Healthcare Improvement Scotland | SIGN Evidence-based clinical guidelines

SIGN 158

British guideline on the management of asthma

A national clinical guideline

First published 2003
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British Thoracic Society

NHS SCOTLAND

KEY TO EVIDENCE STATEMENTS AND GRADES OF RECOMMENDATIONS

LEVELS OF EVIDENCE

1^{++}	High-quality meta-analyses, systematic reviews of RCTs, or RCTs with a very low risk of bias
1^{+}	Well-conducted meta-analyses, systematic reviews of RCTs, or RCTs with a low risk of bias
1^{-}	Meta-analyses, systematic reviews of RCTs, or RCTs with a high risk of bias
2^{++}	High-quality systematic reviews of case-control or cohort studies High-quality case-control or cohort studies with a very low risk of confounding or bias and a high probability that the relationship is causal
2^{+}	Well-conducted case-control or cohort studies with a low risk of confounding or bias and a moderate probability that the relationship is causal
2^{-}	Case-control or cohort studies with a high risk of confounding or bias and a significant risk that the relationship is not causal
3	Non-analytic studies, eg case reports, case series
4	Expert opinion

GRADES OF RECOMMENDATION

Note: The grade of recommendation relates to the strength of the supporting evidence on which the evidence is based. It does not reflect the clinical importance of the recommendation.

A	At least one meta-analysis, systematic review, or RCT rated as 1^{++}, and directly applicable to the target population*; or* A body of evidence consisting principally of studies rated as 1^{+}, directly applicable to the target population, and demonstrating overall consistency of results
B	A body of evidence including studies rated as 2^{++}, directly applicable to the target population, and demonstrating overall consistency of results*; or* Extrapolated evidence from studies rated as 1^{++} or 1^{+}
C	A body of evidence including studies rated as 2^{+}, directly applicable to the target population and demonstrating overall consistency of results*; or* Extrapolated evidence from studies rated as 2^{++}
D	Evidence level 3 or 4*; or* Extrapolated evidence from studies rated as 2^{+}

GOOD-PRACTICE POINTS

✓	Recommended best practice based on the clinical experience of the guideline development group.

Contents

1 Introduction

1.1 The need for a guideline

Asthma is a common condition which produces a significant workload for general practice, hospital outpatient clinics and inpatient services. It is clear that much of this morbidity relates to poor management, particularly around the use of preventative medicine.

1.1.1 Background

In 1999 the British Thoracic Society (BTS) and the Scottish Intercollegiate Guidelines Network (SIGN) agreed to jointly produce a comprehensive new asthma guideline, both having previously published guidance on asthma. The original BTS guideline dated back to 1990 and the SIGN guidelines to 1996. Both organisations recognised the need to develop the new guideline using evidence-based methodology explicitly. The joint process was further strengthened by collaboration with Asthma UK, the Royal College of Physicians of London, the Royal College of Paediatrics and Child Health, the General Practice Airways Group (now Primary Care Respiratory Society UK), and the British Association of Accident and Emergency Medicine (now the College of Emergency Medicine). The outcome of these efforts was the British Guideline on the Management of Asthma, developed using SIGN methodology[1] and published in 2003.[2]

1.1.2 Updating the evidence

Between 2004 and 2012 sections within the guideline were updated annually. Subsequent updates took place in 2014, 2016 and 2019. All updates were published on the BTS and SIGN websites. A list of the key questions addressed in this update is given in Annex 1. Any updates to the guideline in the period between scheduled updates will be noted on the SIGN and BTS websites. This edition of the guideline was issued in 2024 as part of a new asthma pathway.

A summary of the search histories for each section is given in Annex 2. It is hoped that this asthma guideline continues to serve as a basis for high quality management of both acute and chronic asthma and a stimulus for research into areas of management for which there is little evidence *(see section 16.2)*.

No evidence review has taken place in the 2024 revision to this guideline.

1.2 Remit of the guideline

1.2.1 Overall objectives

This guideline provides recommendations based on current evidence for best practice in the management of asthma. It makes recommendations on management of adults, including pregnant women, and adolescents and children with asthma. In section 7 on pharmacological management, and in section 4.3 on predicting future risk of asthma attacks, each recommendation has been graded and the supporting evidence assessed for adults and adolescents over 12 years old, children 5–12 years, and children under 5 years.

The guideline considers diagnosis of asthma and management in all patients with a diagnosis of asthma, although there is less evidence available for people at either age extreme. The guideline does not cover patients whose primary diagnosis is not asthma, for example those with chronic obstructive pulmonary disease (COPD) or cystic fibrosis, but patients with these conditions can also have asthma. Under these circumstances many of the principles set out in this guideline will apply to the management of their asthma symptoms.

The key questions on which the guideline is based can be found on the SIGN website, www.sign.ac.uk, as part of the supporting material for this guideline.

1.2.2 Target users of the guideline

This guideline will be of particular interest to healthcare professionals involved in the care of people with asthma including general practitioners, consultants and specialists in respiratory medicine, nurses, pharmacists and other allied health professionals with an interest in respiratory care. The guideline will also be of interest to people with asthma, their parents and carers; those who interact with people with asthma outside of the NHS, such as teachers; voluntary organisations with an interest in asthma; and those planning the delivery of services in the NHS in England, Wales, Northern Ireland and Scotland.

1.2.3 Summary of updates to the guideline, by section

Guideline section		Year of update
2	Key recommendations	2014, 2016, 2019, 2024
3	Diagnosis	2008, 2011, 2016, 2024
4	Monitoring asthma	2008, 2011, 2019, 2024
5	Supported self management	2004, 2008, 2014, 2016, 2019, 2024
6	Non-pharmacological management	2008, 2014, 2016, 2019
7	Pharmacological management	2004, 2005, 2006, 2008, 2009, 2011, 2014, 2016, 2019, 2024
8	Inhaler devices	2005, 2014, 2019, 2024
9	Management of acute asthma	2004, 2009, 2014, 2016, 2019
10	Difficult asthma	2008, 2014, 2016
11	Asthma in adolescents	2011, 2024
12	Asthma in pregnancy	2005, 2008, 2009, 2014, 2024
13	Occupational asthma	2005, 2008, 2014, 2016
14	Organisation and delivery of care	2008, 2014, 2016

1.2.4 Summary of updates to the 2024 edition of the guideline, by section

The table below lists all the sections and subsections of the guideline that were updated in 2024.

Guideline section		**Description**
2	Key recommendations	The remaining key recommendations after the 2024 revision.
3	Diagnosis	Much of this section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244). *2025 amendment: 20 pack-years*
4	Monitoring asthma	Much of this section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

5	Supported self management	Much of this section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).
7	Pharmacological management	Much of this section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).
8	Inhaler devices	Much of this section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).
9	Management of acute asthma	*2025 amendment: life-threatening asthma criteria*
15	Provision of information	Updates to website addresses.

1.3 Statement of intent

This guideline is not intended to be construed or to serve as a standard of care. Standards of care are determined on the basis of all clinical data available for an individual case and are subject to change as scientific knowledge and technology advance and patterns of care evolve. Adherence to guideline recommendations will not ensure a successful outcome in every case, nor should they be construed as including all proper methods of care or excluding other acceptable methods of care aimed at the same results. The ultimate judgement must be made by the appropriate healthcare professional(s) responsible for clinical decisions regarding a particular clinical procedure or treatment plan. This judgement should only be arrived at through a process of shared decision making with the patient, covering the diagnostic and treatment choices available. It is advised, however, that significant departures from the national guideline or any local guidelines derived from it should be fully documented in the patient's medical records at the time the relevant decision is taken.

1.3.1 Influence of financial and other interests

It has been recognised that financial interests in, or close working relationships with, pharmaceutical companies may have an influence on the interpretation of evidence from clinical studies.

It is not possible to completely eliminate any possible bias from this source, nor even to quantify the degree of bias with any certainty. SIGN requires that all those involved in the work of guideline development should declare all financial interests, whether direct or indirect, annually for as long as they are actively working with the organisation. By being explicit about the influences to which contributors are subjected, SIGN acknowledges the risk of bias and makes it possible for guideline users or reviewers to assess for themselves how likely it is that the conclusions and guideline recommendations are based on a biased interpretation of the evidence.

Signed copies are retained by the SIGN Executive and a register of interests is available in the supporting material section for this guideline at **www.sign.ac.uk**

1.3.2 Patient version

Patient versions of this guideline are available from the SIGN website, **www.sign.ac.uk**

1.3.3 Prescribing of licensed medicines outwith their marketing authorisation

Recommendations within this guideline are based on the best clinical evidence. Some recommendations may be for medicines prescribed outwith the marketing authorisation (MA) also known as product licence. This is known as 'off label' use.

Medicines may be prescribed off label in the following circumstances:

- for an indication not specified within the marketing authorisation
- for administration via a different route
- for administration of a different dose
- for a different patient population.

An unlicensed medicine is a medicine which does not have MA for medicinal use in humans.

Generally 'off label' prescribing of medicines becomes necessary if the clinical need cannot be met by licensed medicines within the marketing authorisation. Such use should be supported by appropriate evidence and experience.[4]

"Prescribing medicines outside the conditions of their marketing authorisation alters (and probably increases) the prescribers' professional responsibility and potential liability."[4]

The General Medical Council (GMC) recommends that when prescribing a medicine 'off label', doctors should:

- be satisfied that there is no suitably licensed medicine that will meet the patient's need
- be satisfied that there is sufficient evidence or experience of using the medicine to show its safety and efficacy
- take responsibility for prescribing the medicine and for overseeing the patient's care, including monitoring the effects of the medicine and any follow-up treatment, or ensure that arrangements are made for another suitable doctor to do so
- make a clear, accurate and legible record of all medicines prescribed and, when not following common practice, the reasons for prescribing an unlicensed medicine.

Non-medical prescribers should ensure that they are familiar with the legislative framework and their own professional prescribing standards.

Prior to any prescribing, the licensing status of a medication should be checked in the summary of product characteristics (www.medicines.org.uk). The prescriber must be competent, operate within the professional code of ethics of their statutory bodies and the prescribing practices of their employers.[5]

1.3.4 Additional advice on the use of new and existing medicines and treatments

The National Institute for Health and Care Excellence (NICE) develops technology appraisals that make recommendations on the use of new and existing medicines and treatments within the NHS in England and Wales.

The Scottish Medicines Consortium (SMC) provides advice to NHS boards and their Area Drug and Therapeutics Committees about the status of all newly-licensed medicines, all new formulations of existing medicines and new indications for established products, within NHSScotland.

Practitioners should be aware of this additional advice on medicines and treatments recommended in this guideline and that recommendations made by these organisations and restrictions on their use may differ between England and Wales and Scotland.

2 Key recommendations

Prior to publication the guideline development group selected the key clinical recommendations that should be prioritised for implementation. The grade of recommendation relates to the strength of the supporting evidence on which the recommendation is based. It does not reflect the clinical importance of the recommendation.

Recommendations that have been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) have been removed.

2.4 Non-pharmacological management

A **Breathing exercise programmes** (including face-to-face physiotherapist-taught methods and audiovisual programmes) **can be offered to adults with asthma as an adjuvant to pharmacological treatment to improve quality of life and reduce symptoms.**

2.7 Acute asthma

2.7.1 Adults

D **Refer to hospital any patients with features of acute severe or life-threatening asthma.**

C **Give controlled supplementary oxygen to all hypoxaemic patients with acute severe asthma titrated to maintain an SpO_2 level of 94–98%. Do not delay oxygen administration in the absence of pulse oximetry but commence monitoring of SaO_2 as soon as it becomes available.**

A **Use high-dose inhaled β_2 agonists as first-line agents in patients with acute asthma and administer as early as possible. Reserve intravenous β_2 agonists for those patients in whom inhaled therapy cannot be used reliably.**

A **Give steroids in adequate doses to all patients with an acute asthma attack.**

2.7.2 Children

✓ Children with life-threatening asthma or SpO_2 <94% should receive high-flow oxygen via a tight-fitting face mask or nasal cannula at sufficient flow rates to achieve normal saturations of 94–98%.

A **Inhaled β_2 agonists are the first-line treatment for acute asthma in children.**

A **Give oral steroids early in the treatment of acute asthma attacks in children.**

2.7.3 All patients

✓ It is essential that the patient's primary care practice is informed within 24 hours of discharge from the emergency department or hospital following an asthma attack. Ideally this communication should be directly with a named individual responsible for asthma care within the practice.

2.8 Difficult asthma

D

Patients with difficult asthma should be systematically evaluated, including:

- **confirmation of the diagnosis of asthma, and**
- **identification of the mechanism of persisting symptoms and assessment of adherence to therapy.**

2.10 Occupational asthma

B

In patients with adult onset, or reappearance of childhood asthma, healthcare professionals should consider that there may be an occupational cause.

✓

Adults with suspected asthma or unexplained airflow obstruction should be asked:

- Are you the same, better, or worse on days away from work?
- Are you the same, better, or worse on holiday?

Those with positive answers should be investigated for occupational asthma.

3 Diagnosis

The diagnosis of asthma is a clinical one. The absence of consistent gold-standard diagnostic criteria means that it is not possible to make unequivocal evidence-based recommendations on how to make a diagnosis of asthma.

3.1 Definition and overarching principles

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

3.2 Predictive value of individual symptoms, signs and diagnostic tests

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

3.3 Practical approach to diagnosis

The majority of this section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

3.3.3 Low probability of asthma based on initial structured clinical assessment

Adults and children who do not have any of the typical features on initial structured clinical assessment or who have symptoms suggestive of an alternative diagnosis *(see Tables 4 and 5)* have a low probability of asthma.

