Primary prevention of asthma in children

Key points

Many modifiable and non-modifiable factors have been associated with increased or decreased risk of asthma development in children.

Although many factors have been associated with increased asthma risk in observational studies, and available data suggest a causal association for some, none have been definitively shown to cause asthma directly. Avoidance or correction of these risk factors has not been shown to prevent asthma developing.

No interventions have definitively been shown to prevent asthma in children.

Prenatal asthma prevention strategies

Advise pregnant women against smoking or exposure to environmental tobacco smoke.

Advise pregnant women and women planning pregnancy to follow current national guidelines for Vitamin D supplementation.

Do not recommend dietary restrictions during pregnancy for the purpose of preventing asthma in children.

Infant feeding

Follow guidance from the Australasian Society of Clinical Immunology and Allergy.

Do not recommend dietary restrictions for breastfeeding women to prevent asthma in their children.

Childhood

Advise parents/carers to ensure babies and children are not exposed to cigarette smoke.

Table

Factors associated with increased or decreased risk of developing asthma

Risk factors
Atopy
Genetics (parent with asthma)
Prematurity
Prenatal exposure to tobacco smoke
Maternal obesity during pregnancy

Prenatal exposure to antibiotics
Prenatal exposure to paracetamol
Delivery by caesarean section
Severe respiratory viral infections (e.g. with respiratory syncytial virus or rhinovirus) during infancy
Exposure to moulds during infancy
Exposure to outdoor air pollution during infancy
Childhood overweight or obesity
Protective factors
Exposure to diverse microflora during infancy
Diets rich in fruits, vegetables, vitamins, whole grains, oily fish and olive oil
High fish oil intake through fish consumption or supplementation with long-chain omega-3 polyunsaturated fatty acids

Tobacco smoke avoidance

Pregnant women should be warned not to smoke, and families should be warned not to smoke when they are with babies or children, or in rooms or cars that are used by them.

Prenatal strategies for the primary prevention of asthma

Maternal diet

Systematic reviews of clinical trials of food allergen avoidance during pregnancy have found no overall reduction in rates of asthma or atopic dermatitis (eczema) in infants.[Kramer 2012, Netting 2014] A 2012 Cochrane review concluded that prescription of antigen-avoidance diets during pregnancy was unlikely to reduce substantially the risk of asthma or allergies in children with a family history of allergies.[Kramer 2012] Restriction diets during pregnancy could also compromise maternal or foetal nutrition.[Kramer 2012]

The Australasian Society of Clinical Immunology and Allergy recommends that pregnant and breastfeeding women maintain a healthy balanced diet, rich in fibre, vegetables and fruit, recommends that up to 3 serves of oily fish per week during pregnancy and breastfeeding may help prevent eczema in children, and recommends against maternal dietary exclusions for allergy prevention.[ASCIA 2020]

Fish oil supplementation in pregnancy

Randomised clinical trials of prenatal fish oil supplementation to prevent allergic disease have reported inconsistent results. A clinical trial comparing prenatal supplementation with fish oil (2.7 g of long-chain omega 3 polyunsaturated fatty acids) versus placebo (olive oil) or no intervention reported a significant reduction in the risk of asthma (measured as prescription of asthma medication) at up to age 18–19 years in the fish oil group, compared with the olive oil group, but no difference between groups in lung function or allergic sensitisation at age 18–19 years.[Hansen 2017] In another randomised clinical trial, prenatal supplementation with 2.4 g fish oil per day was associated with a reduction in the rate of wheeze or asthma in children at 3-year follow-up.[Bisgaard 2016] However, in a study in pregnant women with family history of allergic disease, supplementation with fish oil capsules (800 mg/d docosahexaenoic acid [DHA] and 100mg/d eicosapentaenoic acid [EPA]) had no effect on asthma at 3 or 6 years' follow-up, compared with placebo (vegetable oil capsules).[Best 2018, Best 2016, Palmer 2013]

Systematic reviews of clinical trials evaluating prenatal long-chain omega-3 polyunsaturated fatty acid supplementation for allergy prevention found that supplementation had no effect on asthma or wheeze in children.[Best 2016, Gunaratne 2015] 'Fish oil' is not well defined and the optimal dosing regimen has not been established.[GINA 2025]

Probiotic supplementation in pregnancy

Probiotic supplementation during pregnancy has not been shown to reduce rates of wheezing or asthma in children. [Zuccotti, Azad 2013, Elazab 2014]

