: UNICEF and World Health Organization; 2023. (<https://www.who.int/data/gho/data/themes/topics/joint-child-malnutrition-estimates-unicef-who-wb>).
5. World Health Organization. Global nutrition targets 2025: stunting policy brief. Geneva: World Health Organization; 2014. (<https://www.who.int/publications/i/item/WHO-NMH-NHD-14.3>).
6. Budiastutik I, Nugraheni SA. Determinants of stunting in Indonesia: A literature review. *I J Heal Res.* 2018;2(1):43–9. (<https://doi.org/10.12928/ijhr.v1i2.753>).
7. Pereira PP, Da Mata FA, Figueiredo AC, de Andrade KR, Pereira MG. Maternal active smoking during pregnancy and low birth weight in the Americas: a systematic review and meta-analysis. *Nicotine Tob Res.* 2017 May 1;19(5):497–505. (<https://doi.org/10.1093/ntr/ntw228>).
8. Caleyachetty R, Tait CA, Kengne AP, Corvalan C, Uauy R, Echouff o-Tcheugui JBE. Tobacco use in pregnant women: Analysis of data from Demographic and Health Surveys from 54 low-income and middle-income countries. *Lancet Glob Heal.* 2014;2(9):e513–20. ([https://doi.org/10.1016/S2214-109X\(14\)70283-9](https://doi.org/10.1016/S2214-109X(14)70283-9)).
9. Lange S, Probst C, Rehm J, Popova S. National, regional, and global prevalence of smoking during pregnancy in the general population: a systematic review and meta-analysis. *Lancet Glob Heal.* 2018;6(7):e769–76. ([https://doi.org/10.1016/S2214-109X\(18\)30223-7](https://doi.org/10.1016/S2214-109X(18)30223-7)).
10. Leonardi-Bee J, Smyth A, Britton J, Coleman T. Environmental tobacco smoke and fetal health: Systematic review and meta-analysis. *Arch Dis Child Fetal Neonatal Ed.* 2008;93(5). (<https://doi.org/10.1136/adc.2007.133553>).
11. Health effects of cigarettes: cancer. In: Centers for Disease Control and Prevention [website]. Atlanta: Centers for Disease Control and Prevention; 2024. (<https://www.cdc.gov/tobacco/about/cigarettes-and-cancer.html>).
12. Maciag MC, Yousuf A, Hauptman M. Impact of prenatal exposure to smoking on child health. *Clin Obstet Gynecol.* 2022;65(2):388–96. (<https://doi.org/10.1097/grf.0000000000000698>).
13. Chen D, Niu Q, Liu S, Shao W, Huang Y, Xu Y et al. The correlation between prenatal maternal active smoking and neurodevelopmental disorders in children: a systematic review and meta-analysis. *BMC Public Health.* 2023;23(1):1–13. (<https://doi.org/10.1186/s12889-023-15496-z>).
14. De Onis M, Branca F. Childhood stunting: a global perspective. *Matern Child Nutr.* 2016 May;12 Suppl 1(Suppl 1):12–26. (<https://doi.org/10.1111/mcn.12231>).
15. Leroy JL, Frongillo EA. Perspective: What Does Stunting Really Mean? A Critical Review of the Evidence. *Adv Nutr.* 2019;10(2):196–204. (<https://doi.org/10.1093/advances/nmy101>).
16. Huus KE, Rodriguez-Pozo A, Kapel N, Nestoret A, Habib A, Dede M et al. Immunoglobulin recognition of fecal bacteria in stunted and non-stunted children: findings from the Afribiota study. *Microbiome.* 2020;8(1):113. (<https://doi.org/10.1186/s40168-020-00890-1>).
17. Vaivada T, Akseer N, Akseer S, Somaskandan A, Stefopoulos M, Bhutta ZA. Stunting in childhood: An overview of global burden, trends, determinants, and drivers of decline. *Am J Clin Nutr.* 2020;112:777S–791S. (<https://doi.org/10.1093/ajcn/nqaa159>).
18. Sudfeld CR, McCoy DC, Danaei G, Fink G, Ezzati M, Andrews KG et al. Linear growth and child development in low- and middle-income countries: a meta-analysis. *Pediatrics.* 2015 May;135(5):e1266–75. (<https://doi.org/10.1542/peds.2014-3111>).