Table 4: Clinical clues to alternative diagnoses in wheezy children

Clinical clue	Possible diagnosis
Perinatal and family history	
Symptoms present from birth or perinatal lung problem	Cystic fibrosis; chronic lung disease of prematurity; ciliary dyskinesia; developmental lung anomaly
Family history of unusual chest disease	Cystic fibrosis; neuromuscular disorder
Severe upper respiratory tract disease	Defect of host defence; ciliary dyskinesia
Symptoms and signs	
Persistent moist cough[78]	Cystic fibrosis; bronchiectasis; protracted bacterial bronchitis; recurrent aspiration; host defence disorder; ciliary dyskinesia
Excessive vomiting	Gastro-oesophageal reflux (with or without aspiration)
Paroxysmal coughing bouts leading to vomiting	Pertussis
Dysphagia	Swallowing problems (with or without aspiration)
Breathlessness with light-headedness and peripheral tingling	Dysfunctional breathing, panic attacks
Inspiratory stridor	Tracheal or laryngeal disorder
Abnormal voice or cry	Laryngeal problem
Focal signs in chest	Developmental anomaly; post-infective syndrome; bronchiectasis; tuberculosis
Finger clubbing	Cystic fibrosis; bronchiectasis
Failure to thrive	Cystic fibrosis; host defence disorder; gastro-oesophageal reflux
Investigations	
Focal or persistent radiological changes	Developmental lung anomaly; cystic fibrosis; postinfective disorder; recurrent aspiration; inhaled foreign body; bronchiectasis; tuberculosis

Table 5: Clinical clues to alternative diagnoses in adults

Clinical clue	Possible diagnosis
Without airflow obstruction	
Predominant cough without lung function abnormalities	Chronic cough syndromes; pertussis
Prominent dizziness, light-headedness, peripheral tingling	Dysfunctional breathing
Recurrent severe 'asthma attacks' without objective confirmatory evidence	Vocal cord dysfunction
Predominant nasal symptoms without lung function abnormalities	Rhinitis
Postural and food-related symptoms, predominant cough	Gastro-oesophageal reflux
Orthopnoea, paroxysmal nocturnal dyspnoea, peripheral oedema, pre-existing cardiac disease	Cardiac failure
Crackles on auscultation	Pulmonary fibrosis
With airflow obstruction	
Significant smoking history (ie, >20 pack-years), age of onset >35 years	COPD
Chronic productive cough in the absence of wheeze or breathlessness	Bronchiectasis*; inhaled foreign body*; obliterative bronchiolitis; large airway stenosis
New onset in smoker, systemic symptoms, weight loss, haemoptysis	Lung cancer*; sarcoidosis*

* may also be associated with non-obstructive spirometry

3.4 Organisation of diagnostic services

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

3.5 Wheezing in preschool children and the future risk of developing persistent asthma

Several factors are associated with a risk of developing persisting wheezing or asthma through childhood.[76, 85] The presence of these factors increases the probability that a child with respiratory symptoms will have asthma.

These factors include:

Age at presentation

The natural history of wheeze is dependent on age at first presentation. In general, the earlier the onset of wheeze, the better the prognosis. Cohort studies show a break point at around two years; most children who present before this age become asymptomatic by mid-childhood.[86-89] Coexistent atopy is a risk factor for persistence of wheeze independent of age of presentation.	2^{++}

Sex

Male sex is a risk factor for asthma in prepubertal children. Female sex is a risk factor for the persistence of asthma in the transition from childhood to adulthood.[90, 91] Boys with asthma are more likely to grow out of their asthma during adolescence than girls.[62, 86, 90, 92-105]

Severity and frequency of previous wheezing episodes

Frequent or severe episodes of wheezing in childhood are associated with recurrent wheeze that persists into adolescence.[74, 77, 86, 88, 94, 106-108]	2^{++}

Coexistence of atopic disease

A history of other atopic conditions such as eczema and rhinitis increases the probability of asthma. Positive tests for atopy in a wheezing child also increase the likelihood of asthma. A raised specific IgE to wheat, egg white, or inhalant allergens such as house dust mite and cat dander, predicts later childhood asthma.[109, 110] Other markers of allergic disease at presentation, such as positive skin-prick tests and a raised blood eosinophil count, are related to the severity of current asthma and persistence through childhood.	2^{++}

Family history of atopy

A family history of atopy is the most clearly defined risk factor for atopy and asthma in children. The strongest association is with maternal atopy, which is an important risk factor for the childhood onset of asthma and for recurrent wheezing that persists throughout childhood.[87, 102, 105, 111, 112]	2^{++}

Abnormal lung function

Persistent reductions in baseline airway function and increased airway responsiveness during childhood are associated with having asthma in adult life.[91]	3

4 Monitoring asthma

Regular review of people with asthma offers the opportunity to monitor current symptom control and the impact asthma is having on daily activities and quality of life, to assess future risk of asthma attacks, and to link these to management options.

Asthma is best monitored by routine clinical review on at least an annual basis by a healthcare professional with appropriate training in asthma management. The review can be undertaken in primary and/or secondary care according to clinical need and local service arrangements *(see section 14.3)*.

4.1 Targeting care

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

4.2 Monitoring current asthma symptom control

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

4.3 Predicting future risk of asthma attacks

Identifying future risk of asthma attacks is an important component in the delivery of personalised asthma care.[126]

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

4.3.4 People with severe asthma

In children and adults with severe asthma (defined as more than two asthma attacks a year or persistent symptoms with SABA use more than twice a week despite specialist-level therapy; see section 7.5), evidence from observational studies shows that a history of asthma attacks, current level of symptom control and lung function provide valuable knowledge to evaluate risk of future asthma attacks. These patients will usually be under the care of a specialist asthma clinic. Predictors of future attacks were:

- previous asthma attack[128, 129, 133, 142]
- very poor symptom control in adults[128, 133, 140, 142, 155]
- greater SABA use[140, 142]
- lower lung function (PEF or FEV1 in adults; PEF or FEV1/FVC ratio in children)[133, 142]
- raised FeNO.[129]

3

>12 yrs	5-12 yrs	<5 yrs	
D	D	■	**In individuals with severe asthma, assess risk of future asthma attacks at each visit by asking structured questions about asthma control, reviewing history of previous attacks and measuring lung function.**

4.4 Physiological measures

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

4.5 Other approaches

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

5 Supported self management

5.1 Effectiveness of supported self management

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

5.2 Components of a self-management programme

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

5.2.1 Patient education

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

5.2.2 Personalised asthma action plans

Written PAAPs (for example, those for adults and children from Asthma UK, available at www.asthma.org.uk/advice/manage-your-asthma/action-plans*)* are crucial components of effective self-management education.[91, 166, 168, 178-180, 187] One systematic review identified the features of PAAPs associated with beneficial outcomes.[168]

These include:

- specific advice about recognising loss of asthma control, assessed by symptoms or peak flows or both.[91, 168, 169] In children, symptom-based written plans are effective in reducing emergency consultations for asthma, although (in older children) plans based on peak flow may be as effective for other outcomes.[178, 179] 1++ 1+
- actions, summarised as two or three action points, to take if asthma deteriorates, including seeking emergency help, starting oral steroids (which may include provision of an emergency course of steroid tablets).*[168]*

Recommendations and the Good Practice Point in this sub-section have been revised in the Asthma pathway (SIGN 244).

The role of telehealthcare interventions in supporting self management is covered in section 14.4.

5.3 Self management in specific patient groups

5.3.1 Primary care

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

5.3.2 Secondary care

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

5.3.3 Schoolchildren

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

5.3.4 Preschool children

There is a paucity of evidence about effective self-management strategies delivered to parents of preschool children. Trials recruiting only preschool children (aged five years or under) showed no impact on emergency use of healthcare resources, including ED visits, hospital admissions and unscheduled consultations,[190, 195] and no[190] or limited[195] reduction in symptoms, despite increased ownership of PAAPs.[195]

1-

Other trials including preschool children and children up to the age of eight years showed only small and often transient effects of no apparent clinical significance.[188, 189, 192-194]

5.3.5 Ethnic minority groups

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

5.4 Adherence and concordance

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

5.5 Implementation in practice

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

6 Non-pharmacological management

There is a common perception amongst patients and carers that there are numerous environmental, dietary and other triggers of asthma and that avoiding these triggers will improve asthma and reduce the requirement for pharmacotherapy. Failure to address a patient, parent or carer's concern about environmental triggers may compromise concordance with recommended pharmacotherapy. Evidence that non-pharmacological management is effective can be difficult to obtain and more well-controlled intervention studies are required.

This section distinguishes prevention activities as follows:

- primary prevention - interventions introduced before the onset of disease and designed to reduce its incidence.
- secondary prevention – interventions introduced after the onset of disease to reduce its impact.

6.1 Primary prevention

The evidence for primary interventional strategies is based predominantly on observational studies, although some interventions have been tested using experimental methods. Many are multifaceted and it can be difficult to disentangle the effects of one exposure or intervention from another.

6.1.1 Mono- and multifaceted allergen avoidance

Early life exposure to allergens (including aeroallergens and ingested food allergens) may lead to allergic sensitisation and so potentially increase the risk of subsequent asthma, particularly in children at high risk (that is, children with a family history of asthma or atopy, particularly a parental history). It is unclear whether the risk of developing asthma in children is reduced by interventions to reduce exposure to single allergens (monofaceted), or whether multifaceted interventions targeting the reduction of more than one type of allergen exposure simultaneously will lead to a better outcome or be more effective.

A Cochrane review of trials comparing single (six studies) or multiple (three studies) interventions with a no-intervention control, reported that in children who are at risk of developing childhood asthma there may be a role for multifaceted interventions which involve both dietary allergen reduction and environmental change to reduce exposure to inhaled allergens. Such interventions reduced the odds of a doctor diagnosing asthma later in childhood by half in those over five years of age, odds ratio (OR) 0.52, 95% CI 0.32 to 0.85).[279] However, the effect of these multifaceted interventions on wheeze reported by parents was inconsistent and there was no beneficial effect on night-time coughing or breathlessness. These interventions can be costly, demanding and inconvenient to families, and the cost effectiveness is not established. Healthcare professionals can discuss and support this intervention in families who are motivated to follow the demanding programme. 1++

In children at risk of developing asthma, there is no evidence that reducing in utero or early life exposure to single allergens (either to aeroallergens such as house dust mites or pets, or food allergens) is effective in reducing asthma and single (monofaceted) interventions were not significantly more effective than controls in the reduction of any outcomes.[280]

A **Measures to reduce in utero or early life exposure to single aeroallergens, such as house dust mites or pets, or single food allergens, are not recommended for the primary prevention of asthma.**

A **For children at risk of developing asthma, complex, multifaceted interventions targeting multiple allergens may be considered in families able to meet the costs, demands and inconvenience of such a demanding programme.**

6.1.2 Aeroallergen avoidance

House dust mites

Exposure to high levels of house dust mite allergen in early life is associated with an increased likelihood of sensitisation to house dust mite by three to seven years of age.[281] Sensitisation to house dust mite is an important risk factor for the development of asthma,[282, 283] and a few studies have suggested that exposure to high levels of house dust mites early in life increases the risks of subsequent asthma.[284, 285] A UK study showed that low levels of house dust mite and cat allergen exposures in early life increased the risk of IgE sensitisation and asthma at five years, with some attenuation at high levels of exposure, but there were significant associations with family history and birth order.[286]

Outcomes from intervention studies attempting to reduce exposure to house dust mites are inconsistent. A multifaceted Canadian intervention study showed a reduced prevalence of doctor-diagnosed asthma but no impact on other allergic diseases, positive skin-prick tests or bronchial hyper-responsiveness;[287] others have shown no effect on either allergic sensitisation or symptoms of allergic diseases.[288] In one UK study, early results from environmental manipulation started in early pregnancy and focused mainly on house dust mite avoidance, showed reductions in some respiratory symptoms in the first year of life.[289] Subsequent results showed a paradoxical effect with increased allergy but better lung function in the intervention group.[290] 1+

The considerable variation in the methodology used in these studies precludes the pooling of data or meta-analyses.

A **Healthcare professionals should not recommend house dust mite aeroallergen avoidance for the primary prevention of asthma.**

Pets in the home

A large number of birth cohort studies, longitudinal cohort studies and cross-sectional studies have addressed whether exposure to pets in the home in early life increases or reduces the subsequent risk of asthma and allergy, with contradictory results. Four recent systematic reviews, synthesising evidence from overlapping data sources, have provided conflicting results. One review concluded that exposure to cats in early life has a slight preventative effect on subsequent asthma, while exposure to dogs increases risk.[291] Another concluded, in contrast, that perinatal dog exposure protects against asthma, with no effect from cats.[292] Methodological factors, however, such as avoidance behaviour in at-risk families and other potential confounders, may have affected the analyses. Two further reviews concluded that exposure to cats and/or dogs in early childhood did not impact on asthma or wheeze in school-aged children.[293, 294] The most methodologically sound review pooled individual participant data from 11 European birth cohort studies and so was able to harmonise exposure, outcome and age-group definitions and use individual data rather than pooled risk estimates in heterogeneous groups, to minimise potential confounding.[294] This review concluded that exposure to cats and/or dogs in infancy does not impact on a diagnosis of asthma or on wheezing symptoms in later life, although may influence allergic sensitisation, and that parents should not make choices on pet ownership based on the desire to prevent or reduce asthma symptoms. Several of the studies and reviews reported reduced allergic sensitisation in those with early exposure to pets, but the clinical significance of this is uncertain. 2^{++} 2^{+} 2^{-}

B **Healthcare professionals should not offer advice on pet ownership as a strategy for preventing childhood asthma.**

6.1.3 Food allergen avoidance

Sensitisation to foods, particularly eggs, frequently precedes the development of aeroallergy and subsequent asthma.[295] Food allergen avoidance in pregnancy and postnatally has not been shown to prevent the later development of asthma.[296] Allergen avoidance during 1^{+}

pregnancy may adversely affect maternal, and perhaps fetal, nutrition.[297] High-dose food allergen exposure during pregnancy may reduce subsequent sensitisation rates by inducing tolerance.[298]

B **In the absence of any evidence of benefit and given the potential for adverse effects, maternal food allergen avoidance during pregnancy and lactation is not recommended as a strategy for preventing childhood asthma.**

6.1.4 Breastfeeding

A systematic review of observational studies on the allergy preventive effects of breastfeeding indicates that it is effective for all infants irrespective of family history of allergy. The preventive effect is more pronounced in infants at high risk provided they are breastfed for at least four months.[299] However, not all studies have demonstrated benefit and a large birth cohort study reported no protective effect against atopy and asthma.[300] 2+

Observational studies have the potential to be confounded by, for example higher rates of breastfeeding in atopic families, and taking this into account, the weight of evidence is in favour of breastfeeding as a preventive strategy.

