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Diet and nutrition

Introduction



Key points

- Aspects of diet are risk factors for several respiratory diseases, but it does not always follow that dietary interventions are effective.
- Normal-weight and overweight people have lower respiratory mortality than underweight people.
- Intervention aimed at restoring fat-free mass is recommended in chronic obstructive pulmonary disease.
- A 'balanced diet' with plenty of fruit, vegetables and fish reduces the risk of developing lung diseases, particularly asthma and chronic obstructive pulmonary disease.

Most respiratory diseases result from complex interactions between genes and the environment. Since altering the former is currently impracticable, increasing attention has been given to the management of important environmental factors, such as physical inactivity, air pollution, smoking and diet. There is now a large body of evidence supporting the role of diet in the pathogenesis of respiratory disease, as well as the health value of certain nutritional interventions; for example, in the context of pulmonary rehabilitation.

This chapter summarises the evidence for poor nutrition as a risk factor for, and modulator of, chronic obstructive pulmonary disease (COPD), allergy and asthma, lung cancer, venous thromboembolism and respiratory infections. It reviews the field of nutritional assessment and the effect of nutritional interventions in respiratory diseases. It concludes with recommendations from the World Health Organization (WHO) and academic societies for primary and secondary prevention of respiratory disease.

Diet as a risk factor



Even in developed societies, populations and individuals are exposed to two main potential nutritional hazards: over-nutrition and

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under-nutrition. In 2013, a large meta-analysis of data on healthy cohorts, which included 2.88 million subjects, showed that a body mass index (BMI) of up to $30 \text{ kg}\cdot\text{m}^{-2}$ – the boundary between ‘overweight’ and ‘obese’ – could have a protective effect against death. Furthermore, in a large population-based cohort of more than 1 million South Koreans aged 30–95 years, who were tracked for 12 years, over-nutrition had clear protective effects against death from respiratory causes in nonsmoking women and in both smoking and nonsmoking men. Diet surveys and, more recently, dietary pattern analysis have shown that in addition to abnormal overall calorie intake, the intake of individual nutrients and certain dietary behaviours can have protective or harmful effects. This approach has been used to investigate the role of diet in several chronic diseases, but so far there have been few studies relating to respiratory diseases. Study of dietary patterns may provide insight into combinations of foods and/or nutrients that have a positive or negative impact on the prevalence or severity of respiratory diseases. It should, however, be understood that the existence of an epidemiological link between a risk factor and a respiratory phenotype does not necessarily mean that interventions aimed at modifying diet are justified: large prospective and randomised controlled studies must be carried out first (table 1).

Obstructive lung diseases

Asthma

In asthma, both dietary exposures themselves (food, nutrients and dietary patterns) and the periods of exposure (antenatal, childhood, adulthood) are relevant to the pathogenesis and progress of the disease.

Dietary antioxidant intake has been associated with asthma throughout life. Cohort studies covering the antenatal period have suggested a link between childhood asthma and reduced maternal consumption of vitamin E, zinc, fruit and vegetables; however, randomised controlled trials (RCTs) are lacking. A recent meta-analysis of 62 studies on the effect of childhood food and nutrient intake on the risk of developing wheezing or asthma concluded that there was some evidence (although weak) of protective effects from vitamins A, D, and E, zinc, fruit and vegetables, and of a Mediterranean diet, against the development of asthma. In adults, an

Conditions	Epidemiological study data	Effectiveness of intervention, primary prevention#	Effectiveness of intervention, secondary prevention#	Available recommendations
Allergy and asthma	Risk factors: low level of antioxidants, low vitamin D status, high ratio of omega-6 to omega-3 polyunsaturated fatty acids Protective factors: Mediterranean dietary pattern during childhood (but conflicting results in adults)	NA	NA	No specific recommendations
COPD and chronic respiratory failure	Risk factors: related to 'Western', 'traditional' dietary patterns, cured meat Protective factors: fruit, vegetables and fibre	NA	Of three RCTs, one was positive for slowing the decline in FEV1 A meta-analysis (2012) showed a positive impact for oral supplementation on body composition and functioning in under-nourished patients with COPD	WHO recommendations on chronic diseases (2009) ATS/ERS guideline on pulmonary rehabilitation (updated 2013)
Lung cancer	Protective factors: fruit and vegetables	Two chemoprevention RCTs were negative for benefit, with higher risk in the β -carotene supplement arm; positive long-term prevention in subjects with high intake of fruit, vegetables and carotenoids	Negative results for nutritional support	No specific recommendations
Venous thromboembolism	Risk factor: high BMI	NA	NA	Obesity prevention in general population
Lung infections	Risk factors: low vitamin D status, under-nutrition	RCTs positive for vitamin D intake	RCTs positive for vitamin D intake	General recommendations for vitamin D intake
Cystic fibrosis	NA	NA	Positive cohort studies but no RCTs	Specific recommendations for nutritional support to prevent under-nutrition