19. Black RE, Allen LH, Bhutta ZA, Caulfield LE, de Onis M, Ezzati M et al. Maternal and child undernutrition: global and regional exposures and health consequences. *Lancet.* 2008;371(9608):243–60. (<https://www.sciencedirect.com/science/article/pii/S0140673607616900>).
20. Dewey KG, Begum K. Long-term consequences of stunting in early life. *Matern Child Nutr.* 2011;7(Suppl 3):5–18. (<https://doi.org/10.1111/j.1740-8709.2011.00349.x>).
21. Budree S, Stein DJ, Brittain K, Goddard E, Koen N, Barnett W et al. Maternal and infant factors had a significant impact on birthweight and longitudinal growth in a South African birth cohort. *Acta Paediatr Int J Paediatr.* 2017;106(11):1793–801. (<https://doi.org/10.1111/apa.14015>).
22. Xie C, Epstein LH, Eiden RD, Shenassa ED, Li X, Liao Y et al. Stunting at 5 years among SGA newborns. *Pediatrics.* 2016;137(2):e20152636. (<https://doi.org/10.1542/peds.2015-2636>).
23. Christian P, Lee SE, Angel MD, Adair LS, Arifeen SE, Ashorn P et al. Risk of childhood undernutrition related to small-for-gestational age and preterm birth in low- and middle-income countries. *Int J Epidemiol.* 2013;42(5):1340–55. (<https://doi.org/10.1093/ije/dyt109>).
24. Ye H, Yang X, Hanna F. The Impact of prenatal environmental tobacco smoking (ETS) and exposure on Chinese children: a systematic review. *Children.* 2023;10(8):1354. (<https://doi.org/10.3390/children10081354>).
25. Inamdar AS, Croucher RE, Chokhandre MK, Mashyakhy MH, Marinho VCC. Maternal smokeless tobacco use in pregnancy and adverse health outcomes in newborns: A systematic review. *Nicotine Tob Res.* 2015;17(9):1058–66. (<https://doi.org/10.1093/ntr/ntu255>).
26. Le Roux M, Nel M, Walsh C. Determinants of stunting at 6 weeks in the Northern Cape Province, South Africa. *Front Public Heal.* 2020;8 (June):1–10. (<https://doi.org/10.3389/fpubh.2020.00166>).
27. Jones G, Riley M, Dwyer T. Maternal smoking during pregnancy, growth, and bone mass in prepubertal children. *J Bone Miner Res.* 1999 Jan;14(1):146–51. (<https://doi.org/10.1359/jbmr.1999.14.1.146>).
28. Ng S, Aris IM, Tint MT, Gluckman PD, Godfrey KM, Shek LP-C et al. High maternal circulating cotinine during pregnancy is associated with persistently shorter stature from birth to five years in an Asian cohort. *Nicotine Tob Res.* 2019 Jul;21(8):1103–12. (<https://doi.org/10.1093/ntr/nty148>).
29. Butler NR, Goldstein H. Smoking in pregnancy and subsequent child development. *Br Med J.* 1973 Dec;4(5892):573–5. (<https://doi.org/10.1136/bmj.4.5892.573>).
30. Braillon A, Bewley S, Dubois G. Tobacco harm to the developing child. *Eur J Pediatr.* 2010;169(12):1565–7. (<https://doi.org/10.1007/s00431-010-1241-4>).

31. Ciccarelli C, De Fraja G, Vuri D. Effects of passive smoking on prenatal and infant development: lessons from the past. *Econ Hum Biol.* 2021 Aug;42:101002. (<https://doi.org/10.1016/j.ehb.2021.101002>).
32. Abraham M, Alramadhan S, Iniguez C, Duijts L, Jaddoe VVW, Dekker HTD et al. A systematic review of maternal smoking during pregnancy and fetal measurements with meta-analysis. *PLoS One.* 2017 Feb 23;12(2): e0170946. (<https://doi.org/10.1371/journal.pone.0170946>).
33. Yang L, Feng L, Huang L, Li X, Qiu W, Yang K et al. Maternal factors for intrauterine growth retardation: systematic review and meta-analysis of observational studies. *Reprod Sci.* 2023;30(6):1737–45. (<https://doi.org/10.1007/s43032-021-00756-3>).