Vitamin D supplementation in pregnancy

Clinical trials of vitamin D supplementation during pregnancy suggest a protective effect against wheezing and asthma in early childhood.[Wolsk 2017, Vahdaninia 2017] Earlier supplementation may be more effective in reducing the risk of asthma than late supplementation[Shadid 2023] and maintenance 25(OH) vitamin D levels of at least 30 ng/mL (75 nmol/L) may be important.[Wolsk 2017] One clinical trial reported that vitamin D supplementation (4400 IU/d) during pregnancy significantly reduced the rate of asthma in offspring at ages 3 and 6 years, compared with standard prenatal multivitamin with vitamin D (400 IU/d).[Weiss 2024]

However, the Royal Australian and New Zealand College of Obstetricians and Gynaecologists recommends that all pregnant women take 400 IU vitamin D per day as part of a multivitamin supplement, and recommends against routine vitamin D level testing.[RANZCOG 2019]

Infant feeding strategies for the primary prevention of asthma

Higher diversity of food during the first year of life has been associated with lower risk of developing asthma.[Lis-Swiety 2016]

The Australasian Society of Clinical Immunology and Allergy does not provide specific guidance on prevention of allergic asthma, but advice on allergy prevention includes introduction of solid foods at around age 6 months (not before 4 months), and introduction of common food allergens before age 12 months unless the child is already known to be allergic to a food.[ASCIA 2020]

Restrictions and supplements

A systematic review of clinical trials evaluating infant supplements found that polyunsaturated fatty acids given as supplements or added to infant formula did not affect rates of asthma at up to age 2 years or at age 2–5 years.[Schindler 2016]

Perinatal supplementation with oral prebiotics and probiotics has not been shown to reduce the risk of childhood asthma.[von Mutius 2020]

The effects of oral bacterial lysates in infancy on later risk of wheezing is under investigation.[University of Arizona 2024]

The Australasian Society of Clinical Immunology and Allergy recommends against hydrolysed infant formula (partial and extensive) for the prevention of allergic disease.[ASCIA 2020]

Breastfeeding

There is no conclusive evidence that breastfeeding protects against development of asthma.[von Mutius 2020]

The Australasian Society of Clinical Immunology and Allergy recommends breastfeeding for at least 6 months, for its general benefits, with a standard cow's milk based formula if breastfeeding is not possible.[ASCIA 2020] It advises against cow's milk, goat's milk (or milk other mammals), soy milk, nut milk of cereal milk as the main source of milk before age 12 months.[ASCIA 2020]

Resources

Australasian Society of Clinical Immunology and Allergy's **clinical update on infant feeding and allergy prevention**

Royal Australian and New Zealand College of Obstetricians and Gynaecologists' **position statement on vitamin and mineral supplementation and pregnancy**

Allergen avoidance strategies for primary prevention of asthma

Despite a positive association between early life exposure to aeroallergens, or sensitisation to aeroallergens, and the development of asthma,[Gaffin 2014, Arshad 2010, von Mutius 2020] allergen avoidance measures in homes have not been established as effective and feasible strategies for preventing asthma in children.

Single allergen reduction strategies, such as the use of mattress covers that are impermeable to house dust mite, are not effective in preventing the development of wheezing or asthma in children.[Arroyave 2014, Maas 2009] An Australian controlled clinical trial that compared house dust mite avoidance (acaricide and impermeable mattress covers), from birth to 5 years, with simple advice on cleaning, vacuuming, dusting and maintaining adequate ventilation,[Peat 2004, Marks 2006] reported no reduction in the risk of developing asthma at age 11.5 years.[Toelle 2013] Multimodal allergen avoidance strategies may reduce the risk of asthma in children.[Arshad 2003, Becker 2004, Schonberger 2005, Chan-Yeung 2005, van Schayck 2007, Maas 2009, Scott 2012] However, these strategies require intensive effort and may not be feasible for many families.