Table 1 – Dietary risk factors, protective factors and interventions in respiratory diseases. COPD: chronic obstructive pulmonary disease; NA: not available; RCT: randomised controlled trial; FEV1: forced expiratory volume in 1 second; WHO: World Health Organization; ATS: American Thoracic Society; ERS: European Respiratory Society; BMI: body mass index. #: primary/prevention is the prevention of a disease in healthy people; secondary prevention aims to halt or slow worsening of a disease in people who already have the disease.

association between asthma and lower intake of antioxidants has been reported but data from RCTs do not support supplementation with vitamin C or selenium.

During the antenatal period, and throughout life, observational studies have reported associations between asthma and a high intake of omega-6 polyunsaturated fatty acids, as well as a decreased intake of omega-3 polyunsaturated fatty acids. However, RCTs are either lacking or show minimal or no benefit for dietary intervention in adults.

Birth cohort studies to examine the association between maternal dietary intake of vitamin D during pregnancy and wheezing and asthma have yielded conflicting results. Studies on children already diagnosed with asthma have shown an association between low levels of vitamin D and asthma exacerbations. These studies have also shown that in patients with mild or moderate persistent asthma treated with inhaled corticosteroids, vitamin D sufficiency is associated with better lung function. These results suggest that vitamin D levels should be monitored in asthmatic children. A longitudinal study conducted in children in Australia reported that low vitamin D levels measured at 6 and 14 years of age were predictive of allergy phenotypes and bronchial hyperresponsiveness, but not of asthma, at those ages. However, low vitamin D levels at 6 years of age were predictive of later asthma and atopy phenotypes at 14 years of age. One RCT using data from the Northern Finland Birth Cohort 1966 reported that high-dose vitamin D supplementation in infancy was associated with an increased risk of atopy, allergic rhinitis, and asthma later in life (at age 31 years). Few studies have been conducted in adults, but a recent US study reported a strong protective effect of vitamin D against wheezing and exacerbations of asthma, supporting the notion that vitamin D status might influence the risk of respiratory disease.

Studies do not support an association between dietary pattern during pregnancy and asthma or wheezing in the child. Although research suggests an association between children's dietary patterns and asthma and wheezing, all such studies have been cross-sectional and therefore, in theory, prone to incorrect attribution of cause and effect. In adults, the overall results are conflicting: cross-sectional studies suggest that certain dietary patterns are associated with asthma, but these findings have not been confirmed in longitudinal surveys. Few studies relating asthma severity and control to diet have been performed, but 'Western'-type dietary patterns (e.g. refined grains, cured and red meats, desserts, French fries) are reported to be associated with a higher frequency of asthma attacks and with poor asthma control.

Chronic obstructive pulmonary disease

The main risk factor for COPD in the developed world is cigarette smoking, but up to one-third of patients with COPD (especially in developing countries) have never smoked, implying that other factors are also important. Diet is probably one such factor, but data on a diet-COPD association remain scarce.

Over the past decade, there has been growing research into dietary factors with antioxidant or anti-inflammatory properties that might affect lung function or COPD symptoms. Most of these epidemiological studies have been cross-sectional, but a



few longitudinal studies have reported associations between specific dietary factors and a slower decline in lung function. In large prospective epidemiological studies in the USA, it was reported that a high intake of a 'prudent' dietary pattern (e.g. fruit, vegetables, fish, whole-grain products) decreased the risk of newly diagnosed COPD, whereas a high intake of a Western-type pattern increased risk. More recently, it has been reported that a 'traditional' dietary pattern (with high intake of red meat, processed meat, boiled vegetables, added fat, coffee, beer, and potatoes, but reduced consumption of soy products, low-fat dairy products, tea, breakfast cereal, brown rice, pizza, juice and fruit) was associated with reduced lung function and a higher prevalence of COPD. A high intake of refined foods was associated with an accelerated decline in lung function over 5 years.