C **Breastfeeding should be encouraged for its many benefits, including a potential protective effect in relation to early asthma.**

6.1.5 Modified infant milk formulae

Trials of modified milk formulae have not included sufficiently long follow up to establish whether there is any impact on asthma. A Cochrane review identified inconsistencies in findings and methodological concerns amongst studies, which mean that hydrolysed formulae cannot currently be recommended as part of an asthma prevention strategy.[301] A review of the use of soy formulae found no significant effect on asthma or any other allergic disease.[302] 1+

In the absence of any evidence of benefit from the use of modified infant milk formulae it is not possible to recommend it as a strategy for preventing childhood asthma.

6.1.6 Weaning

There are conflicting data on the association between early introduction of allergenic foods into the infant diet and the subsequent development of allergy and atopic eczema. No evidence was identified in relation to asthma.[303] In one study late introduction of egg was associated with a non-significant increase in wheezing in preschool children.[304]

In the absence of evidence on outcomes in relation to asthma no recommendations on modified weaning can be made.

6.1.7 Nutritional supplementation

Fish Oils

Fish oils have a high level of omega-3 polyunsaturated fatty acids (n-3PUFAs). Western diets have a low intake of n-3PUFAs with a corresponding increase in intake of n-6PUFAs. This change has been associated with increasing rates of allergic disease and asthma.[303] Two RCTs have investigated early-life fish oil dietary supplementation in relation to asthma outcomes in children at high risk of atopic disease (at least one parent or sibling had atopy with or without asthma). In a study, powered only to detect differences in cord blood, maternal dietary fish oil supplementation during pregnancy was associated with reduced cytokine release from allergen-stimulated cord blood mononuclear cells. However, effects on clinical outcomes at one year, in relation to atopic eczema, wheeze and cough, were marginal.[305] In a second study, fish oil supplementation started in early infancy with or without additional house dust mite avoidance was associated with a significant reduction in wheeze at 18 1+

months of age. By five years of age fish oil supplementation was not associated with effects on asthma or other atopic diseases.[306]

In the absence of any evidence of benefit from the use of fish oil supplementation in pregnancy it is not possible to recommend it as a strategy for preventing childhood asthma.

Other nutrients

A number of observational studies have suggested an increased risk of subsequent asthma following reduced (maternal) intakes of selenium (based on umbilical cord levels),[307] or vitamin E based on maternal pregnancy intake.[308] No intervention studies in relation to selenium or vitamin E have yet been conducted and overall there is insufficient evidence to make any recommendations on maternal dietary supplementation as an asthma prevention strategy.[303] Observational studies suggest that intervention trials are warranted.

6.1.8 Weight reduction in overweight and obese patients

There is consistent evidence that being overweight or obese increases the risk of a subsequent physician diagnosis of asthma by up to 50% in children and adults of both sexes.[309, 310] A high birth weight is also associated with a higher risk of asthma.[309] The quality of the evidence is, however, low as there was no adjustment for confounders. In addition, since obesity can have direct effects on respiratory symptoms and on lung mechanics, the mechanism of this relationship is unclear. 2⁻

Two systematic reviews looking at the association between being overweight or obese in childhood and the development of asthma concluded that high body mass index (BMI) increases the risk of incident asthma, with a dose-dependent relationship that was stronger in boys.[311, 312] These reviews are, however, based on epidemiological studies and cannot confirm a causal link. 2⁺

A systematic review of the association between maternal obesity and gestational weight gain in pregnancy, and childhood asthma, concluded that maternal obesity was associated with an increased risk of diagnosed asthma and of ever-wheeze in children from these pregnancies, with each 1 kg/m^2 increase in maternal BMI associated with a 2–3% increase in odds of childhood asthma. High gestational weight gain was associated with higher odds of asthma or ever-wheeze in children (OR 1.16).[313] Prospective studies of weight-loss programmes during pregnancy for obese women and those with high gestational weight gain are needed to clarify the role of this intervention in the prevention of asthma in children resulting from these pregnancies. 2⁺

C **Weight reduction is recommended in obese patients to promote general health and to reduce subsequent respiratory symptoms consistent with asthma.**

C **Obese and overweight children should be offered weight-loss programmes to reduce the likelihood of respiratory symptoms suggestive of asthma.**

6.1.9 Microbial exposure

The 'hygiene hypothesis' suggested that early exposure to microbial products would switch off allergic responses thereby preventing allergic diseases such as asthma. The hypothesis is supported by some epidemiological studies comparing large populations who have or have not had such exposure.[314, 315]

The concept is sometimes described as the 'microbial exposure hypothesis'. A double-blinded placebo-controlled trial of the probiotic *Lactobacillus rhamnosus GG* given to mothers resulted in a reduced incidence of atopic eczema in their children but had no effect on IgE antibody or allergic skin test responses. The small sample size and short follow up in this study limit its interpretation.[316] There remains insufficient understanding of the ecology of gut flora in infancy in relation to outcomes. Bifidobacteria may be more important than lactobacilli in reducing susceptibility to allergic disease.[317]

There is insufficient evidence to indicate that the use of dietary probiotics in pregnancy reduces the incidence of childhood asthma.

6.1.10 Avoidance of tobacco smoke and other air pollutants

No evidence was identified to support a link between exposure to environmental tobacco smoke (ETS) or other air pollutants and the induction of allergy.

There is an increased risk of infant wheezing associated with maternal smoking during pregnancy which adversely affects infant lung function.[318-321] Evidence suggests that early life ETS exposure is associated with later persistent asthma,[322, 323] with a strong interaction with genetic polymorphisms which affect antioxidant activity.[324] 2+

B **Current and prospective parents should be advised of the many adverse effects which smoking has on their children including increased wheezing in infancy and increased risk of persistent asthma.**

The limited data on antenatal or early-life exposure to other pollutants suggest similar effects to those for ETS, namely increased infant wheezing, enhanced by additional ETS exposure and antioxidant gene variations.[325-327] There is one small study suggesting that vitamin C supplementation will modify the combined effects of genetic polymorphisms and pollution on lung function in children with asthma.[328] Further research is required before recommendations for practice can be made. 3 4

6.1.11 Immunisation

In keeping with the microbial exposure hypothesis some studies have suggested an association between tuberculin responsiveness and subsequent reduced prevalence of allergy, implying a protective effect of Bacillus Calmette-Guérin (BCG). At present, it is not possible to determine whether poor tuberculin responsiveness represents an underlying defect which increases the risk of allergy and asthma or whether the immunisation itself has a protective effect.[329] 2+

Investigation of the effects of other childhood immunisation suggests that at worst there is no influence on subsequent allergic disease and may be some protective effect against the development of asthma.[330]

C **All childhood immunisations should proceed normally as there is no evidence of an adverse effect on the incidence of asthma.**

6.2 Secondary prevention

6.2.1 House dust mite avoidance

Allergic sensitisation to house dust mite-associated aeroallergens is common in people with asthma and exposure to house dust can act as a trigger in sensitised asthmatic individuals. Physical (for example mattress covers, vacuum cleaning, heating, ventilation, freezing, washing, air filtration and ionisers) and chemical (acaricides) measures to reduce house dust mite (HDM) aeroallergen levels and so reduce exposure have been advocated but there has been uncertainty as to whether the currently available physical and chemical measures, alone or in conjunction, can reduce the exposure levels sufficiently to allow a clinically relevant effect to be apparent.

A systematic review of 72 studies (64 RCTs and eight non-RCTs) including 37 studies evaluating single interventions (seven acaricides, nine air purification, one high-efficiency particulate air-filtration, 17 mattress covers, two pest-control measures, one pet removal) and 30 studies evaluating multicomponent strategies. The included studies enrolled adults, children or mixed populations. Taking a narrative approach, the review concluded that single component interventions are not effective at improving asthma control or reducing asthma attacks despite HDM levels being significantly reduced in many studies. Multicomponent 1+

interventions were found to have some clinical effects. However, the heterogeneity of interventions, how studies were combined and the small number of studies precluded definitive conclusions.[331] There is, therefore, continuing clinical uncertainty about which HDM avoidance measures may be clinically effective in asthma and further research is required.

B **Physical and chemical methods of reducing house dust mite levels in the home (including acaricides, mattress covers, vacuum cleaning, heating, ventilation, freezing, washing, air filtration and ionisers) should not be routinely recommended by healthcare professionals for the management of asthma.**

6.2.2 Other allergens

Animal allergens, particularly from cats and dogs, are potent provokers of asthma symptoms. The reported effects of removal of pets from homes are paradoxical, with either no benefit for asthma[332, 333] or a potential for continued high exposure to induce a degree of tolerance.[334] In homes where there is no cat but still detectable cat allergen, there may be a benefit from introducing additional avoidance measures such as high-efficiency vacuum cleaners for patients allergic to cats, although there is insufficient evidence on which to base a recommendation.[331]

Although fungal exposure has been strongly associated with hospitalisation and increased mortality in asthma, no controlled trials have addressed the efficacy of reducing fungal exposure in relation to control of asthma. Cockroach allergy is not a common problem in the UK and studies of attempts to avoid this allergen elsewhere have produced conflicting results.[331]

Studies of individual aeroallergen avoidance strategies show that single interventions have limited or no benefit.[331] A multifaceted approach is more likely to be effective if it addresses all the indoor asthma triggers but there remains considerable uncertainty about which, if any, are the most effective strategies.[331] A strategy with a potential impact on mites, mould allergens and indoor pollutants is the use of a mechanical ventilation system to reduce humidity and increase indoor air exchange. A systematic review of this topic concluded that more research is required to determine whether this approach is effective.[335]

6.2.3 Smoking

Direct or passive exposure to cigarette smoke adversely affects quality of life, lung function, need for rescue medications for acute episodes of asthma and long-term control with ICS.[336-339]

In children with asthma, exposure to environmental tobacco smoke is associated with worsening asthma symptoms.[340] Smoking cessation interventions aimed at families and carers have been shown to reduce childhood respiratory symptoms including those associated with asthma.[341] One study in adults with asthma suggested that smoking cessation improved asthma specific quality of life, symptoms and drug requirements.[342] 1++ 2+

Uptake of smoking in teenagers increases the risks of persisting asthma. One study showed a doubling of risk for the development of asthma over six years in children aged 14 who started to smoke *(see section 7.2.6 for the effect of smoking on treatment)*.[343]

B **People with asthma and parents/carers of children with asthma should be advised about the dangers of smoking and second-hand tobacco smoke exposure, and should be offered appropriate support to stop smoking.**

6.2.4 Air pollution

Challenge studies demonstrate that various pollutants can enhance the response to allergen inhalation in patients with asthma.[344, 345] Time-series and other observational studies suggest that air pollution may provoke acute asthma attacks or aggravate existing chronic asthma although the effects are very much less than in those with infection or allergen exposure.[346,

[347] Increased asthma symptoms in young children (mean age ≤9) have been linked, in observational studies, to exposure to air pollutants, including particulates, nitrogen dioxide, sulphur dioxide and ozone.[340] Much less attention has been focused on indoor pollutants in relation to asthma and more work is required.[348, 349]

Information on current levels of air pollution, recommended actions and health advice is available from The Daily Air Quality Index (available at www.uk-air.defra.gov.uk/).

6.2.5 Electrolytes

Increasing dietary sodium has been implicated in the geographical variations in asthma mortality and high sodium intake is associated with increased bronchial hyper-responsiveness.[350-352] A systematic review of intervention studies reducing salt intake identified only minimal effects and concluded that dietary salt reduction could not be recommended in the management of asthma.[353] Low magnesium intake has been associated with a higher prevalence of asthma with increasing intake resulting in reduced bronchial hyper-responsiveness and higher lung function.[354] Magnesium plays a beneficial role in the treatment of asthma through bronchial smooth muscle relaxation, leading to the use of intravenous or inhaled preparations of magnesium sulphate for acute asthma attacks.[355] Studies of oral supplementation are limited and more trials are required.[356-358]

6.2.6 Fish oils/Lipids

In vitro studies suggest that supplementing the diet with n-3PUFAs, which are most commonly found in fish oils, might reduce the inflammation associated with asthma.[359, 360] Results from observational studies are inconsistent and a Cochrane review of nine RCTs concluded that there was insufficient evidence to recommend fish oil supplementation for the treatment of asthma.[361]

6.2.7 Antioxidants

Observational studies have reported that low intakes of vitamin C, vitamin E and selenium are associated with a higher prevalence of asthma.[303] Intervention studies suggest that neither supplementation with vitamin C, vitamin E nor selenium is associated with clinical benefits in people with asthma.[362-364] Observational studies in both adults and children have also consistently shown that a high intake of fresh fruit and vegetable is associated with less asthma and better pulmonary function.[365-371] No intervention studies evaluating the intake of fruit or vegetables and their effects on asthma have been reported.