Allergen immunotherapy for primary prevention of asthma

Specific-allergen immunotherapy for children with grass pollen allergic rhinitis or house dust mite allergic rhinitis has not been definitively shown to prevent the development of asthma, but evidence from clinical trials of at least 3 years' treatment suggest a possible reduction in new diagnoses.[Arshad 2022, Farraia 2022]

RSV infection in infancy is associated with increased risk of developing asthma.[Rosas-Salazar 2023, Martinez 2019]

Prophylaxis with palivizumab (humanised IgG_1 monoclonal antibody directed against RSV) in infants has not been shown to reduce the risk of physician-diagnosed asthma or lung function at 6 years.[Scheltema 2018]

RSV vaccination of pregnant women[Kampmann 2023] and healthy infants[Hammitt 2022] reduces RSV infection requiring medical treatment in the first year of life. It has not yet been established whether RSV prenatal vaccination will prevent development of recurrent wheeze or asthma in children.[GINA 2025]

The Australian Technical Advisory Group on Immunisation recommends RSV vaccination for pregnant women. RSV vaccination for eligible pregnant women is funded under for National Immunisation Program.[Australian Government 2025]

The Australian Technical Advisory Group on Immunisation recommends passive immunisation with monoclonal antibody against RSV (nirsevimab) for neonates and infants younger than 8 months whose mothers were not vaccinated at least 2 weeks before delivery or who are at increased risk of severe disease.[Australian Government 2025]

Resources

Australian Immunisation Handbook recommendations on **Respiratory syncytial virus**

Reported protective factors for asthma

Microbial and allergen environment

Early-life microbial exposure appears to be important for activation of the innate immune system and the development of regulatory immune responses, and may contribute to protection against asthma and allergy.[Smits 2016]

Living on traditional European or Amish farms has consistently been associated with reduced risk of developing wheeze in pre-school children or asthma in school-aged children.[von Mutius 2016] This association is thought to be due to exposure high concentrations of allergens, other plant and animal materials, bacteria, fungi, and other microbes.[von Mutius 2016]

Living with pets during early childhood is associated with reduced risk of developing asthma.[Indolfi 2023]

Dietary factors

Overall, dietary intake of fruits and vegetables, and a range of vitamins, has been associated with lower rates of asthma or wheeze in systematic reviews of observational studies (mainly cross-sectional studies).[Garcia-Larsen 2016, Hosseini 2017, Seyedrezazadeh 2014] The 'Mediterranean diet' (high in fruits and vegetables, whole grains, oily fish and olive oil, and low in red meat) has been associated with lower rate of asthma or wheeze in systematic review of observational studies.[Garcia-Larsen 2016]

High fish oil intake (both fish consumption and supplementation with long-chain omega-3 polyunsaturated fatty acids) has been associated with reduced asthma risk reduced in children. A systematic review of prospective observational studies and RCTs found that asthma risk was reduced by high fish oil intake in children, including both fish consumption and long-chain omega-3 polyunsaturated fatty acids intake.[Yang 2013] Most studies were designed to measure other allergic outcomes (e.g. atopic dermatitis) and were not powered to detect effects on asthma risk.

Dietary levels of vitamins C, D, and E in childhood are associated with lower rate of asthma or wheeze.[Garcia-Larsen 2016]

Reported risk factors for asthma

Many modifiable and non-modifiable factors have been associated with increased or decreased risk of asthma development in children.

Table

Factors associated with increased or decreased risk of developing asthma

Risk factors
Atopy
Genetics (parent with asthma)
Prematurity
Prenatal exposure to tobacco smoke
Maternal obesity during pregnancy
Prenatal exposure to antibiotics
Prenatal exposure to paracetamol
Delivery by caesarean section
Severe respiratory viral infections (e.g. with respiratory syncytial virus or rhinovirus) during infancy
Exposure to moulds during infancy
Exposure to outdoor air pollution during infancy
Childhood overweight or obesity
Protective factors
Exposure to diverse microflora during infancy
Diets rich in fruits, vegetables, vitamins, whole grains, oily fish and olive oil
High fish oil intake through fish consumption or supplementation with long-chain omega-3 polyunsaturated fatty acids

Heredity and genetics

A child's risk of developing asthma is increased if a parent has a history of asthma; approximately 3 times higher for mothers and 2.4 times higher for fathers.[Castro-Rodriguez 2016]

Caesarean section

Systematic reviews and meta-analyses of data from observational studies show an association between Caesarean section and a small increase in the child's risk of developing asthma, compared with vaginal delivery.[Lis-Swiety 2016, Huang 2015] The mechanism is thought to be due to effects of altered intestinal bacterial flora on the infant's developing immune system.[Lis-Swiety 2016, Huang 2015]

Low birth weight and prematurity

Prematurity and low birth weight are associated with increased risk of developing asthma, but this finding may not reflect direct causation.[von Mutius 2020]