In relation to specific foods, special attention has been paid to fibre intake. It has been reported among several groups that dietary fibre intake has independent inverse associations with the incidence and symptoms of COPD and with decline in lung function. In addition to foods and nutrients with potential beneficial effects, several studies have focused on those with potential harmful effects. Two studies have reported associations between frequent or high consumption of cured meats and the risk of developing COPD. A recent study has extended this association to include the evolution of the disease, revealing that high cured meat consumption is linked to a higher risk of readmission to hospital with COPD.

Nutritional factors are also important in relation to mortality from COPD, with reports from diverse clinical settings showing that a low BMI is a major predictor of mortality among patients with COPD. The poor prognosis for COPD patients with a low BMI has been confirmed by a study showing that mortality is higher among COPD patients with recent weight loss.

Other respiratory diseases

Lung cancer

Lung cancer is the leading cause of cancer-related death worldwide in men and the second-commonest cause in women. Evidence from several observational, retrospective and prospective studies strongly suggests that high consumption of fruit or vegetables, or both, reduces the risk of lung cancer by approximately 20–30%, with a similar magnitude of reduction for current smokers, ex-smokers and never-smokers.

However, vitamin supplementation has not been shown to decrease lung cancer risk. In fact, the results of two major primary randomised prevention trials of vitamin supplementation showed a higher lung cancer incidence in the group receiving high doses of beta-carotene. A re-analysis of data from the beta-Carotene and Retinol Efficacy Trial (CARET) showed that a high intake of fruit and vegetables decreased the risk of lung cancer in the placebo arm after 12 years of follow-up. Similarly, in the Alpha-Tocopherol Beta-Carotene (ATBC) trial, after 14 years of follow-up, higher dietary intake and serum levels of carotenoids, including carotene, were related to a lower risk of lung cancer. These findings suggest that other potentially protective dietary factors associated with fruit and vegetable intake are playing a part.

Venous thromboembolism

In a prospective cohort study of 87 226 female nurses, the risk of new cases of pulmonary embolism was nearly six-fold higher among those with a BMI of ≥ 35 $\text{kg}\cdot\text{m}^{-2}$. The risk was present in multiple subgroups and increased in linear fashion with BMI.

Respiratory infections

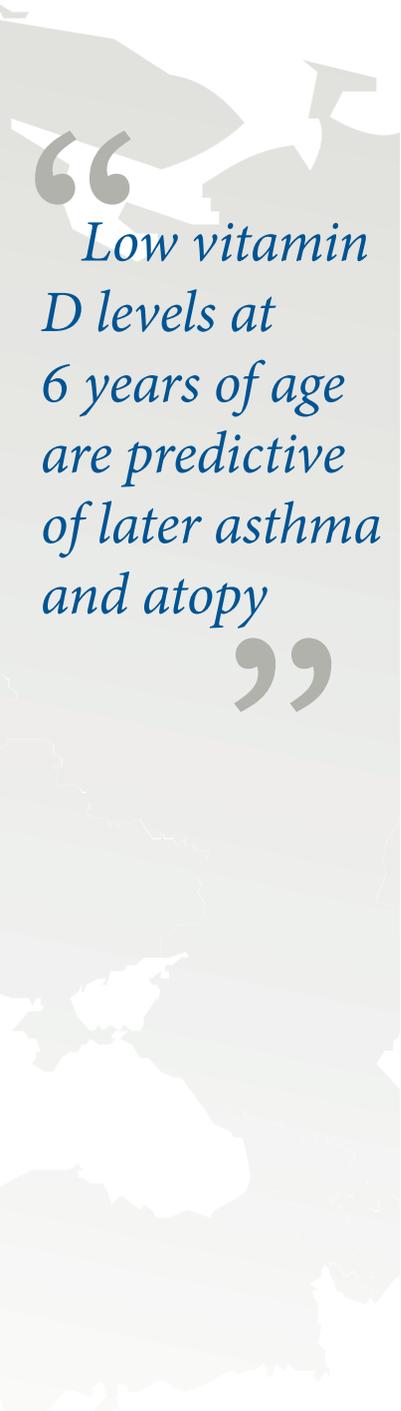
Although the respiratory tract is only the third-commonest site of infection in the body, it is the commonest site of fatal infections, which often represent the 'final common pathway' complicating the many effects of under-nutrition. For example, deaths among the malnourished are frequently due to pneumonia. The D vitamins have a demonstrated protective effect in preventing lung infections.