6.2.8 Vitamin D

A systematic review of nine RCTs (adults, n=658, children, n=435) examined whether administration of vitamin D reduced severe asthma exacerbations (defined as those requiring oral corticosteroids) or improved asthma symptom control. In three of the nine included trials (n=680/1093), of predominantly adults with mild to moderate asthma on treatment with ICS, vitamin D reduced the risk of severe asthma exacerbation. The number of exacerbations in children was too low to evaluate this outcome.[372]

A further subgroup analysis reported that it was not clear whether the reduction in risk of exacerbation was confined to people with lower baseline vitamin D status. Vitamin D dosage regimes varied between trials and no evidence was provided about the optimum dose of vitamin D or circulating 25-hydroxyvitamin D concentrations. Serious adverse effects did not vary between those receiving vitamin D or placebo.[373] 1++

Further research is required on whether the effects of vitamin D supplementation are confined to people with lower baseline vitamin D status, and into the effects in children, and in people with frequent severe asthma attacks.

6.2.9 Weight reduction in overweight and obese patients with asthma

The current evidence base for weight reduction interventions to improve asthma control is inadequate in quantity and quality. A Cochrane review concluded that as the benefit of weight 1++

loss as an intervention for asthma control is uncertain, "...clinicians should be prepared to help patients to make a decision that is consistent with their own values...".[374]

Two RCTs in adults and one pilot RCT in children investigating the effects of interventions to reduce weight on asthma control and biomarkers of asthma severity, reported reductions in BMI but varying effects on asthma control and biomarkers.[375-377] The pilot study in children (n=32) reported that a 10-week dietary intervention improved asthma control and lung function but had no effect on inflammation. This study was not, however, powered to determine clinical changes; baseline differences between control and intervention groups and in interactions with healthcare staff may have influenced the results.[375] In adults, a trial (n=46) combining dietary (including two free meal replacements a day) and exercise (free gym membership and personal training sessions) components reported improved lung function, asthma symptoms and biomarkers of neutrophilic inflammation with a 5–10% weight loss.[377] A larger trial (n=330), however, reported no significant differences in asthma outcomes between obese adults with asthma receiving a weight-loss intervention (combining dietary and exercise components) and those in the control group. Weight loss of more than 10% in either group was, however, associated with improvements in asthma symptom control compared with those with unchanged weight.[376] 1+

Although evidence is limited, these studies show that dietary and weight-loss interventions are feasible in overweight or obese adults and children with asthma and that they may improve asthma control, lung function and inflammation, although weight loss of greater than 10% may be necessary to achieve benefit.

B **Weight-loss interventions (including dietary and exercise-based programmes) should be considered for overweight and obese adults and children with asthma to improve asthma control.**

6.2.10 Probiotics

Studies have suggested that an imbalance in gut flora is associated with a higher risk of development of allergy.[378] Trials have investigated the use of probiotics in the treatment of established allergic disease with variable results.[379, 380] Only one study focused on asthma, finding a decrease in eosinophilia but no effect on clinical parameters.[381] 1+ 2+

In the absence of evidence of benefit, it is not possible to recommend the use of probiotics in the management of asthma.

6.2.11 Immunisation

A number of large studies have concluded that high vaccination coverage has no significant impact on any allergic outcome or asthma. There is a suggestion that the higher the vaccine coverage the greater the possibility that there is a degree of protection against the development of allergy in the first years of life.[382-385]

There is some discussion about whether BCG immunisation may confer protection against allergy and asthma. Research has focused on primary prophylaxis *(see section 6.1.11)*, although there are some studies investigating the use of BCG, with or without allergen, as a means to switch off allergic immune responses. There are some observations suggesting that benefit might occur,[386] but results of trials have been disappointing.[387, 388] This is an area that requires further investigation.

There has been concern that influenza vaccination might aggravate respiratory symptoms, although any such effect would be outweighed by the benefits of the vaccination.[389] Studies in children have suggested that immunisation with the vaccine does not exacerbate asthma,[390] but has a small beneficial effect on quality of life in children with asthma.[391] The immune response to the immunisation may be adversely affected by high-dose ICS therapy and this requires further investigation.[392] A Cochrane review of pneumococcal vaccine found very limited evidence to support its use specifically in individuals with asthma.[393] 1++

B	**Immunisations should be administered independent of any considerations related to asthma. Responses to vaccines may be attenuated by high-dose inhaled corticosteroids.**

6.2.12 Acupuncture

A Cochrane review of 21 trials highlighted many methodological problems with the studies reviewed. Only seven of the trials, involving 174 patients, employed randomisation to active or sham acupuncture points (with no recognised activity) for the treatment of persistent or chronic asthma. Blinding was a major problem in the assessment of the results and there were considerable inconsistencies in methodology. The review concluded that there was no evidence for a clinically valuable benefit from acupuncture and no significant benefits in relation to lung function.[394] A later systematic review and meta-analysis of 11 RCTs found no evidence of an effect in reducing asthma severity but a suggestion that where bronchoconstriction was induced to establish efficacy of acupuncture there was a beneficial effect. Concern was expressed about potential publication bias in favour of positive outcome studies.[395] Two other trials of acupuncture in relation to induced asthma were also negative.[396, 397] 1+

6.2.13 Air Ionisers

Ionisers have been widely promoted as being of benefit for patients with asthma. A Cochrane review of six studies, five using negative ion generators and one with a positive ion generator, found no evidence that air ionisers are of benefit in reducing symptoms in patients with asthma. One of the included studies in children (n=12, age range 3–11) showed that positively-ionised air was associated with bronchoconstriction, and another (n=20, age range 9–15) showed an increase in night-time cough, although this was not statistically significant.[398] 1++ 1+

A	**Air ionisers are not recommended for the treatment of asthma.**

6.2.14 Breathing Exercises

Behavioural programmes centred on breathing exercises and dysfunctional breathing reduction techniques (including physiotherapist-delivered breathing programmes such as the Papworth method, and the Buteyko method) can lead to modest improvements in asthma symptoms and quality of life, and reduce bronchodilator requirement in adults with asthma, although have little effect on lung function or airway inflammation.[399-402] These techniques involve instruction by a trained therapist in exercises to reduce respiratory rate, minute volume and to promote nasal, diaphragmatic breathing. Trials that include more than five hours of intervention appeared more likely to be effective than shorter courses.[400] They should ideally be provided as part of integrated medical care. 1++ 1+

A systematic review of inspiratory muscle training for adults with asthma (n=113), including five RCTs, reported that evidence for its use was inconclusive.[403] 1++

One high-quality RCT, including 655 adults with asthma and impaired asthma-related quality of life, demonstrated that breathing retraining can be successfully delivered as a self-guided audiovisual programme, leading to equivalent quality-of-life benefits, measured by the AQLQ, and likely greater cost effectiveness compared with a programme delivered face-to-face by a physiotherapist.[399] There were, however, clinically important improvements in AQLQ scores in a substantial proportion of the usual treatment group as well as in the two intervention groups. 1++

In a systematic review of yoga for asthma including 15 RCTs (13 in adults) and 1,048 participants (number of children not specified), meta-analysis of five of the eight studies that included quality of life as an outcome, suggested that yoga may improve quality of life,[404] although improvements were mostly observed in trials which did not include a sham or 1++

placebo intervention in the control arm. Furthermore, the yoga interventions studied included breathing, postures, and meditation, and results were not presented for the effects of breathing exercises alone. Although current evidence does not support yoga as a routine intervention for people with asthma, it could be considered as an additional therapy or as an alternative to other forms of breathing exercises.[405]

There is currently insufficient evidence on breathing exercises or yoga in children and adolescents aged 12 and under on which to base a recommendation.[404, 406]

A	**Breathing exercise programmes** (including face-to-face physiotherapist-taught methods and audiovisual programmes) **can be offered to adults with asthma as an adjuvant to pharmacological treatment to improve quality of life and reduce symptoms.**

6.2.15 Herbal and traditional Chinese medicine

A Cochrane review identified 17 trials, nine of which reported some improvement in lung function but it was not clear that the results would be generalisable.[407] A more recent double-blinded placebo-controlled trial of a Chinese herb decoction (Ding Chuan Tang) showed improvement in airway hyper-responsiveness in children with stable asthma.[408] It is difficult to disentangle the effects of multiple ingredients; Ding Chuan Tang for example contains nine components. In a second study, 100 children with asthma found that a five-herb mixture gave some benefits in relation to lung function and symptoms compared with placebo.[409] 1+

The conclusions of these trials of Chinese herbal therapy are not generalisable due to variations in the herbal mixtures and study designs. There are likely to be pharmacologically active ingredients in the mixtures and further investigations are warranted. There is a need for large appropriately powered controlled studies.

6.2.16 Homeopathy

A Cochrane review identified only three methodologically sound RCTs, two of which reported some positive effects. A criticism of the studies was that they did not employ individualised homeopathy, which is the essence of this approach to treatment.[410] A more recent trial of individualised homeopathy in childhood asthma, which was placebo controlled and appropriately powered, failed to show any evidence of benefit over conventional treatment in primary care.[411] 1++ 1+

6.2.17 Hypnosis and relaxation therapies

A systematic review of relaxation therapies, including hypnotherapy, identified five controlled trials, two of which showed some benefits. Overall the methodology of the studies was poor and the review concluded that there was a lack of evidence of efficacy but that muscle relaxation could conceivably benefit lung function in patients with asthma.[412] 1++

6.2.18 Manual therapy including massage and spinal manipulation

A Cochrane review identified four relevant RCTs.[413] The two trials of chiropractic suggest that there is no role for this modality of treatment in the management of asthma. No conclusions can be drawn on massage therapy.

6.2.19 Physical exercise training

A Cochrane review has shown no effect of physical training on PEF, FEV_1, FVC or ventilation at maximal exercise capacity (V_{Emax}).[414] However, oxygen consumption, maximum heart rate, and work capacity all increased significantly. Most studies discussed the potential problems of exercise-induced asthma, but none made any observations on this phenomenon. As physical training improves indices of cardiopulmonary efficiency, it should be seen as part of a general approach to improving lifestyle and rehabilitation in people with asthma, with appropriate precautions advised about exercise-induced asthma (*see section 7.7.2).*

6.2.20 Family therapy

A Cochrane review identified two trials (n=55) showing that family therapy may be a useful adjunct to medication in children with asthma.[415] Small study size limits the ability to form recommendations.

✓ For those with difficult asthma in childhood, there may be a role for family therapy as an adjunct to pharmacotherapy.

7 Pharmacological management

The aim of asthma management is control of the disease. Complete control of asthma is defined as:

- no daytime symptoms
- no night-time awakening due to asthma
- no need for rescue medication
- no asthma attacks
- no limitations on activity including exercise
- normal lung function
- minimal side effects from medication.

7.1 Intermittent reliever therapy

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

7.2 Regular preventer therapy

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

7.3 Initial add-on therapy

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

7.4 Additional controller therapies

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

7.5 Specialist therapies

In a small proportion of patients asthma is not adequately controlled on the recommended initial or additional controller therapies. There are very few clinical trials in this specific patient group to guide management. For this reason, these patients should be referred for specialist care.

The majority of this section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

7.5.2 Other approaches

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

7.5.3 Continuous or frequent use of oral steroids

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

The aim of treatment is to control asthma using the lowest possible doses of medication.

✓ For the small number of patients not controlled on high-dose therapies, use daily steroid tablets in the lowest dose providing adequate control.

✓ Patients requiring frequent or continuous use of oral corticosteroids should be under the care of a specialist asthma service.

Patients on long-term steroid tablets (for example, longer than three months) or requiring frequent courses of steroid tablets (for example three to four per year) will be at risk of systemic side effects.[449] To prevent and treat steroid tablet-induced side effects:

- blood pressure should be monitored
- urine or blood sugar and cholesterol should be checked: diabetes mellitus and hyperlipidaemia may occur
- bone mineral density should be monitored in adults. When a significant reduction occurs, treatment with a long-acting bisphosphonate should be offered. See also, SIGN 142 Management of osteoporosis and the prevention of fragility fractures.[487]
- bone mineral density should be monitored in children >5 [488]
- growth (height and weight centile) should be monitored in children
- cataracts and glaucoma may be screened for through community optometric services.

Prednisolone is the most widely used steroid for maintenance therapy in patients with chronic asthma. There is no evidence that other steroids offer an advantage.

Although popular in paediatric practice, there are no studies to show whether alternate day steroids produce fewer side effects than daily steroids. No evidence was identified to guide timing of dose or dose splitting.

7.5.4 Monoclonal antibody

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

7.5.5 Other agents

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

7.5.6 Immunotherapy for asthma

Studies using both subcutaneous and sublingual allergen immunotherapy (SCIT and SLIT) have shown some benefit in reducing asthma symptoms and bronchial hyper-reactivity (BHR) in children and adults currently on a range of other preventative strategies including ICS. There are, however, few studies comparing immunotherapy with ICS or of adding immunotherapy to ICS so there is difficulty precisely defining where in asthma management this approach should sit.

Subcutaneous immunotherapy

	> 12 years	5–12 years	<5 years
Trials of allergen-specific immunotherapy by subcutaneous injection of increasing doses of allergen extracts have consistently demonstrated beneficial effects compared with placebo in the management of allergic asthma. Allergens included house dust mite, grass pollen, tree pollen, cat and dog allergen and moulds. Cochrane reviews have concluded that immunotherapy reduces asthma symptoms, the use of asthma medications and improves BHR; the most recent of these included 42 trials with house dust mite, 27 with pollen, 10 with animal allergens, two with *Cladosporium* mould, two with latex and six with multiple allergens.[502]	1++		
The effect of immunotherapy is difficult to quantify due to the use of different symptom scores and variation in the way outcomes are reported. Reductions in asthma medication use and a small symptomatic benefit have been reported but there are significant side effects including 1 in 16 patients reporting a local adverse reaction and 11% reporting a systemic adverse reaction defined as anaphylaxis, asthma, rhinitis, urticaria or a combination of these.[502] Immunotherapy is not licensed for the treatment of asthma; the current licence is for allergic rhinitis induced by grass pollen.	1++	1++	
One study directly compared allergen immunotherapy with ICS and found that symptoms and lung function improved more rapidly in the group on ICS.[503]	2++		
Immunotherapy for allergic rhinitis has been shown to have a carry-over effect after therapy has stopped.[504]	3		

>12 yrs	5-12 yrs	<5 yrs	
B	B		**The use of subcutaneous immunotherapy is not recommended for the treatment of asthma in adults or children.**

Sublingual immunotherapy

There has been increasing interest in the use of sublingual immunotherapy (SLIT), which is associated with fewer adverse reactions than subcutaneous immunotherapy.