34. Victora CG, Villar J, Barros FC, Ismail LC, Chumlea C, Papageorgiou AT et al. Anthropometric characterization of impaired fetal growth: risk factors for and prognosis of newborns with stunting or wasting. *JAMA Pediatr.* 2015 Jul;169(7):e151431. (<https://doi.org/10.1001/jamapediatrics.2015.1431>).
35. Sbrana E, Suter MA, Abramovici AR, Hawkins HK, Moss JE, Patterson L et al. Maternal tobacco use is associated with increased markers of oxidative stress in the placenta. *Am J Obstet Gynecol.* 2011;205(3):246.e1–7. (<http://dx.doi.org/10.1016/j.ajog.2011.06.023>).
36. Rotroff DM, Joubert BR, Marvel SW, Håberg SE, Wu MC, Nilsen RM et al. Maternal smoking impacts key biological pathways in newborns through epigenetic modification in Utero. *BMC Genomics.* 2016;17(1):976. (<http://dx.doi.org/10.1186/s12864-016-3310-1>).
37. Rousseaux S, Seyve E, Chuffart F, Bourova-Flin E, Benmerad M, Charles MA et al. Immediate and durable effects of maternal tobacco consumption alter placental DNA methylation in enhancer and imprinted gene-containing regions. *BMC Med.* 2020;18(1):306. (<https://doi.org/10.1186/s12916-020-01736-1>).
38. Knopik VS, Maccani MA, Franczio S, McGeary JE. The epigenetics of maternal cigarette smoking during pregnancy and effects on child development. *Dev Psychopathol.* 2012 Nov;24(4):1377–90. (<https://doi.org/10.1017/s0954579412000776>).
39. Nakamura A, François O, Lepeule J. Epigenetic alterations of maternal tobacco smoking during pregnancy: A narrative review. *Int J Environ Res Public Health.* 2021;18(10):5083. (<https://doi.org/10.3390/ijerph18105083>).
40. Akl EA, Gaddam S, Gunukula SK, Honeine R, Jaoude PA, Irani J. The effects of waterpipe tobacco smoking on health outcomes: a systematic review. *Int J Epidemiol [Internet].* 2010 Jun 1;39(3):834–57. (<https://doi.org/10.1093/ije/dyq002>).
41. Waziry R, Jawad M, Ballout RA, Al Akel M, Akl EA. The effects of waterpipe tobacco smoking on health outcomes: a systematic review. *Int J Epidemiol [Internet].* 2017 Feb 1;46(1):32–43. (<https://doi.org/10.1093/ije/dyw021>).
42. Quelhas D, Kompala C, Wittenbrink B, Han Z, Parker M, Shapiro M et al. The association between active tobacco use during pregnancy and growth outcomes of children under five years of age: a systematic review and meta-analysis. *BMC Public Health.* 2018;18(1): 1372. (<https://doi.org/10.1186/s12889-018-6137-7>).
43. Martinez IKC, Sparks NRL, Madrid JV, Talbot P, Zur Nieden NI. Exposure to cigarette smoke impedes human osteoblast differentiation independently of nicotine. *Nicotine Tob Res.* 2022 Nov 12;24(12):1921–26. (<https://doi.org/10.1093/ntr/ntac144>).
44. Kumar SN, Bastia B, Borgohain D, Agrawal U, Raisuddin S, Jain AK. Structural changes, increased hypoxia, and oxidative DNA damage in placenta due to maternal smokeless tobacco use. *Birth Defects Res.* 2021 Oct 1;113(16):1198–1214. (<https://doi.org/10.1002/bdr2.1941>).
45. England LJ, Kim SY, Shapiro-Mendoza CK, Wilson HG, Kendrick JS, Satten GA et al. Maternal smokeless tobacco use in Alaska Native women and singleton infant birth size. *Acta Obstet Gynecol Scand.* 2012 Jan;91(1):93–103. (<https://doi.org/10.1111/j.1600-0412.2011.01273.x>).
46. Ganganahalli P, Pratinidhi A, Patil J, Kakade S V. Correlation of cotinine levels with use of smokeless tobacco (mishri) among pregnant women and anthropometry of newborn. *J Clin Diagn Res.* 2017 Mar;11(3):LC16–19. (<https://doi.org/10.7860/jcdr/2017/23340.9534>).