Prenatal and childhood exposure to tobacco smoke

Exposure to tobacco smoke toxins *in utero* or in infancy is associated with increased risk of wheezing and asthma in children.[Burke 2012]

Maternal smoking during pregnancy is associated with an almost twofold increase in asthma in infants aged 2 years or younger.[Burke 2012]

Exposure to environmental tobacco smoke during pregnancy is an independent risk factor for wheeze in children up to the age of 2 years.[Vardavas 2016] In children, exposure to environmental tobacco smoke is associated with an increase in childhood asthma, but the association is weaker than for wheezing.[Tinuoye 2013]

Evidence from an Australian cohort study suggests that children with asthma whose mothers smoked during pregnancy benefit less from treatment with inhaled corticosteroids, and show less improvement in airway hyperresponsiveness over time, than those with asthma but no intrauterine exposure to smoke.[Cohen 2012]

Respiratory viral infections in early life

Early-life viral lower respiratory tract infection with respiratory syncytial virus (RSV) or rhinovirus, both of which cause bronchiolitis in infants, is strongly associated with recurrent wheeze and allergic asthma in childhood.[Rosas-Salazar 2023, Martinez 2019] Estimates of attributable risk of asthma due to RSV are 13–22% among children aged 5 years and under, 11–27% among children aged 5–11 years, and 32% among children 12 years and over.[Szabo 2013]

Parental and household smoking has been associated with increased risk of bronchiolitis in infancy.[Jones 2011]

Prenatal and childhood exposure to medicines

Several studies have reported an association between prenatal or early-life exposure to antibiotics and increased risk of childhood asthma.[Baron 2020]

Prenatal and childhood paracetamol use has been associated with increased asthma risk in several observational studies. However, causality has not been demonstrated.

Meta-analyses of observational studies (mainly prospective cohorts) show that paracetamol use during pregnancy is associated with increases in the risk of wheeze in early childhood and of childhood asthma at age 5 or older.[Castro-Rodriguez 2016, Cheelo 2015, Dick 2014, Eyers 2011, Etminan 2009] However, this finding must be interpreted with caution because of heterogeneity among studies and the fact that some studies did not control for maternal respiratory tract infections.

Several systematic reviews have reported an association between paracetamol use in infancy and development of asthma. [Dick 2014, Etminan 2009, Heintze 2013] However, many of the included studies were of low quality and the association may be due to confounding by indication. A meta-analysis of observational studies found that increasing frequency of use of paracetamol during infancy was associated with a small increase in the risk of childhood asthma, but the effect was reduced to very small after adjusting for respiratory tract infections.[Cheelo 2015] A 2016 systematic review of systematic reviews (overview) concluded that there was no significant association between paracetamol use during infancy and childhood asthma, after adjustment for lower respiratory tract infections.[Castro-Rodriguez 2016]

Maternal and childhood diet

There is epidemiological evidence for an association between low vitamin D in pregnancy and development of asthma during the first 10 years of life.[Lis-Swiety 2016] A systematic review reported a U-shaped relationship between maternal blood 25-hydroxyvitamin D levels and risk of childhood asthma, with the lowest risk at approximately 70 nmol/L.[Song 2017]

Low maternal vitamin E intake during pregnancy is associated with increased risk of asthma in offspring up to age 10 years. [Lis-Swiety 2016]

High intake of fast foods by children has been associated with increased risk of developing asthma in observational studies. [Hijazi 2000, Wickens 2005, Carey 1996, Huang 2001]

Maternal and childhood obesity

Maternal obesity during pregnancy increases the risk of asthma or wheeze in children, based on a meta-analysis of observational studies.[Forno 2014]

High gestational weight gain was also associated with higher risk of asthma or wheeze.[Forno 2014]

Childhood overweight or obesity have been associated with increased risk of developing asthma or wheeze.[Deng 2019]

Allergies and exposure to allergens

Population-based studies have observed a positive association between early life exposure to aeroallergens (e.g. house dust mite, indoor mould) or sensitisation to aeroallergens and the development of asthma,[Gaffin 2014, Arshad 2010, von Mutius 2020] Allergic rhinitis is a major risk factor for asthma and often precedes it.[Pawankar 2009, Burgess 2007, Shaaban 2008] These associations probably reflect the common allergic causes of both conditions, rather than a causal link. [Shaaban 2008]