	> 12 years	5–12 years	<5 years
A systematic review including 52 studies of SLIT in adults and children (n=5,077), most of whom had intermittent or mild asthma symptoms, showed no clear benefit of SLIT. Asthma symptoms scores were the most commonly reported outcome measure (in 42/52 studies) and although overall results were inconclusive, there was some evidence of improvements in asthma symptom scores (in nine studies) and/or medication use (in five studies). Symptom scores and medication use were, however, mostly assessed using unvalidated scales and meta-analysis was not possible. There was no evidence of improvement in lung function, quality of life or asthma attacks, although data on these outcomes was limited. Adverse events were significantly more common in those receiving SLIT (absolute increase 327/1,000 SLIT *v* 222/1,000 control) although these were mostly mild or transient. Serious adverse events were rare with only five of 22 studies reporting any events and no difference between groups in the rate of events (1.3%); all events were thought to be unrelated to treatment.[505]	1++	1++	

Despite the large volume of evidence evaluating the safety and clinical effectiveness of SLIT in adults and children, heterogeneity in studies (including in doses, allergens, treatment duration, other asthma medication and presence of asthma symptoms), together with the lack of data on its long-term effectiveness and concerns about study quality, mean there is currently insufficient evidence to recommend use of SLIT in adults or children with asthma.

Sublingual immunotherapy is not licensed for use in the treatment of asthma.

>12 yrs	5-12 yrs	<5 yrs	
B	B		**Sublingual immunotherapy is not recommended for the treatment of asthma in children or adults.**

7.5.7 Bronchial thermoplasty

The aim of bronchial thermoplasty is to reduce bronchial smooth muscle mass, thus reducing the capacity for bronchoconstriction. Currently only a few UK centres offer this treatment which has considerable cost and resource implications.

	> 12 years	5–12 years	<5 years
A systematic review of three RCTs (n=429) looking at the use of bronchial thermoplasty for moderate or severe persistent asthma in adults (aged 18 and over) showed a significantly lower rate of severe asthma exacerbations at 12 months in those treated with bronchial thermoplasty in one trial that included a sham intervention in the control group. A second trial, with no sham intervention in the control group, showed a decrease in severe exacerbations in both the intervention and control groups. There were no significant differences in asthma control, lung function, changes in doses of regular medication or use of rescue medication between the intervention and control groups. A small, but statistically significant improvement in quality-of-life scores (measured using AQLQ) with bronchial thermoplasty compared with control groups was seen only in the two studies without a sham intervention. In the study with a sham intervention, QoL scores improved in both groups.[506]	1++		
Bronchial thermoplasty is an invasive procedure and is associated with an increased rate of adverse respiratory events in the short term. Significantly more patients receiving bronchial thermoplasty than controls were admitted to hospital because of respiratory adverse events within the first 12 weeks following treatment (8 per 100 *v* 2 per 100; risk ratio (RR) 3.5, 95% CI 1.26 to 9.68). By 12 months following treatment, there was no difference between groups.[506]	1++		
A systematic review looking at the long-term efficacy and safety of bronchial thermoplasty, including the same three RCTs, reported a significant reduction in respiratory adverse events in patients after five years compared to one year following treatment, although these results were not compared to a control group who had not received bronchial thermoplasty. There was no difference in the number of ED visits or hospitalisations for respiratory adverse events between one and five years of follow up in those treated with bronchial thermoplasty. The longer-term effects of bronchial thermoplasty, beyond five years following treatment, are not known.[507]	1++		

Further research is needed to identify which patients with asthma might benefit from bronchial thermoplasty. However, it is likely that patients who remain uncontrolled despite optimal medical treatment and who have been considered for biological treatments and are either unsuitable for or fail a trial of such a treatment may be an appropriate group, as other treatment options for these patients are elusive. There are no trials comparing the efficacy of bronchial thermoplasty with biological treatments for people with asthma.

B **Bronchial thermoplasty may be considered for the treatment of adult patients (aged 18 and over) with severe asthma who have poorly-controlled asthma despite optimal medical therapy.**

✓

- Patients being considered for bronchial thermoplasty should be assessed to confirm the diagnosis of asthma, that uncontrolled asthma is the cause of their ongoing symptoms, and that they are adherent with current treatment.
- An asthma specialist with expertise in bronchial thermoplasty should assess patients prior to undergoing treatment, and treatment should take place in a specialist centre with the appropriate resources and training, including access to an intensive care unit.
- Patients undergoing bronchial thermoplasty should have their details entered onto the UK Severe Asthma Registry.

7.6 Decreasing treatment

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

7.7 Specific management issues

7.7.1 Asthma attacks

There is some limited evidence that leukotriene antagonists may be used intermittently in children with episodic asthma. Treatment is started at the onset of either asthma symptoms or of coryzal symptoms and continued for seven days.[508]

> 12 years	5–12 years	<5 years
	1+	1+

7.7.2 Exercise-induced asthma

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

7.7.3 Comorbid rhinitis

Patients with asthma often have rhinitis. The most effective therapy for rhinitis is intranasal steroids.[521, 522] Treatment of allergic rhinitis with intranasal steroids has not been shown, in double-blinded placebo-controlled trials, to improve asthma control.

> 12 years	5–12 years	<5 years
1+	1+	

7.7.4 Allergic bronchopulmonary aspergillosis

In adult patients with allergic bronchopulmonary aspergillosis, itraconazole may decrease steroid tablet dose and improve asthma control.[523]

> 12 years	5–12 years	<5 years
2+		

>12 yrs	5-12 yrs	<5 yrs	
C			**In adult patients with allergic bronchopulmonary aspergillosis, a four-month trial of itraconazole should be considered.**
✓			Careful monitoring for side effects, particularly hepatic, is recommended.

7.7.5 Aspirin-intolerant asthma

There are theoretical reasons to suggest that leukotriene receptor antagonists might be of particular value in the treatment of aspirin-intolerant asthma. However, there is little evidence to justify managing patients with aspirin-intolerant asthma in a different manner to other patients with asthma, apart from the rigorous avoidance of non-steroidal anti-inflammatory medications.[524, 525]

7.7.6 Comorbid gastro-oesophageal reflux

A Cochrane review of twelve double-blinded controlled trials found that treatment of gastro-oesophageal reflux disease (GORD) had no benefit on asthma symptoms or lung function when both conditions were present. Reduction in dry cough was observed although this was probably not due to improved asthma control.[526, 527]

A systematic review identified a single RCT which found that proton-pump inhibitors did not improve asthma symptoms in children with GORD.[528]

A further systematic review, including 11 trials and 2,524 patients who had received at least four weeks of daily therapy with proton-pump inhibitors found a small but statistically significant improvement in morning peak expiratory flow (8.86 l/min, 95% CI 2.35 to 15.02) in study

> 12 years	5–12 years	<5 years
1++		

participants compared with controls, but no differences in asthma symptom score, Asthma Quality of Life Questionnaire score, evening PEF, FEV_1 and adverse events. The review concluded that there was insufficient evidence to support the routine use of proton-pump inhibitors in the treatment of asthma. [529]

7.7.7 Beta blockers

Beta blockers, including eye drops, are contraindicated in patients with asthma. Current guidance can be found in the British National Formulary.[4]

8 Inhaler devices

8.1 Technique and training

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

8.2 β_2 agonist delivery

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

8.3 Inhaled corticosteroids for stable asthma

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

8.4 Prescribing devices

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

8.5 Use and care of spacers

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

8.6 Environmental impact of metered-dose inhalers

Metered-dose inhalers contain propellants which are liquefied, compressed gases used as a driving force and an energy source for atomisation of the drug. Chlorofluorocarbons (CFCs), which were used originally, are potent greenhouse gases and ozone-depleting substances, and were phased out under the Montreal Protocol. They have been replaced by two hydrofluoroalkane (HFA) propellants: 1,1,1,2-tetrafluoroethane (HFA134a) and 1,1,1,2,3,3,3-heptafluoropropane (HFA227ea), identified as having a high global-warming potential.[542] As a result of this change, MDIs currently contribute an estimated 3.5% of the carbon footprint of the NHS in the UK.[543] The UK has a high proportion of MDI use (70%) compared with the rest of Europe (< 50%) and Scandinavia (10–30%).[544]

The good practice points in this sub section have been superseded by and revised in Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and are included in the Asthma pathway (SIGN 244).

9 Management of acute asthma

9.1 Lessons from asthma deaths and near-fatal asthma

Confidential enquires into over 200 asthma deaths in the UK conclude there are factors associated with the disease, the medical management and the patient's behaviour or psychosocial status which contribute to death. Most deaths occurred before admission to hospital.[545-549] The report of the UK-wide National Review of Asthma Deaths (NRAD) in 2014 reiterates many of the findings from earlier studies.[550]

9.1.1 Disease factors

Most patients who died of asthma had chronically severe asthma. In a minority the fatal attack occurred suddenly in a patient with mild or moderately severe background disease. [545-549, 551] 2++

9.1.2 Medical management

Many of the deaths occurred in patients who had received inadequate treatment with ICS or steroid tablets and/or inadequate objective monitoring of their asthma. Follow up was inadequate in some and others should have been referred earlier for specialist advice. There was widespread underuse of written management plans. Heavy or increasing use of SABA therapy was associated with asthma death.[545-549, 552, 553] The NRAD report recommended that prescription of more than 12 SABA inhalers a year should prompt review of a patient's management.[550] 2++

Deaths continue to be reported following inappropriate prescription of beta blockers and non-steroidal anti-inflammatory drugs; all asthma patients should be asked about past reactions to these agents *(see sections 7.7.7 and 7.7.5).*

Patients with an acute asthma attack should not be sedated unless this is to allow anaesthetic or intensive care procedures (*see section 9.3.12*).[551]

The NRAD report highlighted that there is an increased risk of death within one month of discharge from hospital following an acute attack and that follow up in primary care is therefore essential *(see section 9.6).*[550]

9.1.3 Adverse psychosocial and behavioural factors

Behavioural and adverse psychosocial factors were recorded in the majority of patients who died of asthma.[545-549] The most important of these are shown in Table 14.

Compared with control patients admitted to hospital with asthma, those who died were significantly more likely to have learning difficulties, psychosis or prescribed antipsychotic drugs, financial or employment problems, repeatedly failed to attend appointments or discharged themselves from hospital, drug or alcohol abuse, obesity or a previous near-fatal attack.[554, 555] 2++

Compared with control patients with asthma in the community, patients who died had more severe disease, more likelihood of a hospital admission or visit to the ED for their asthma in the previous year, more likelihood of a previous near-fatal attack, poor medical management, failure to measure pulmonary function, and non-adherence.

B **Healthcare professionals must be aware that patients with severe asthma and one or more adverse psychosocial factors are at risk of death.**

Table 14: Patients at risk of developing near-fatal or fatal asthma[545-549, 552, 553]

A combination of severe asthma recognised by one or more of:
• previous near-fatal asthma, eg previous ventilation or respiratory acidosis
• previous admission for asthma, especially if in the last year
• requiring three or more classes of asthma medication
• heavy use of β_2 agonist
• repeated attendances at ED for asthma care, especially if in the last year
AND adverse behavioural or psychosocial features recognised by one or more of:
• non-adherence with treatment or monitoring
• failure to attend appointments
• fewer GP contacts
• frequent home visits
• self discharge from hospital
• psychosis, depression, other psychiatric illness or deliberate self harm
• current or recent major tranquilliser use
• denial
• alcohol or drug abuse
• obesity
• learning difficulties
• employment problems
• income problems
• social isolation
• childhood abuse
• severe domestic, marital or legal stress.

Studies comparing near-fatal asthma with deaths from asthma have concluded that patients with near-fatal asthma have identical adverse factors to those described in Table 14, and that these contribute to the near-fatal asthma attack.[556-558] Compared with patients who die, those with near-fatal asthma are significantly younger, are significantly more likely to have had a previous near-fatal asthma attack, are more likely to have ready access to acute medical care, and are less likely to have concurrent medical conditions or to experience delay in receiving medical care. 2^+

With near-fatal asthma it is advisable to involve a close relative when discussing future management.

Patients with difficult asthma should also be identified *(see section 10.1)*.

✓ Keep patients who have had a near-fatal asthma attack under specialist supervision indefinitely.

9.1.4 Seasonal factors

In the UK there is a peak of asthma deaths in young people aged up to 44 years in July and August and in December and January in older people.[556, 559] 2^{++}

9.1.5 Prediction and Prevention of a Severe Asthma Attack

Most attacks of asthma severe enough to require hospital admission develop relatively slowly over a period of six hours or more. In one study, over 80% developed over more than 48 hours.[560-565] There is therefore time for effective action to reduce the number of attacks requiring hospitalisation. There are many similarities between patients who die from asthma, patients with near-fatal asthma and control patients with asthma who are admitted to hospital. 2++

✓ A respiratory specialist should follow up patients admitted with a severe asthma attack for at least one year after the admission.