47. Gupta PC, Subramoney S. Smokeless tobacco use, birth weight, and gestational age: population based, prospective cohort study of 1217 women in Mumbai, India. *BMJ.* 2004 Jun;328(7455):1538. (<https://doi.org/10.1136/bmj.38113.687882.eb>).
48. Rygh E, Gallefoss F, Grøtvedt L. Trends in maternal use of snus and smoking tobacco in pregnancy. A register study in southern Norway. *BMC Pregnancy Childbirth.* 2019 Dec;19(1):500. (<https://doi.org/10.1186/s12884-019-2624-9>).
49. Steyn K, de Wet T, Saloojee Y, Nel H, Yach D. The influence of maternal cigarette smoking, snuff use and passive smoking on pregnancy outcomes: the Birth To Ten Study. *Paediatr Perinat Epidemiol.* 2006 Mar;20(2):90–99. (<https://doi.org/10.1111/j.1365-3016.2006.00707.x>).
50. Bella A, Dartanto T, Nurshadrina DS, Kusnadi G, Moeis FR, Nurhasana R et al. Do parental smoking behaviors affect children's thinness, stunting, and overweight status in Indonesia? Evidence from a large-scale longitudinal survey. *J Fam Econ Issues.* 2023;44(3):714–26. (<https://doi.org/10.1007/s10834-022-09864-x>).
51. Nayab D, Kishwar S, Siddique O. Parental tobacco smoking and child malnutrition [[working paper]. Pakistan Institute of Development Economics. 2022. (<https://www.tobacconomics.org/research/parental-tobacco-smoking-and-child-malnutrition>).
52. Kyu HH, Georgiades K, Boyle MH. Maternal smoking, biofuel smoke exposure and child height-for-age in seven developing countries. *Int J Epidemiol.* 2009 Oct 1;38(5):1342–50. (<https://doi.org/10.1093/ije/dyp253>).
53. Ravsanjanie MM, Pawitra AS, Diyanah KC, Zakaria ZA, Marmaya NH. Utilization of clean water, personal hygiene of toddler caregivers, and smoking behavior of family members as risk factors for cases of stunting toddlers. *J Kesehat Lingkung.* 2021;13(1):48–56. (<https://dx.doi.org/10.20473/jkl.v13i1.2021.48-56>).
54. Muchlis N, Yusuf RA, Rusydi AR, Mahmud NU, Hikmah N, Qanitha A et al. Cigarette smoke exposure and stunting among under-five children in rural and poor families in Indonesia. *Environ Health Insights.* 2023;17: 11786302231185210. (<https://doi.org/10.1177/11786302231185210>).
55. Best CM, Sun K, de Pee S, Sari M, Bloem MW, Semba RD. Paternal smoking and increased risk of child malnutrition among families in rural Indonesia. *Tob Control.* 2008 Feb;17(1):38–45. (<https://doi.org/10.1136/tc.2007.020875>).
56. Astuti DD, Handayani TW, Astuti DP. Cigarette smoke exposure and increased risks of stunting among under-five children. *Clin Epidemiol Glob Heal.* 2020;8(3):943–8. (<https://www.sciencedirect.com/science/article/pii/S2213398420300671>).
57. Kaur J, Upendra S, Barde S. Inhaling hazards, exhaling insights: a systematic review unveiling the silent health impacts of secondhand smoke pollution on children and adolescents. *Int J Environ Health Res.* 2024 Dec;34(12):4059–4073. (<https://doi.org/10.1080/09603123.2024.2337837>).
58. Nadhiroh SR, Djokosujono K, Utari DM. The association between secondhand smoke exposure and growth outcomes of children: A systematic literature review. *Tob Induc Dis.* 2020 Mar 3;18:12. (<https://doi.org/10.18332/tid/117958>).
59. Singh A, Kapoor R. Is second hand smoke associated with child's nutritional status? A meta-analysis. *Research Square;* 2020. (<https://doi.org/10.21203/rs.3.rs-99899/v1>).

# Tobacco and stunting

60. Wijaya-Erhardt M. Nutritional status of Indonesian children in low-income households with fathers that smoke. *Osong Public Heal Res Perspect*. 2019;10(2):64–71. (<https://doi.org/10.24171/j.phrp.2019.10.2.04>).