Outdoor air pollution

Observational studies show an association between pollution and asthma risk in children. However, it is difficult to control for the influence of confounding factors such as socioeconomic status. Systematic reviews and meta-analyses have reported that prenatal exposure to air pollution (including nitrogen dioxide, particulate matter) was associated with increased risk of wheezing and asthma in children,[Hehua 2017] early-life exposure to air pollution (nitrogen dioxide, ozone, volatile organic compounds, and particulate matter) was associated with increased risk of allergic asthma in children,[Gaffin 2017] and childhood exposure to traffic pollution (including soot from vehicle emissions, nitrogen dioxide, fine particulate matter, carbon monoxide and particulate matter) was associated with increased risk of asthma.[Khreis 2017, Gasana 2012]

Indoor air pollution

Epidemiological studies have consistently reported an association between early life exposure to indoor dampness and mould (particularly visible mould and mould odour) and increased risk of developing asthma or wheeze.[Quansah 2012, Mendell 2011, Tischer 2011, Tischer 2011] However, it is difficult to control for the influence of confounding factors such as socioeconomic status.

Exposure to fumes from polyvinyl chloride products (PVC) surface materials is associated with increased risk of asthma in children, while exposure to heated PVC fumes (mainly in the workplace) is associated with increased risk of asthma in adults.[Jaakkola 2008]

The use of gas stoves or ovens in the home has also been associated with development of asthma in children.[Lanphear 2001]

References

ASCIA. Infant Feeding and Allergy Prevention Clinical Update. Australasian Society of Clinical Immunology and Allergy, 2020.

Arroyave W, Rabito F, Carlson J, et al. Impermeable dust mite covers in the primary and tertiary prevention of allergic disease: a meta-analysis. Ann Allergy Asthma Immunol 2014; 112: 237-48.

Arshad S. Does exposure to indoor allergens contribute to the development of asthma and allergy? Curr Allergy Asthma Rep 2010; 10: 49-55.

Arshad SH. Does allergen immunotherapy for allergic rhinitis prevent asthma? Ann Allergy Asthma Immunol 2022; 129: 286-291.

Arshad S, Bateman B, Matthews SM. Primary prevention of asthma and atopy during childhood by allergen avoidance in infancy: a randomised controlled study. Thorax 2003; 58: 489-493.

Australian Government Department of Health and Aged Care. Australian immunisation handbook (website) [accessed March 2025] https://immunisationhandbook.health.gov.au

Azad, M, Coneys J, Kozyrskyj A, et al. Probiotic supplementation during pregnancy or infancy for the prevention of asthma and wheeze: systematic review and meta-analysis. BMJ 2013; 347: f6471.

Baron R, Taye M, der Vaart IB, et al. The relationship of prenatal antibiotic exposure and infant antibiotic administration with childhood allergies: a systematic review. BMC Pediatr 2020; 20: 312.

Becker A, Watson W, Ferguson A, et al. The Canadian asthma primary prevention study: outcomes at 2 years of age. J Allergy Clin Immunol 2004; 113: 650-656.

Best KP, Sullivan TR, Palmer DJ, et al. Prenatal omega-3 LCPUFA and symptoms of allergic disease and sensitization throughout early childhood - a longitudinal analysis of long-term follow-up of a randomized controlled trial. World Allergy Organ J 2018; 11: 10.

Best K, Sullivan T, Palmer D, et al. Prenatal fish oil supplementation and allergy: 6-year follow-up of a randomized controlled trial. Pediatrics 2016; 137: e20154443

Best K, Gold M, Kennedy D, et al. Omega-3 long-chain PUFA intake during pregnancy and allergic disease outcomes in the offspring: a systematic review and meta-analysis of observational studies and randomized controlled trials. Am J Clin Nutr 2016; 103: 128-43.

Bisgaard H, Stokholm J, Chawes B, et al. Fish oil-derived fatty acids in pregnancy and wheeze and asthma in offspring. N Engl J Med 2016; 375: 2530-2539.

Burgess, J A, Walters, E H, Byrnes, G B, et al. Childhood allergic rhinitis predicts asthma incidence and persistence to middle age: a longitudinal study. J Allergy Clin Immunol 2007; 120: 863-969.

Burke H, Leonardi-Bee J, Hashim A, et al. Prenatal and passive smoke exposure and incidence of asthma and wheeze: systematic review and meta-analysis. Pediatrics 2012; 129: 735-44.

Castro-Rodriguez J, Forno E, Rodriguez-Martinez C, et al. Risk and protective factors for childhood asthma: what is the evidence?. J Allergy Clin Immunol Pract 2016; 4: 1111-1122.