9.2 Acute Asthma in Adults

Annexes 3–5 contain algorithms summarising the recommended treatment for patients presenting with moderate, acute severe or life-threatening asthma in general practice *(see Annex 3)*, the ED *(see Annex 4)*, and hospital *(see Annex 5)*.

9.2.1 Recognition of Acute Asthma

Definitions of increasing levels of severity of acute asthma attacks are provided in Table 15.[566-571] Predicted PEF values should be used only if the recent best PEF (within two years) is unknown.[572] 2+ 4

9.2.2 Self treatment by patients developing acute or uncontrolled asthma

Patients with asthma, and all patients with severe asthma, should have an agreed written PAAP and their own peak-flow meter, with regular checks of inhaler technique and adherence. They should know when and how to increase their medication and when to seek medical assistance. Written PAAPs can decrease hospitalisation for,[166] and deaths from asthma *(see section 5.3.2)*.[573]

9.2.3 Initial assessment

All possible initial contact personnel, for example practice receptionists, ambulance call takers, NHS 111 (England and Wales), NHS 24 (Scotland), and out-of-hours providers, should be aware that asthma patients complaining of respiratory symptoms are at risk of becoming seriously unwell very quickly. Such patients should have immediate access to a healthcare professional trained in the emergency treatment of asthma. The assessments required to determine whether the patient is suffering from an acute attack of asthma, the severity of the attack and the nature of treatment required are detailed in Tables 15 and 16. It may be helpful to use a systematic recording process. Proformas have proved useful in the ED setting.[574]

Table 15: Levels of severity of acute asthma attacks in adults[566-571]

<table>
<tr><td>Moderate acute asthma</td><td colspan="2">Increasing symptoms
PEF >50–75% best or predicted
No features of acute severe asthma</td></tr>
<tr><td>Acute severe asthma</td><td colspan="2">Any one of:
• PEF 33–50% best or predicted
• respiratory rate ≥25/min
• heart rate ≥110/min
• inability to complete sentences in one breath</td></tr>
<tr><td rowspan="3">Life-threatening asthma</td><td colspan="2">SpO_2 <92% plus any one of the following in a patient with severe asthma:</td></tr>
<tr><td>Clinical signs</td><td>Measurements</td></tr>
<tr><td>• Altered conscious level
• Exhaustion
• Arrhythmia
• Hypotension
• Cyanosis
• Silent chest
• Poor respiratory effort</td><td>• PEF <33% best or predicted
• PaO_2 <8 kPa
• ’normal’ $PaCO_2$ (4.6–6.0 kPa)</td></tr>
<tr><td>Near-fatal asthma</td><td colspan="2">Raised $PaCO_2$ and/or requiring mechanical ventilation with raised inflation pressures[555-557]</td></tr>
</table>

SpO_2: oxygen saturation measured by a pulse oximeter
PaO_2: partial arterial pressure of oxygen
kPa: kilopascals
$PaCO_2$: partial arterial pressure of carbon dioxide

9.2.4 Prevention of acute deterioration

A register of patients at risk may help healthcare professionals in primary care to identify patients who are more likely to die from their asthma. A system should be in place to ensure that these patients are contacted if they fail to attend for follow up.

9.2.5 Criteria for referral

D **Refer to hospital any patients with features of acute severe or life-threatening asthma.**

Other factors, such as failure to respond to treatment, social circumstances or concomitant disease, may warrant hospital referral.

Table 16: Initial assessment of symptoms, signs and measurements

Clinical features	Clinical features can identify some patients with severe asthma, eg severe breathlessness (including too breathless to complete sentences in one breath), tachypnoea, tachycardia, silent chest, cyanosis, accessory muscle use, altered consciousness or collapse.[566-571, 575] None of these singly or together is specific. Their absence does not exclude a severe attack.	2^+
PEF or FEV_1	Measurements of airway calibre improve recognition of the degree of severity, the appropriateness or intensity of therapy, and decisions about management in hospital or at home.[576, 577] PEF or FEV_1 are useful and valid measures of airway calibre. PEF is more convenient in the acute situation. PEF expressed as a percentage of the patient's previous best value is most useful clinically. PEF as a percentage of predicted gives a rough guide in the absence of a known previous best value. Different peak-flow meters give different readings. Where possible the same or similar type of peak-flow meter should be used.	2^+
Pulse oximetry	Measure oxygen saturation (SpO_2) with a pulse oximeter to determine the adequacy of oxygen therapy and the need for arterial blood gas measurement. The aim of oxygen therapy is to maintain SpO_2 94–98%.[578]	
Blood gases	Patients with SpO_2 <92% (irrespective of whether the patient is on air or oxygen) or other features of life-threatening asthma require arterial blood gas measurement.[566-569, 571, 579] SpO_2 <92% is associated with a risk of hypercapnia. Hypercapnia is not detected by pulse oximetry.[579] In contrast, the risk of hypercapnia with SpO_2 >92% is much less.[578]	2^+ 4
Chest X-ray	Chest X-ray is not routinely recommended in the absence of: – suspected pneumomediastinum or pneumothorax – suspected consolidation – life-threatening asthma – failure to respond to treatment satisfactorily – requirement for ventilation.	4
Systolic paradox	Systolic paradox (*pulsus paradoxus*) is an inadequate indicator of the severity of an attack and should not be used.[566-571, 580]	2^+

9.2.6 Criteria for admission

Adult patients with any feature of a life-threatening or near-fatal asthma attack or a severe asthma attack that does not resolve after initial treatment should be admitted to hospital. Admission may also be appropriate when peak flow has improved to greater than 75% best or predicted one hour after initial treatment but concerns remain about symptoms, previous history or psychosocial issues *(see sections 9.1 and 9.2).*[556, 558, 566-571] 2++ 2+

B **Admit patients with any feature of a life-threatening or near-fatal asthma attack.**

B **Admit patients with any feature of a severe asthma attack persisting after initial treatment.**

C **Patients whose peak flow is greater than 75% best or predicted one hour after initial treatment may be discharged from ED unless they meet any of the following criteria, when admission may be appropriate:**

- **still have significant symptoms**
- **concerns about adherence**
- **living alone/socially isolated**
- **psychological problems**
- **physical disability or learning difficulties**
- **previous near-fatal asthma attack**
- **asthma attack despite adequate dose of oral corticosteroid prior to presentation**
- **presentation at night**
- **pregnancy.**

9.3 Treatment of acute asthma in adults

9.3.1 Oxygen

Many patients with acute severe asthma are hypoxaemic.[581-584] Supplementary oxygen should be given urgently to hypoxaemic patients, using a face mask, Venturi mask or nasal cannulae with flow rates adjusted as necessary to maintain SpO_2 of 94–98%,[578] taking care to avoid overoxygenation which may be detrimental.[585] 1+ 2+ 4

Emergency oxygen should be available in hospitals, ambulances and primary care.

Hypercapnia indicates the development of near-fatal asthma and the need for emergency specialist/anaesthetic intervention. In this situation care should be taken to avoid hypoxia as well as overoxygenation.

C **Give controlled supplementary oxygen to all hypoxaemic patients with acute severe asthma titrated to maintain an SpO_2 level of 94–98%. Do not delay oxygen administration in the absence of pulse oximetry but commence monitoring of SpO_2 as soon as it becomes available.**

9.3.2 β_2 agonist bronchodilators

In most cases inhaled β_2 agonists given in high doses act quickly to relieve bronchospasm with few side effects.[586-588] There is no evidence for any difference in efficacy between salbutamol and terbutaline. Nebulised adrenaline (epinephrine), a non-selective β_2 agonist, does not have significant benefit over salbutamol or terbutaline.[589] 1++ 1+

In patients with mild to moderate asthma attacks, β_2 agonists can be administered by repeated activations of a pMDI via an appropriate large volume spacer. There are insufficient data on which to make a recommendation about the use of metered dose inhalers with spacers in acute-severe or life-threatening asthma. In such patients, β_2 agonists should be administered by wet nebulisation driven by oxygen, if available.[531] Inhaled β_2 agonists are as efficacious and preferable to intravenous β_2 agonists (meta- 1++ 3

analysis has excluded subcutaneous trials) in adult acute asthma in the majority of cases.[590] If intravenous β_2 agonists are used, consider monitoring serum lactate.[591]

A **Use high-dose inhaled β_2 agonists as first-line agents in patients with acute asthma and administer as early as possible. Reserve intravenous β_2 agonists for those patients in whom inhaled therapy cannot be used reliably.**

✓ If intravenous β_2 agonists are used, consider monitoring serum lactate to monitor for toxicity.

Oxygen-driven nebulisers are preferred for nebulising β_2 agonist bronchodilators because of the risk of oxygen desaturation while using air-driven compressors.[531, 566, 592] 1++

A flow rate of 6 L/min is required to drive most nebulisers. Where oxygen cylinders are used, a high-flow regulator must be fitted.[578] 4

The absence of supplemental oxygen should not prevent nebulised therapy from being administered when appropriate.[593] 4

A **In hospital, ambulance and primary care, nebulisers for giving β_2 agonist bronchodilators should preferably be driven by oxygen.**

✓ In patients with acute asthma with acute-severe or life-threatening features the nebulised route (oxygen-driven) is recommended.

Parenteral β_2 agonists, in addition to inhaled β_2 agonists, may have a role in ventilated patients or those in extremis, however there is limited evidence to support this.

Most acute asthma attacks will respond adequately to bolus nebulisation of β_2 agonists. Continuous nebulisation of β_2 agonists with an appropriate nebuliser may be more effective than bolus nebulisation in relieving acute asthma for patients with a poor response to initial therapy.[594-597] 1+

A **In patients with severe asthma that is poorly responsive to an initial bolus dose of β_2 agonist, consider continuous nebulisation with an appropriate nebuliser.**

Repeat doses of β_2 agonists at 15–30 minute intervals or give continuous nebulisation of salbutamol at 5–10 mg/hour (requires the appropriate nebuliser) if there is an inadequate response to initial treatment. Higher bolus doses, for example 10 mg of salbutamol, are unlikely to be more effective.

9.3.3 Steroid therapy

Steroids reduce mortality, relapses, subsequent hospital admission and requirement for β_2 agonist therapy. The earlier they are given in the acute attack the better the outcome.[598, 599] 1++

A **Give steroids in adequate doses to all patients with an acute asthma attack.**

Steroid tablets are as effective as injected steroids, provided they can be swallowed and retained.[598] Prednisolone 40–50 mg daily or parenteral hydrocortisone 400 mg daily (100 mg six hourly) are as effective as higher doses.[600] Where necessary soluble prednisolone (sodium phosphate) 5 mg tablets are available. In cases where oral treatment may be a problem consider intramuscular methylprednisolone (160 mg) as an alternative to a course of oral prednisolone.[601] 1++

✓ Continue prednisolone (40–50 mg daily) for at least five days or until recovery if longer.

Following recovery from the acute asthma attack steroids can be stopped abruptly. Doses do not need tapering provided the patient receives ICS (apart from patients on maintenance steroid treatment or rare instances where steroids are required for three or more weeks).[602, 603] 1+

It is not known if ICS provide further benefit in addition to systemic steroids.[604, 605] 1+

✓ Do not stop inhaled corticosteroids during prescription of oral corticosteroids.

9.3.4 Ipratropium Bromide

Combining nebulised ipratropium bromide with a nebulised β_2 agonist produces significantly greater bronchodilation than β_2 agonist alone, leading to faster recovery and shorter duration of admission. Anticholinergic treatment is not necessary and may not be beneficial in milder asthma attacks or after stabilisation.[606-608] 1++

B **Add nebulised ipratropium bromide (0.5 mg 4–6 hourly) to β_2 agonist treatment for patients with acute severe or life-threatening asthma or those with a poor initial response to β_2 agonist therapy.**

9.3.5 Magnesium sulphate

A systematic review of 25 RCTs (13 including adults) involving 2,907 patients with asthma showed that nebulised magnesium sulphate when used in addition to nebulised β_2 agonist (with or without nebulised ipratropium) provided no benefit in terms of lung function or need for hospital admission.[609] Subgroup analysis of the most severe patients was not possible due to heterogeneity in studies and the use of multiple different end-points. Some smaller studies noted modest improvements in lung function with nebulised magnesium in the most severe subgroup (presenting FEV_1 <50%), but the results were not significant. 1++

A double-blinded, placebo-controlled study of 1,109 patients aged over 16 years presenting with an acute asthma attack to 34 emergency departments across the UK randomised patients to intravenous or nebulised magnesium or to placebo.[610] Many of these patients had PEF >50% at presentation and the study failed to show improvement in either rate of hospital admission or breathlessness as judged by a visual analogue score. A single dose of intravenous magnesium sulphate is safe and may improve lung function and reduce intubation rates in patients with acute severe asthma.[355, 611-613] Intravenous magnesium sulphate may also reduce hospital admissions in adults with acute asthma who have had little or no response to standard treatment. However, the heterogeneous nature of the studies included in this review and lack of information on the severity of the asthma attack or when intravenous magnesium was given in relation to standard treatment limit the conclusions that can be drawn.[613] 1++ 1+

The safety and efficacy of repeated intravenous (IV) doses of magnesium sulphate have not been assessed. Repeated doses could cause hypermagnesaemia with muscle weakness and respiratory fatigue.

A **Nebulised magnesium sulphate is not recommended for treatment in adults with acute asthma.**

B **Consider giving a single dose of intravenous magnesium sulphate to patients with acute severe asthma (PEF <50% best or predicted) who have not had a good initial response to inhaled bronchodilator therapy.**

✓ Magnesium sulphate (1.2–2 g IV infusion over 20 minutes) should only be used following consultation with senior medical staff.

9.3.6 Intravenous aminophylline

In an acute asthma attack, IV aminophylline is not likely to result in any additional bronchodilation compared with standard care with inhaled bronchodilators and steroids. Side effects such as arrhythmias and vomiting are increased if IV aminophylline is used. [614] | 1++

✓ Use IV aminophylline only after consultation with senior medical staff.