Nutritional status and interventions

Chronic obstructive pulmonary disease

As with other chronic diseases, COPD is often accompanied by abnormalities of body composition. This can mean loss of muscle bulk and cachexia ('wasting'), but also, increasingly, it means obesity. Various indices can signify under-nutrition in COPD: these include a BMI of < 21 $\text{kg}\cdot\text{m}^{-2}$, involuntary loss of more than 5% of total bodyweight in the past year, and a low fat-free mass index (< 15 $\text{kg}\cdot\text{m}^{-2}$ in women or < 16 $\text{kg}\cdot\text{m}^{-2}$ in men).

Nutritional depletion in COPD results from multiple and complex mechanisms, and nutritional intervention alone cannot address all of the issues raised. Consequently, clinical guidelines recommend nutritional intervention in the context of pulmonary rehabilitation in all patients with COPD, particularly in those who are already nutritionally depleted. After decades of scepticism, nutritional intervention aimed at restoring fat-free mass is now recommended and a recent meta-analysis of original data has shown a positive benefit from such supplementation. Nutritional intervention in COPD should be integrated into pulmonary rehabilitation, both at an early stage and in end-stage disease when patients are on long-term oxygen therapy and/or noninvasive ventilation.



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*Low vitamin
D levels at
6 years of age
are predictive
of later asthma
and atopy*
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Allergies and asthma

Epidemiological findings underscore the importance of conducting prospective studies and clinical trials to clarify the role of antioxidants, omega-3 polyunsaturated fatty acids and vitamin D in asthma and wheezing, in both children and adults. Further studies are also needed to better understand how dietary habits might modulate asthma severity and/or control in adults. A recent exhaustive review of the association between asthma and diet concluded that until the results of forthcoming trials are available, the practical consequences of research linking diet with asthma are minimal, and, based on current evidence, people with asthma, pregnant women, parents, and children should not be advised to change or supplement their diet to treat or reduce the risk of developing asthma.

Clinical epidemiological studies suggest a strong relationship between obesity and poor control of asthma, and treatment by bariatric surgery has been advocated to control very severe cases.

Bronchial carcinoma

Nutritional principles indicate that a healthy diet should include at least moderate amounts of fruit and vegetables, but the available data suggest that general increases in fruit and vegetable intake would have little effect on cancer rates, at least in well-nourished populations. Advice in relation to diet and cancer should include the recommendation to consume adequate amounts of fruit and vegetables, but should put most emphasis on the well-established adverse effects of obesity and high alcohol intake. Specific nutritional intervention in patients treated for lung cancer has not resulted in a better quality of life.

Obstructive sleep apnoea syndrome and obesity hypoventilation syndrome

Obesity, especially affecting the trunk and neck, is a major risk factor for obstructive sleep apnoea syndrome (OSAS); although other factors may contribute to its pathogenesis, obesity is reported in 60–90% of individuals with OSAS. Patients with obesity hypoventilation syndrome (OHS) usually have very severe obesity, often in the ‘morbid’ range (a BMI of $>40 \text{ kg}\cdot\text{m}^{-2}$). Although OHS is much less common than OSAS, its prevalence is increasing in many countries, in parallel with the ‘epidemic’ of obesity in the population. Either OSAS or OHS may coexist with COPD, particularly in

smokers, increasing morbidity. Weight loss may lead to resolution of OSAS or OHS but, even if successful, this is likely to take several months and in severely obese individuals, bariatric surgery may be indicated. Effective treatment of the breathing problems should not be delayed while waiting for weight loss to occur (see chapter 23).

Cystic fibrosis

A major area of recent progress in cystic fibrosis has been the emphasis on the central role of under-nutrition. The patient's diet and BMI are monitored very closely, and pancreatic enzyme supplementation should be used to combat pancreatic insufficiency.

Amyotrophic lateral sclerosis

Amyotrophic lateral sclerosis is a cause of severe weakness of the respiratory muscles. Enteral nutrition (feeding directly into the stomach or lower down the digestive tract), together with noninvasive ventilation can offer palliation and prolongation of life with acceptable side-effects. Percutaneous endoscopic gastrostomy (PEG) should be considered to stabilise weight and to prolong survival.

Clinical recommendations

The following are drawn from recommendations by WHO, the European Food Safety Authority (EFSA), the European Respiratory Society (ERS), the American Thoracic Society (ATS) and the Société de Pneumologie de Langue Française (SPLF).

Eating foods rich in antioxidants can counter the damage done to the body by oxidative stress, as antioxidants effectively 'mop up' free radicals and so prevent them from causing damage. Sources of vitamin C include citrus fruits (oranges, lemons, grapefruit), kiwi fruit, broccoli and green peppers; beta-carotene is present in apricots, mangoes, carrots, peppers and spinach; vitamin E can be found in grains, wheatgerm, almonds and peanuts; lycopene is found in tomatoes and processed tomato products; and grains, Brazil nuts, animal products (especially organ meats) and seafood contain selenium.