Carey OJ, Cookson JB, Britton J, et al. The effect of lifestyle on wheeze, atopy, and bronchial hyperreactivity in Asian and white children. Am J Respir Crit Care Med 1996; 154: 537-40.

Chan-Yeung M, Ferguson A, Watson W, et al. The Canadian Childhood Asthma Primary Prevention Study: outcomes at 7 years of age. J Allergy Clin Immunol 2005; 116: 49-55.

Cheelo M, Lodge C, Dharmage S, et al. Paracetamol exposure in pregnancy and early childhood and development of childhood asthma: a systematic review and meta-analysis. Arch Dis Child 2015; 100: 81-9.

Cohen RT, Raby BA, Van Steen K, et al. In utero smoke exposure and impaired response to inhaled corticosteroids in children with asthma. J Allergy Clin Immunol 2010; 126: 491-7.

Deng X, Ma J, Yuan Y, et al. Association between overweight or obesity and the risk for childhood asthma and wheeze: An updated meta-analysis on 18 articles and 73 252 children. Pediatr Obes 2019; 14: e12532.

Dick S, Friend A, Dynes K, et al. A systematic review of associations between environmental exposures and development of asthma in children aged up to 9 years. BMJ Open 2014; 4: e006554.

Elazab N, Mendy A, Gasana J, et al. Probiotic administration in early life, atopy, and asthma: a meta-analysis of clinical trials. Pediatrics 2013; 132: e666-76.

Etminan M, Sadatsafavi M, Jafari S, et al. Acetaminophen use and the risk of asthma in children and adults: a systematic review and metaanalysis. Chest 2009; 136: 1316-1323.

Eyers S, Weatherall M, Jefferies S, et al. Paracetamol in pregnancy and the risk of wheezing in offspring: a systematic review and meta-analysis. Clin Exp Allergy 2011; 41: 482-9.

Farraia M, Paciência I, Castro Mendes F, et al. Allergen immunotherapy for asthma prevention: A systematic review and meta-analysis of randomized and non-randomized controlled studies. Allergy 2022; 77: 1719-1735.

Forno E, Young O, Kumar R, et al. Maternal obesity in pregnancy, gestational weight gain, and risk of childhood asthma. Pediatrics 2014; 134: e535-46.

Gaffin J, Kanchongkittiphon W, Phipatanakul W. Perinatal and early childhood environmental factors influencing allergic asthma immunopathogenesis. Int Immunopharmacol 2014; 22: 21-30.

Garcia-Larsen V, Del Giacco SR, Moreira A, et al. Asthma and dietary intake: an overview of systematic reviews. Allergy 2016; 71: 433-42.

Gasana J, Dillikar D, Mendy A, et al. Motor vehicle air pollution and asthma in children: a meta-analysis. Environ Res 2012; 117: 36-45.

Global Initiative for Asthma. Global Strategy for Asthma Management and Prevention, 2025. Available from: www.ginasthma.org

Gunaratne A, Makrides M, Collins C. Maternal prenatal and/or postnatal n-3 long chain polyunsaturated fatty acids (LCPUFA) supplementation for preventing allergies in early childhood. Cochrane Database Syst Rev 2015; Issue 7: CD010085.

Hammitt LL, Dagan R, Yuan Y, et al. Nirsevimab for prevention of RSV in healthy late preterm and term infants. N Engl J Med 2022; 386: 837-846.

Hansen S, Strom M, Maslova E, et al. Fish oil supplementation during pregnancy and allergic respiratory disease in the adult offspring. J Allergy Clin Immunol 2017; 139: 104-111.e104

Hehua Z, Qing C, Shanyan G, et al. The impact of prenatal exposure to air pollution on childhood wheezing and asthma: A systematic review. Environ Res 2017; 159: 519-530.

Heintze K, Petersen K. The case of drug causation of childhood asthma: antibiotics and paracetamol. Eur J Clin Pharmacol 2013; 69: 1197-209.

Hijazi, N, Abalkhail, B, Seaton, A. Diet and childhood asthma in a society in transition: a study in urban and rural Saudi Arabia. Thorax 2000; 55: 775-9.

Hosseini B, Berthon B, Wark P, et al. Effects of fruit and vegetable consumption on risk of asthma, wheezing and immune responses: a systematic review and meta-analysis. Nutrients 2017; 9: 341.