Some patients with near-fatal asthma or life-threatening asthma with a poor response to initial therapy may gain additional benefit from IV aminophylline (5 mg/kg loading dose over 20 minutes unless on maintenance oral therapy, then infusion of 0.5–0.7 mg/kg/hr). Such patients are probably rare and were not identified in a meta-analysis of trials.[614] If IV aminophylline is given to patients already taking oral aminophylline or theophylline, blood levels should be checked on admission. Levels should be checked daily for all patients on aminophylline infusions.

9.3.7 Leukotriene receptor antagonists

Current evidence on oral leukotriene receptor antagonists does not support their use in patients with acute asthma.[615] Further studies are required to assess whether IV treatment is effective and safe. | 1++

9.3.8 Antibiotics

When an infection precipitates an asthma attack it is likely to be viral. The role of bacterial infection has been overestimated.[616] Decision making regarding the use of antibiotics in patients with acute asthma should be guided by objective measures including procalcitonin where available.[617, 618] | 1++ 1+

B **Routine prescription of antibiotics is not indicated for patients with acute asthma.**

9.3.9 Heliox

The use of heliox, (helium/oxygen mixture in a ratio of 80:20 or 70:30), either as a driving gas for nebulisers, as a breathing gas, or for artificial ventilation in adults with acute asthma is not supported.[619, 620] A systematic review of ten trials, including 544 patients with acute asthma, found no improvement in pulmonary function or other outcomes in adults treated with heliox, although the possibility of benefit in patients with more severe obstruction exists.[621, 622] Heliox requires the use of specifically designed or modified breathing circuits and ventilators. | 1++ 1+

B **Heliox is not recommended for use in patients with acute asthma outside a clinical trial setting.**

9.3.10 Intravenous fluids

There are no controlled trials, observational or cohort studies of differing fluid regimes in patients with acute asthma. Some patients require rehydration and correction of electrolyte imbalance. Hypokalaemia can be caused or exacerbated by β_2 agonist and/or steroid treatment and must be corrected.

9.3.11 Nebulised furosemide

Although theoretically furosemide may produce bronchodilation, a review of three small trials failed to show any significant benefit of treatment with nebulised furosemide compared to β_2 agonists.[623] | 1+

9.3.12 Critical care settings

In adults with acute asthma and a poor response to standard therapy (inhaled bronchodilators, steroids, oxygen and intravenous bronchodilators) other therapies may be considered in the appropriate critical care setting with the appropriate available expertise. There is little high-quality evidence to guide treatment at this stage of an acute asthma attack and it is important to involve a clinician with the appropriate skills in airway management and critical care support as early as possible.

Indications for admission to intensive care or high-dependency units include patients requiring ventilatory support and those with acute severe or life-threatening asthma who are failing to respond to therapy, as evidenced by:[566, 567]

- deteriorating PEF
- persisting or worsening hypoxia
- hypercapnia
- arterial blood gas analysis showing fall in pH or rising hydrogen concentration
- exhaustion, feeble respiration
- drowsiness, confusion, altered conscious state
- respiratory arrest.

Ketamine

A review (including 12 case reports, three RCTs and five other observational studies) of ketamine use in adults and children in status asthmaticus reported that ketamine is a potential bronchodilator but that prospective trials are needed before conclusions about effectiveness can be drawn.[624] 2-

Extracorporeal membrane oxygenation

Extracorporeal membrane oxygenation (ECMO) is thought to help to provide adequate gas exchange whilst helping to prevent the barotraumas caused by aggressive mechanical ventilation. Currently, there are five centres in the UK with ECMO facilities for adults (Glenfield Hospital, Leicester; Papworth Hospital, Cambridge; Wythenshawe Hospital, Manchester; Guy's & St Thomas' Hospital, London; Royal Brompton & Harefield Hospital, London).

An international retrospective registry study of 272 adult patients with near-fatal asthma most of whom were put on venovenous ECMO showed a survival rate to hospital discharge of 83.5%. The rate of in-hospital complications was high (65.1%), the most common of which was haemorrhage (28.3%), most commonly at a manageable cannulation site (13.1%); only 1.5% died as a result of the haemorrhage. Other complications were renal (26.8%), cardiovascular (26.1%), mechanical (24.6%), metabolic (22.4%), infection (16.5%), neurologic (4.8%), and limb ischemia (2.6%). The most common cause of death was organ failure (37.8%, 17/45 complications). Long-term complications of ECMO were not considered.[625] 3

Although it is unclear which patients would benefit the most from venovenous ECMO, survivors were younger (34.7 *v* 43.4, p=0.001), had a lower mean pH (7.1 *v* 7.2, p=0.045), higher oxygen saturation (92.3 *v* 85.2, p=0.03) and lower positive end-expiratory pressure (7.8 *v* 11.5, p=0.002) than those who died.

Limitations of the registry include the lack of selection criteria for inclusion, and consequent lack of clarity about whether patients were on optimal or even similar ventilator settings, and the voluntary nature of reporting of cases which may lead to reporting bias. Despite these limitations, the use of ECMO provides a potential rescue therapy in patients with near-fatal asthma refractory to conventional ventilator treatment.

D **Where available, extracorporeal membrane oxygenation may be considered in adults with near-fatal asthma refractory to conventional ventilator treatment.**

Recombinant human deoxyribonuclease

A pilot RCT of the use of recombinant human deoxyribonuclease in severely ill, non-intubated adults with asthma refractory to bronchodilators reported no benefit from its use in this patient group.[626] | 1+

✓ Adults with asthma not responding to standard treatment should be evaluated by a specialist with the appropriate experience and skills to use and assess medication encountered in critical care settings.

✓ In patients with acute severe or life-threatening asthma, anaesthetists and intensivists should be notified as soon as possible if there is no improvement in or deterioration of asthma.

Not all patients admitted to the intensive care unit (ICU) need ventilation, but those with worsening hypoxia or hypercapnia, drowsiness or unconsciousness and those who have had a respiratory arrest require intermittent positive pressure ventilation. Intubation in such patients is very difficult and should be performed by an anaesthetist or ICU consultant.[566, 567] | 2+

C **All patients transferred to intensive care units should be accompanied by a doctor suitably equipped and skilled to intubate if necessary.**

9.3.13 Non-invasive ventilation

Non-invasive ventilation (NIV) is well established in the management of ventilatory failure caused by extrapulmonary restrictive conditions and exacerbations of COPD. Hypercapnic respiratory failure developing during an acute asthmatic attack is an indication for urgent ICU admission. It is unlikely that NIV would replace intubation in these very unstable patients but it has been suggested that this treatment can be used safely and effectively.[627] | 4

Evidence to support the use of NIV in adults is limited and inconclusive. A Cochrane review found only one trial on NIV, with 30 patients, which showed improvement in hospitalisation rates, discharge from emergency departments and lung function.[628] Two further small studies suggest that NIV may be safe and feasible in treating patients with severe asthma exacerbations but provide little evidence of benefit compared with standard care.[629, 630] | 1++ 1+ 2-

Larger RCTs are needed to determine the role of NIV in treating patients with acute asthma.[628] Future trials should include measurable clinical outcomes such as respiratory parameters, physiological variables and blood gases.

✓ NIV should only be considered in an ICU or equivalent clinical setting.

9.4 Further investigation and monitoring

✓
- Measure and record PEF 15–30 minutes after starting treatment, and thereafter according to the response. Measure and record PEF before and after nebulised or inhaled β_2 agonist.
- Record oxygen saturation by oximetry and maintain arterial SpO_2 at 94–98%.
- Repeat measurements of blood gas tensions within one hour of starting treatment if:
- the initial PaO_2 is <8 kPa unless SpO_2 is >92%; or
- the initial $PaCO_2$ is normal or raised; or
- the patient's condition deteriorates.

✓

- Measure them again if the patient's condition has not improved by 4–6 hours.
- Measure and record the heart rate.
- Measure serum potassium and blood glucose concentrations.
- Measure the serum theophylline concentration if aminophylline is continued for more than 24 hours (aim for a concentration of 10–20 mg/L or 55–110 mol/L).

9.5 Asthma management protocols and proformas

The use of structured proformas facilitates improvements in the process of care in emergency departments and hospital wards and improves patient outcomes. The use of this type of documentation can assist data collection aimed at determining the quality of care and outcomes.[574, 631, 632] 2++

9.6 Hospital discharge and follow up

Annex 5 summarises management of acute asthma in hospital.

An asthma care bundle developed by the BTS is also available from the BTS website (www.brit-thoracic.org.uk).

9.6.1 Timing of discharge

No single physiological parameter defines absolutely the timing of discharge from an admission with acute asthma. Patients should have clinical signs compatible with home management, be on reducing amounts of β_2 agonist (preferably no more than four hourly) and be on medical therapy they can continue safely at home.

Although diurnal variability of PEF is not always present during an asthma attack, evidence suggests that patients discharged with PEF <75% best or predicted and with diurnal variability >25% are at greater risk of early relapse and readmission.[633, 634] 2+

9.6.2 Patient education

Following discharge from hospital or emergency departments, a proportion of patients reattend with more than 15% reattending within two weeks. Some repeat attenders need emergency care, but many delay seeking help, and are undertreated and/or undermonitored.[635] 2+

Prior to discharge, trained staff should give asthma education. This should include education on inhaler technique and PEF record keeping, with a written PEF and symptom-based PAAP being provided allowing the patient to adjust their therapy within recommendations. These measures have been shown to reduce morbidity after the asthma attack and reduce relapse rates.[636] 1++

Some patients may use emergency departments rather than primary care services for their asthma care. Education has been shown to reduce subsequent hospital admission and improve scheduled appointments and self-management techniques but does not improve reattendance at emergency departments.[187] 1++

For the above groups there is a role for a trained asthma liaison nurse based in, or associated with, the emergency department.[187]

Patient education is covered in section 5.2.1

9.6.3 Follow up

A careful history should elicit the reasons for the asthma attack and explore possible actions the patient should take to prevent future emergency presentations.

Medication should be altered depending upon the assessment and the patient provided with an asthma action plan aimed at preventing relapse, optimising treatment and preventing delay in seeking assistance in the future.

Prior to discharge, follow up should be arranged with the patient's general practitioner or asthma nurse within two working days and with a hospital specialist asthma nurse or respiratory physician at about one month after admission.

In a small RCT, follow-up care by a nurse specialist was as effective and safe as that given by a respiratory doctor.[637] 1+

Assisting patients in making appointments while being treated for an acute asthma attack in emergency departments may improve subsequent attendance at primary care centres.[638] 1+

✓ It is essential that the patient's primary care practice is informed within 24 hours of discharge from the emergency department or hospital following an asthma attack. Ideally this communication should be directly with a named individual responsible for asthma care within the practice.

9.7 Acute asthma in children

The assessment of acute asthma in children under five can be difficult. Intermittent wheezing attacks are usually triggered by viral infection and the response to asthma medication may be inconsistent. Prematurity and low birth weight are risk factors for recurrent wheezing. The differential diagnosis of symptoms includes aspiration pneumonitis, pneumonia, bronchiolitis, tracheomalacia, and complications of underlying conditions such as congenital anomalies and cystic fibrosis. This guideline is intended for children who are thought to have acute wheeze related to underlying asthma and should be used with caution in younger children who do yet have a considered diagnosis of asthma, particularly those under two years of age. The guideline is not intended for children under one year of age unless directed by a respiratory paediatrician. The guideline should not be used to treat acute bronchiolitis.

9.7.1 Clinical assessment

Table 17 details criteria for assessment of severity of acute asthma attacks in children. Annexes 6–9 contain algorithms summarising the recommended treatments for children presenting with acute or uncontrolled asthma in general practice *(see Annex 6)*, the ED *(see Annex 7)*, and hospital *(see Annexes 8 and 9)*.

Table 17: Levels of severity of acute asthma attacks in children[639]

<table>
<tr><td>Moderate acute asthma</td><td colspan="2">Able to talk in sentences
SpO_2 ≥92%
PEF ≥50% best or predicted
Heart rate ≤140/min in children aged 1–5 years
≤125/min in children >5 years
Respiratory rate ≤40/min in children aged 1–5 years
≤30/min in children >5 years</td></tr>
<tr><td>Acute severe asthma</td><td colspan="2">Can't complete sentences in one breath or too breathless to talk or feed
SpO_2 <92%
PEF 33–50% best or predicted
Heart rate >140/min in children aged 1–5 years
>125/min in children >5 years
Respiratory rate >40/min in children aged 1–5 years
>30/min in children >5 years</td></tr>
<tr><td>Life-threatening asthma</td><td colspan="2">SpO_2 <92% plus any one of the following in a child with severe asthma:</td></tr>
<tr><td></td><td>Clinical signs</td><td>Measurements</td></tr>
<tr><td></td><td>• Exhaustion
• Hypotension
• Cyanosis
• Silent chest
• Poor respiratory effort
• Confusion</td><td>• PEF <33% best or predicted</td></tr>
</table>

Before children can receive appropriate treatment for an acute asthma attack in any setting, it is essential to assess accurately the severity of their symptoms. The following clinical signs should be recorded:

- Pulse rate
  - increasing tachycardia generally denotes worsening asthma; a fall in heart rate in life-threatening asthma is a pre-terminal event
- Respiratory rate and degree of breathlessness
  - ie too breathless to complete sentences in one breath or to feed
- Use of accessory muscles of respiration
  - best noted by palpation of neck muscles
- Amount of wheezing
  - which might become biphasic or less apparent with increasing airways obstruction
- Degree of agitation and conscious level
  - always give calm reassurance.

Clinical signs correlate poorly with the severity of airways obstruction.[640-643] Some children with acute severe asthma do not appear distressed. 2++

✓ Decisions about admission should be made by trained clinicians after repeated assessment of the response to bronchodilator treatment.