61. Chowdhury F, Chisti MJ, Hossain MI, Malek MA, Salam MA, Faruque ASG. Association between paternal smoking and nutritional status of under-five children attending Diarrhoeal Hospital, Dhaka, Bangladesh. *Acta Paediatr*. 2011 Mar;100(3):390–95. (<https://doi.org/10.1111/j.1651-2227.2010.02067.x>).
62. Ramadani M, Utomo B, Achadi EL, Gunardi H. Prenatal secondhand smoke exposure: correlation between nicotine in umbilical cord blood and neonatal anthropometry. *Osong Public Heal Res Perspect*. 2019 Aug;10(4):234–39. (<https://doi.org/10.24171/j.phrp.2019.10.4.06>).
63. Hawsawi AM, Bryant LO, Goodfellow LT. Association between exposure to secondhand smoke during pregnancy and low birthweight: a narrative review. *Respir Care*. 2015 Jan;60(1):135–40. (<https://doi.org/10.4187/respcare.02798>).
64. Edi M, Chin YS, Woon FC, Appannah G, Lim PY, Mother and Infant Cohort Study (MICOS) Group.. Inadequate gestational weight gain and exposure to second-hand smoke during pregnancy increase the risk of low birth weight: a cross-sectional study among full-term infants. *Int J Environ Res Public Health*. 2021 Jan;18(3). (<https://doi.org/10.3390/ijerph18031068>).
65. Wahabi HA, Mandil AA, Alzeidan RA, Bahnassy AA, Fayed AA. The independent effects of second hand smoke exposure and maternal body mass index on the anthropometric measurements of the newborn. *BMC Public Health*. 2013 Nov;13:1058. (<https://doi.org/10.1186/1471-2458-13-1058>).
66. Wang R, Sun T, Yang Q, Yang Q, Wang J, Li H et al. Low birthweight of children is positively associated with mother's prenatal tobacco smoke exposure in Shanghai: a cross-sectional study. *BMC Pregnancy Childbirth*. 2020 Oct;20(1):603. (<https://doi.org/10.1186/s12884-020-03307-x>).
67. Hoyt AT, Canfield MA, Romitti PA, Botto LD, Anderka MT, Krikov SV et al. Does maternal exposure to secondhand tobacco smoke during pregnancy increase the risk for preterm or small-for-gestational age birth? *Matern Child Health J*. 2018 Oct;22(10):1418–29. (<https://doi.org/10.1007/s10995-018-2522-1>).
68. Soesanti F, Uiterwaal CSPM, Grobbee DE, Hendarto A, Dalmeijer GW, Idris NS. Antenatal exposure to second hand smoke of non-smoking mothers and growth rate of their infants. *PLoS One*. 2019;14(6):e0218577. (<https://doi.org/10.1371/journal.pone.0218577>).
69. Niu Z, Xie C, Wen X, Tian F, Ding P, He Y et al. Placenta mediates the association between maternal second-hand smoke exposure during pregnancy and small for gestational age. *Placenta*. 2015 Aug;36(8):876–80. (<https://doi.org/10.1016/j.placenta.2015.05.005>).
70. Niu Z, Xie C, Wen X, Tian F, Yuan S, Jia D et al. Potential pathways by which maternal second-hand smoke exposure during pregnancy causes full-term low birth weight. *Sci Rep*. 2016 Apr;6:24987. (<https://doi.org/10.1038/srep24987>).
71. Hosokawa Y, Zaitsum M, Okawa S, Morisaki N, Hori A, Nishihama Y et al. Association between heated tobacco product use during pregnancy and fetal growth in Japan: a nationwide web-based survey. *Int J Environ Res Public Health*. 2022 Sep 19;19(18):11826. (<https://doi.org/10.3390/ijerph191811826>).
72. Ammar L, Tindle HA, Miller AM, Adgent MA, Nian H, Ryckman KK et al. Electronic cigarette use during pregnancy and the risk of adverse birth outcomes: a cross-sectional surveillance study of the US Pregnancy Risk Assessment Monitoring System (PRAMS) population. *PLoS One*. 2023;18(10):e0287348. (<https://doi.org/10.1371/journal.pone.0287348>).