Magnesium is the fourth-most abundant mineral in the body and is essential for good health. Magnesium aids the action of the enzymes that facilitate the chemical reactions in the body. Magnesium may also help the airway smooth muscle to relax and help control the body's response to infection. It is found in nuts, cereals, seeds, carrots, spinach and seafood.

Omega-3 polyunsaturated fatty acids are essential for good health but are deficient in most people's diets. Omega-6 fatty acids are also essential but are over-consumed. The ideal ratio of omega-6 to omega-3 in the diet is 4 to 1. However, in the average modern diet the ratio is closer to 20 to 1. Omega-3 fatty acids are found in oily fish and shellfish, soy and leafy vegetables.

A balanced diet

A balanced diet with a high intake of fruit, vegetables and fish reduces the risk of developing lung diseases, especially asthma and COPD. Although the effects of diet on the lungs are still under study, it is clear that the following advice can help to maintain good lung health:

- Eat a balanced diet with a lot of fruit, vegetables and fish.
- Reduce salt intake.
- Restrict the amount of trans- and omega-6 fatty acids in the diet.
- Maintain an ideal weight, with a BMI of 21–30 kg·m⁻².
- Undertake moderate exercise.

Further reading



Diet as a risk factor for respiratory morbidity and mortality

- Flegal KM, Kit BK, Orpana H, *et al.* Association of all-cause mortality with overweight and obesity using standard body mass index categories: a systematic review and meta-analysis. *JAMA* 2013; 309: 71–82.
- Gallicchio L, Boyd K, Matanoski G, *et al.* Carotenoids and the risk of developing lung cancer: a systematic review. *Am J Clin Nutr* 2008; 88: 372–383.
- Jee SH, Sull JW, Park J, *et al.* Body-mass index and mortality in Korean men and women. *N Engl J Med* 2006; 355: 779–787.
- Varraso R. Nutrition and asthma. *Curr Allergy Asthma Rep* 2012; 12: 201–210.
- Varraso R, Camargo CA Jr. More evidence for the importance of nutritional factors in chronic obstructive pulmonary disease. *Am J Clin Nutr* 2012; 95: 1301–1302.

Assessment of nutritional status and interventions in respiratory diseases

- Allan K, Devereux G. Diet and asthma: nutrition implications from prevention to treatment. *J Am Diet Assoc* 2012; 111: 258–268.
- Aniwidyarningsih W, Varraso R, Cano N, *et al.* Impact of nutritional status on body functioning in chronic obstructive pulmonary disease and how to intervene. *Curr Opin Clin Nutr Metab Care* 2008; 11: 435–442.
- Cohen-Cyberknoh M, Shoseyov D, Kerem E. Managing cystic fibrosis: strategies that increase life expectancy and improve quality of life. *Am J Respir Crit Care Med* 2011; 183: 1463–1471.
- Dixon AE, Pratley RE, Forgione PM, *et al.* Effects of obesity and bariatric surgery on airway hyperresponsiveness, asthma control, and inflammation. *J Allergy Clin Immunol* 2011; 128: 508–515.
- Nurmatov U, Devereux G, Sheikh A. Nutrients and foods for the primary prevention of asthma and allergy: systematic review and meta-analysis. *J Allergy Clin Immunol* 2011; 127: 724–733.

Recommendations of WHO, ERS/ATS, SPLF

- Collins PF, Stratton RJ, Elia M. Nutritional support in chronic obstructive pulmonary disease: a systematic review and meta-analysis. *Am J Clin Nutr* 2012; 95: 1385–1395.
- European Food Safety Authority. Dietary reference values and dietary guidelines. www.efsa.europa.eu/topics/topic/drvtm 2012
- Nici L, Donner C, Wouters E, *et al.* American Thoracic Society/European Respiratory Society statement on pulmonary rehabilitation. *Am J Respir Crit Care Med* 2006; 173: 1390–1413.
- Société de Pneumologie de Langue Française. Recommandation pour la pratique clinique. Prise en charge de la BPCO. Mise à jour 2009. *Rev Mal Respir* 2010; 27: 522–548.
- World Health Organization. Diet, Nutrition and the Prevention of Chronic Diseases. WHO Technical Report Series 916. Geneva, World Health Organization, 2003. whqlibdoc.who.int/trs/who_trs_916.pdf