Huang SL, Lin KC, Pan WH. Dietary factors associated with physician-diagnosed asthma and allergic rhinitis in teenagers: analyses of the first Nutrition and Health Survey in Taiwan. Clin Exp Allergy 2001; 31: 259-64.

Indolfi C, D'Addio E, Bencivenga CL, et al. The primary prevention of atopy: does early exposure to cats and dogs prevent the development of allergy and asthma in children? A comprehensive analysis of the literature. Life (Basel) 2023; 13: 1859.

Jaakkola J, Knight T. The role of exposure to phthalates from polyvinyl chloride products in the development of asthma and allergies: a systematic review and meta-analysis. Environ Health Perspect 2008; 116: 845-53.

Jones LL, Hashim A, McKeever T, et al. Parental and household smoking and the increased risk of bronchitis, bronchiolitis and other lower respiratory infections in infancy: systematic review and meta-analysis. Respir Res 2011; 12: 5.

Kampmann B, Madhi SA, Munjal I, et al. Bivalent prefusion F vaccine in pregnancy to prevent RSV illness in infants. N Engl J Med 2023; 388: 1451-1464.

Kramer M, Kakuma R. Maternal dietary antigen avoidance during pregnancy or lactation, or both, for preventing or treating atopic disease in the child. Cochrane Database Syst Rev 2012; 9: CD000133.

Khreis H, Kelly C, Tate J, et al. Exposure to traffic-related air pollution and risk of development of childhood asthma: A systematic review and meta-analysis. Environ Int 2017; 100: 1-31.

Lanphear B, Aligne C, Auinger P, et al. Residential exposures associated with asthma in US children. Pediatrics 2001; 107: 505-511.

Lis-Swiety A, Milewska-Wrobel D, Janicka I. Dietary strategies for primary prevention of atopic diseases – what do we know?. Dev Period Med 2016; 20: 68-74.

Maas T, Kaper J, Sheikh A, et al. Mono and multifaceted inhalant and/or food allergen reduction interventions for preventing asthma in children at high risk of developing asthma. Cochrane Database Syst Rev 2009; 3: CD006480.

Marks G, Mihrshahi S, Kemp A, et al. Prevention of asthma during the first 5 years of life: a randomized controlled trial. J Allergy Clin Immunol 2006; 118: 53-61.

Martinez FD. Childhood asthma inception and progression: role of microbial exposures, susceptibility to viruses and early allergic sensitization. Immunol Allergy Clin North Am 2019; 39:141-150.

Mendell M, Mirer A, Cheung K, et al. Respiratory and allergic health effects of dampness, mold, and dampness-related agents: a review of the epidemiologic evidence. Environ Health Perspect 2011; 119: 748-756.

Netting MJ, Middleton PF, Makrides M. Does maternal diet during pregnancy and lactation affect outcomes in offspring? A systematic review of food-based approaches. Nutrition 2014; 30: 1225-41.

Palmer D, Sullivan T, Gold M, et al. Randomized controlled trial of fish oil supplementation in pregnancy on childhood allergies. Allergy 2013; 68: 1370-1376.

Pawankar R, Bunnag C, Chen Y, et al. Allergic rhinitis and its impact on asthma update (ARIA 2008)–western and Asian-Pacific perspective. Asian Pac J Allergy Immunol 2009; 27: 237-243.

Peat, J, Mihrshahi S, Kemp A, et al. Three-year outcomes of dietary fatty acid modification and house dust mite reduction in the Childhood Asthma Prevention Study. J Allergy Clin Immunol 2004; 114: 807-13.

Quansah R, Jaakkola M, Hugg T, et al. Residential dampness and molds and the risk of developing asthma: a systematic review and meta-analysis. PLoS One 2012; 7: e47526.

RANZCOG. Vitamin and mineral supplementation and pregnancy. Royal Australian College of Obstetricians and Gynaecologists, 2019.

Rosas-Salazar C, Chirkova T, Gebretsadik T, et al. Respiratory syncytial virus infection during infancy and asthma during childhood in the USA (INSPIRE): a population-based, prospective birth cohort study. Lancet 2023; 401: 1669-1680.

Scheltema NM, Nibbelke EE, Pouw J, et al. Respiratory syncytial virus prevention and asthma in healthy preterm infants: a randomised controlled trial. Lancet Respir Med 2018; 6: 257-64.

Schindler T, Sinn J, Osborn D. Polyunsaturated fatty acid supplementation in infancy for the prevention of allergy. Cochrane Database Syst Rev 2016; Issue 10: CD010112.