73. Ozekin YH, Saal ML, Pineda RH, Moehn K, Ordonez-Erives MA, Delgado Figueroa MF et al. Intrauterine exposure to nicotine through maternal vaping disrupts embryonic lung and skeletal development via the Kcnj2 potassium channel. *Dev Biol*. 2023 Sep;501:111–23. (<https://doi.org/10.1016/j.ydbio.2023.06.002>).
74. Kirkham MN, Cooper C, Broberg E, Robertson P, Clarke D, Pickett BE et al. Different lengths of gestational exposure to secondhand smoke or e-cigarette vapor induce the development of placental disease symptoms. *Cells*. 2024 Jun;13(12):1009. (<https://doi.org/10.3390/cells13121009>).
75. MPOWER. In: World Health Organization [website]. Geneva: World Health Organization; n.d. (<https://www.who.int/initiatives/mpower>).
76. WHO Framework Convention on Tobacco Control Overview. In: World Health Organization [website]. Geneva: World Health Organization; 2024. (<https://fctc.who.int/convention>).
77. World Health Organization. WHO report on the global tobacco epidemic 2019: offer help to quit tobacco use. Geneva: World Health Organization; 2019. (<https://www.who.int/teams/health-promotion/tobacco-control/who-report-on-the-global-tobacco-epidemic-2019>).
78. World Health Organization. Tackling NCDs: best buys and other recommended interventions for the prevention and control of noncommunicable diseases. Geneva: World Health Organization; 2024. (<https://iris.who.int/bitstream/handle/10665/376624/9789240091078-eng.pdf?sequence=1>).
79. Bhutta ZA, Ahmed T, Black RE, Cousens S, Dewey K, Giugliani E et al. What works? Interventions for maternal and child undernutrition and survival. *Lancet*. 2008;371(9610):417–40. ([https://doi.org/10.1016/S0140-6736\(07\)61693-6](https://doi.org/10.1016/S0140-6736(07)61693-6)).
80. Bhutta ZA, Das JK, Rizvi A, Gaffey MF, Walker N, Horton S, et al. Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost? *Lancet*. 2013;382(9890):452–77. ([https://doi.org/10.1016/S0140-6736\(13\)60996-4](https://doi.org/10.1016/S0140-6736(13)60996-4)).
81. Behbod B, Sharma M, Baxi R, Roseby R, Webster P. Family and carer smoking control programmes for reducing children's exposure to environmental tobacco smoke. *Cochrane Database Syst Rev*. 2018 Jan 31;1(1):CD001746. (<https://doi.org/10.1002/14651858.cd001746.pub4>).
82. Fanshawe TR, Halliwell W, Lindson N, Aveyard P, Livingstone-Banks J ; Hartmann-Boyce J. Tobacco cessation interventions for young people. *Cochrane Database Syst Rev*. 2017 Nov 17;11(11):CD003289. (<https://doi.org/10.1002/14651858.cd003289.pub6>).
83. Wolfenden L, Goldman S, Stacey FG, Grady A, Kingsland M, Williams CM et al. Strategies to improve the implementation of workplace-based policies or practices targeting tobacco, alcohol, diet, physical activity and obesity. *Cochrane Database Syst Rev*. 2018 Nov 14;11(11):CD012439. (<https://doi.org/10.1002/14651858.cd012439.pub2>).
84. Wolfenden L, McCrabb S, Barnes C, O'Brien KM, Ng KN, Nathan N et al. Strategies for enhancing the implementation of school-based policies or practices targeting diet, physical activity, obesity, tobacco or alcohol use. *Cochrane Database Syst Rev*. 2022 Aug 29;8(8):CD011677. (<https://doi.org/10.1002/14651858.cd011677.pub3>).
85. Frazer K, Callinan JE, McHugh J, Van Baarsel S, Clarke A, Doherty K et al. Legislative smoking bans for reducing secondhand smoke exposure, smoking prevalence and tobacco consumption. *Cochrane Database Syst Rev*. 2016 Feb 4;2(2):CD005992. (<https://doi.org/10.1002/14651858.cd005992.pub3>).

Tobacco and stunting: WHO tobacco knowledge summaries

ISBN 978-92-4-011202-5 (electronic version)

ISBN 978-92-4-011203-2 (print version)

© World Health Organization 2025. Some rights reserved. This work is available under the [CC BY-NC-SA 3.0 IGO](https://creativecommons.org/licenses/by-nc-sa/3.0/) licence.