Schonberger HJAM, Dompeling E, Knottnerus JA, et al. The PREVASC study: the clinical effect of a multifaceted educational intervention to prevent childhood asthma. Eur Respir J 2005; 25: 660-670.

Scott M, Roberts G, Kurukulaaratchy RJ, et al. Multifaceted allergen avoidance during infancy reduces asthma during childhood with the effect persisting until age 18 years. Thorax 2012; 67: 1046-1051.

Seyedrezazadeh E, Moghaddam MP, Ansarin K, et al. Fruit and vegetable intake and risk of wheezing and asthma: a systematic review and meta-analysis. Nutr Rev 2014; 72: 411-28.

Shaaban R, Zureik M, Soussan D, et al. Rhinitis and onset of asthma: a longitudinal population-based study. Lancet 2008; 372: 1047-1057.

Shadid IL, Brustad N, Lu M, et al. The impact of baseline 25-hydroxyvitamin D level and gestational age on prenatal vitamin D supplementation to prevent offspring asthma or recurrent wheezing. Am J Clin Nutr 2023; 117: 1342-1352.

Smits H, van der Vlugt L, von Mutius E, et al. Childhood allergies and asthma: New insights on environmental exposures and local immunity at the lung barrier. Curr Opin Immunol 2016; 42: 41-47.

Song H, Yang L, Jia C. Maternal vitamin D status during pregnancy and risk of childhood asthma: A meta-analysis of prospective studies. Mol Nutr Food Res 2017; 61: 10.1002.

Szabo S, Levy A, Gooch K et al. Elevated risk of asthma after hospitalization for respiratory syncytial virus infection in infancy. Paediatr Respir Rev 2013; 13 Suppl 2: S9-15.

Tinuoye O, Pell J, Mackay D. Meta-analysis of the association between secondhand smoke exposure and physician-diagnosed childhood asthma. Nicotine Tob Res 2013; 15: 1475-83.

Association between domestic mould and mould components, and asthma and allergy in children: a systematic review. Eur Respir J 2011; 38: 812-824.

Tischer C, Hohmann C, Thiering E, et al. Meta-analysis of mould and dampness exposure on asthma and allergy in eight European birth cohorts: an ENRIECO initiative. Allergy 2011; 66: 1570-1579.

Toelle BG, Garden FL, Ng KK, et al. Outcomes of the Childhood Asthma Prevention Study at 11.5 years. J Allergy Clin Immunol 2013; 132: 1120-1222.

University of Arizona. Oral Bacterial Extract for the Prevention of Wheezing Lower Respiratory Tract Illness (ORBEX). Clinical trial NCT02148796 (updated 29 August 2024). ClinicalTrials.gov.

Vardavas C, Hohmann C, Patelarou E, et al. The independent role of prenatal and postnatal exposure to active and passive smoking on the development of early wheeze in children. Eur Respir J 2016; 48: 115-24.

van Schayck OCP, Maas T, Kaper J, et al. Is there any role for allergen avoidance in the primary prevention of childhood asthma? J Allergy Clin Immunol 2007; 119: 1323-1328.

von Mutius E. The microbial environment and its influence on asthma prevention in early life. J Allergy Clin Immunol 2016; 137: 680-689.

von Mutius E, Smits H. Primary prevention of asthma: from risk and protective factors to targeted strategies for prevention. Lancet 2020; 396: 854-866.

Weiss ST, Mirzakhani H, Carey VJ, et al. Prenatal vitamin D supplementation to prevent childhood asthma: 15-year results from the Vitamin D Antenatal Asthma Reduction Trial (VDAART). J Allergy Clin Immunol 2024; 153: 378-388.

Wickens K, Barry D, Friezema A, et al. Fast foods – are they a risk factor for asthma? Allergy 2005; 60: 1537-41.

Wolsk H, Chawes B, Litonjua A, et al. Prenatal vitamin D supplementation reduces risk of asthma/recurrent wheeze in early childhood: A combined analysis of two randomized controlled trials. PloS one 2017; 12: e0186657.

Yang H, Xun P, He K. Fish and fish oil intake in relation to risk of asthma: a systematic review and meta-analysis. PloS One 2013; 8: e80048.

Zuccotti G, Meneghin F, Aceti A, et al. Probiotics for prevention of atopic diseases in infants: systematic review and meta-analysis. Allergy 2015; 70: 1356-71.