9.7.2 Pulse oximetry

Accurate measurements of oxygen saturation are essential in the assessment of all children with acute wheezing. Oxygen saturation monitors should be available for use by all healthcare professionals assessing acute asthma in both primary and secondary care settings.

Low oxygen saturations after initial bronchodilator treatment selects a group of patients with more severe asthma.[640, 643] 2++

B **Consider intensive inpatient treatment of children with SpO_2 <92% in air after initial bronchodilator treatment.**

9.7.3 Peak expiratory flow

PEF measurements can be of benefit in assessing children who are familiar with the use of such devices. The best of three PEF measurements, ideally expressed as a percentage of personal best, can be useful in assessing the response to treatment.

A measurement of <50% predicted PEF or FEV_1 with poor improvement after initial bronchodilator treatment is predictive of a more prolonged asthma attack.

9.7.4 Chest x-ray

Chest X-rays rarely provide additional useful information and are not routinely indicated.[644, 645]

✓ A chest X-ray should be performed if there is subcutaneous emphysema, persisting unilateral signs suggesting pneumothorax, lobar collapse or consolidation and/or life-threatening asthma not responding to treatment.

9.7.5 Blood gases

Blood gas measurements should be considered if there are life-threatening features not responding to treatment. Arteriolised ear lobe blood gases can be used to obtain an accurate measure of pH and $PaCO_2$.[578] If ear lobe sampling is not practicable a finger prick sample can be an alternative. Normal or raised $PaCO_2$ levels are indicative of worsening asthma. A more easily obtained free flowing venous blood $PaCO_2$ measurement of <6 kPa (45 millimetres of mercury) excludes hypercapnia.[578] 4

9.8 Initial treatment of acute asthma in children

There is good evidence supporting recommendations for the initial treatment of children with acute asthma presenting to primary and secondary healthcare centres. There is less evidence to guide the use of second-line therapies to treat the small number of severe cases of acute asthma poorly responsive to first-line measures. Despite this, the risks of death and other adverse outcomes after admission to hospital are extremely low irrespective of the treatment options chosen.

Emergency departments attending to children with acute asthma should have a nurse trained in paediatrics available on duty at all times and staff familiar with the specific needs of children. Using a proforma can increase the accuracy of severity assessment.

The use of an assessment-driven algorithm and an integrated care pathway has been shown to reduce hospital stay without substantial increases in treatment costs.[646] 4

D **The use of structured care protocols detailing bronchodilator usage, clinical assessment, and specific criteria for safe discharge is recommended.**

9.8.1 Oxygen

✓ Children with life-threatening asthma or SpO_2 <94% should receive high-flow oxygen via a tight fitting face mask or nasal cannula at sufficient flow rates to achieve normal saturations of 94–98%.

9.8.2 Inhaled short-acting β_2 agonists

Inhaled β_2 agonists are the first-line treatment for acute asthma in children aged two years and over.[647-650] Assessment of response should be based on accurately recorded clinical observations and repeat measurements of oxygenation (SpO_2) (*see Table 17)*. Children receiving β_2 agonists via a pMDI + spacer are less likely to have tachycardia and hypoxia than when the same drug is given via a nebuliser.[531] In children under two who have a poor initial response to β_2 agonists administered with adequate technique, consider an alternative diagnosis and other treatment options. 1+

A **Inhaled β_2 agonists are the first-line treatment for acute asthma in children.**

✓ Discontinue long-acting β_2 agonists when short-acting β_2 agonists are required more often than four hourly.

A **A pMDI + spacer is the preferred option for children with mild to moderate asthma.**

Children under three years of age are likely to require a face mask connected to the mouthpiece of a spacer for successful drug delivery. Inhalers should be actuated into the spacer in individual puffs and inhaled immediately by tidal breathing (for five breaths).

Frequent doses of β_2 agonists are safe for the treatment of acute asthma,[647-649] although children with mild symptoms benefit from lower doses.[650] 1+

B **Individualise drug dosing according to severity and adjust according to the patient's response.**

Two to four puffs of salbutamol (100 micrograms via a pMDI + spacer) might be sufficient for mild asthma attacks, although up to 10 puffs might be needed for more severe attacks. Single puffs should be given one at a time and inhaled separately with five tidal breaths. Relief from symptoms should last 3–4 hours. If symptoms return within this time a further or larger dose (maximum 10 puffs) should be given and the parents/carer should seek urgent medical advice.

Children with severe or life-threatening asthma (SpO_2 <92%) should receive frequent doses of nebulised bronchodilators driven by oxygen (2.5–5 mg salbutamol). If there is poor response to the initial dose of β_2 agonists, subsequent doses should be given in combination with nebulised ipratropium bromide *(see section 9.8.3)*. Doses of nebulised bronchodilator can be repeated every 20–30 minutes. Continuous nebulised β_2 agonists are of no greater benefit than the use of frequent intermittent doses in the same total hourly dosage.[651, 652] Once improving on two- to four-hourly salbutamol, patients should be switched to a pMDI and spacer treatment as tolerated.

Schools can hold a generic reliever inhaler enabling them to treat an acutely wheezy child whilst awaiting medical advice. This is safe and potentially life saving.

✓ Increase β_2 agonist dose by giving one puff every 30–60 seconds, according to response, up to a maximum of ten puffs.

✓ Parents/carers of children with an acute asthma attack at home, and symptoms not controlled by up to 10 puffs of salbutamol via a pMDI and spacer, should seek urgent medical attention.

✓ If symptoms are severe additional doses of bronchodilator should be given as needed whilst awaiting medical attention.

✓ Paramedics attending to children with an acute asthma attack should administer nebulised salbutamol, using a nebuliser driven by oxygen if symptoms are severe, whilst transferring the child to the emergency department.

✓ Children with severe or life-threatening asthma should be transferred to hospital urgently.

9.8.3 Ipratropium bromide

There is good evidence for the safety and efficacy of frequent doses of ipratropium bromide (every 20–30 minutes) used in addition to β_2 agonists for the first two hours of a severe asthma attack. Benefits are more apparent in the most severe patients.[653] 1+

A **If symptoms are refractory to initial β_2 agonist treatment, add ipratropium bromide** (250 micrograms/dose mixed with the nebulised β_2 agonist solution)**.**

Frequent doses up to every 20–30 minutes (250 micrograms/dose mixed with 5 mg of salbutamol solution in the same nebuliser) should be used for the first few hours of admission. Salbutamol dose should be tapered to one to two hourly thereafter according to clinical response. The ipratropium dose should be tapered to four- to six-hourly or discontinued.

✓ Repeated doses of ipratropium bromide should be given early to treat children who are poorly responsive to β_2 agonists.

9.8.4 Steroid therapy

The early use of steroids in emergency departments and assessment units can reduce the need for hospital admission and prevent a relapse in symptoms after initial presentation.[598, 599] Benefits can be apparent within three to four hours. In head-to-head comparisons there is insufficient evidence to suggest that dexamethasone offers an advantage over prednisolone for the management of mild to moderate acute asthma in children. Further studies may indicate whether a single dose of dexamethasone may offer clinical benefit over multiple doses of prednisolone.[654-656] 1+ 1-

A large UK study of preschool children with mild to moderate wheeze associated with viral infection showed no reduction in hospital stay (or other outcomes) following treatment with oral steroids. In the acute situation, it is often difficult to determine whether a preschool child has asthma or episodic viral wheeze. Children with severe symptoms requiring hospital admission should still receive oral steroids. In children who present with moderate to severe wheeze without a previous diagnosis of asthma it is still advisable to give oral steroids. For children with frequent episodes of wheeze associated with viruses caution should be taken in prescribing multiple courses of oral steroids.[657] 1++

A **Give oral steroids early in the treatment of acute asthma attacks in children.**

B **Oral prednisolone is the steroid of choice for asthma attacks in children unless the patient is unable to tolerate the dose.**

Use a dose of 10 mg of prednisolone for children under two years of age, a dose of 20 mg for children aged 2–5 years and a dose of 30–40 mg for children older than five years.

Oral and intravenous steroids are of similar efficacy.[600, 658, 659] Intravenous hydrocortisone (4 mg/kg repeated four hourly) should be reserved for severely affected children who are unable to retain oral medication. 1+

Larger doses do not appear to offer a therapeutic advantage for the majority of children.[660] There is no need to taper the dose of steroid tablets at the end of treatment.[602, 603] 2+

✓
- Use a dose of 10 mg prednisolone for children under two years of age, 20 mg for children aged 2–5 years and 30–40 mg for children older than five years. Those already receiving maintenance steroid tablets should receive 2 mg/kg prednisolone up to a maximum dose of 60 mg.
- Repeat the dose of predisolone in children who vomit and consider intravenous steroids in those who are unable to retain orally ingested medication.
- Treatment for up to three days is usually sufficient, but the length of course should be tailored to the number of days necessary to bring about recovery. Tapering is unnecessary unless the course of steroids exceeds 14 days.

Inhaled corticosteroids

There is insufficient evidence to support the use of ICS as alternative or additional treatment to steroid tablets for children with acute asthma.[604, 661-668] 1++ 1+ 1-

A **Do not use inhaled corticosteroids in place of oral steroids to treat children with an acute asthma attack.**

Children with chronic asthma not receiving regular preventative treatment will benefit from starting ICS as part of their long-term management. There is no evidence that increasing the dose of ICS is effective in treating acute symptoms, but it is good practice for children already receiving ICS to continue with their usual maintenance doses.

✓ It is good practice for children already receiving inhaled corticosteroids to continue with their usual maintenance dose during an asthma attack whilst receiving additional treatment.

9.8.5 Antibiotics

There is insufficient evidence to support or refute the role of antibiotics in acute asthma, but the majority of acute asthma attacks are triggered by viral infection.[458]

✓ Do not give antibiotics routinely in the management of children with acute asthma.

9.8.6 Leukotriene receptor antagonists

Initiating oral montelukast in primary care settings, early after the onset of an acute asthma attack, can result in decreased asthma symptoms and the need for subsequent healthcare attendances in those with mild asthma attacks.[508, 669] Current evidence shows no benefit for the addition of leukotriene receptor antagonists to standard asthma treatment for moderate to severe asthma attacks.[615] 1++ 1+

9.8.7 Nebulised magnesium sulphate

There is no evidence to support the use of nebulised magnesium sulphate, either in place of or in conjunction with inhaled β_2 agonists, in children with mild to moderate asthma.[609] A subgroup analysis from a large RCT suggests a possible role in children with more severe asthma attacks (SpO_2 <92%) or with short duration of deterioration. Further studies are required to evaluate which clinical groups would benefit the most from this intervention.[670] 1++

A **Nebulised magnesium sulphate is not recommended for children with mild to moderate asthma attacks.**

C **Consider adding 150 mg magnesium sulphate to each nebulised salbutamol and ipratropium in the first hour in children with a short duration of acute severe asthma symptoms presenting with an SpO_2 <92%.**

9.9 Second-line treatment of acute asthma in children

Children with continuing severe asthma despite optimal first-line treatments, frequent nebulised β_2 agonists and ipratropium bromide plus oral steroids, and those with life-threatening features, need urgent review by a specialist with a view to management in an appropriate high-dependency area or transfer to a paediatric intensive care unit to receive second-line intravenous therapies.

Three options, IV magnesium sulphate, IV β_2 agonist or IV aminophylline can be considered. In one RCT comparing all three agents in 100 children, a bolus of magnesium sulphate was shown to reduce clinical symptoms faster than the other treatments. There were no significant side effects documented in the magnesium sulphate group.[671] A systematic review of four paediatric trials comparing IV salbutamol with IV aminophylline demonstrated equivalence. One study found a shorter length of stay in the aminophylline group although these patients received a bolus followed by an infusion, compared to a single bolus of IV salbutamol. Both IV salbutamol and IV aminophylline can cause side effects and should be administered with appropriate monitoring.[672] 1++ 1+

9.9.1 Intravenous salbutamol

The role of intravenous β_2 agonists in addition to nebulised treatment remains unclear.[590] One study has shown that an IV bolus of salbutamol given in addition to near-maximal doses of nebulised salbutamol results in clinically significant benefits for those with moderate to severe asthma.[590] 1+

B **Consider early addition of a single bolus dose of intravenous salbutamol** (15 micrograms/kg over 10 minutes) **in a severe asthma attack where the child has not responded to initial inhaled therapy.**

A continuous intravenous infusion of salbutamol should be considered when there is uncertainty about reliable inhalation or for severe refractory asthma. This should be given in a high dependency unit with continuous electrocardiogram (ECG) monitoring and twice daily electrolyte monitoring. Doses above 1–2 micrograms/kg/min (200 micrograms/ml solution) should be given in a paediatric intensive care unit setting (up to 5 micrograms/kg/min). Nebulised bronchodilators should be continued while the patient is receiving intravenous bronchodilators. Once the patient is improving the intravenous infusion should be reduced before reducing the frequency of nebulised bronchodilators.

✓ When inserting an IV cannula take a blood sample to measure serum electrolytes. Serum potassium levels are often low after multiple doses of β_2 agonists and should be replaced.

✓ If intravenous β_2 agonist infusions are used, consider monitoring serum lactate to monitor for toxicity.

9.9.2 Intravenous aminophylline

There is no evidence that aminophylline is of benefit for mild to moderate asthma and side effects are common and troublesome.[612, 614, 673, 674] One well-conducted study has shown evidence of benefit in children with acute severe asthma unresponsive to multiple doses of β_2 agonists and steroids, although the loading dose used was double that currently recommended in the UK and a third of patients were withdrawn from active medication because of vomiting.[675]

1+
2+

A **Aminophylline is not recommended in children with mild to moderate acute asthma.**

A **Consider aminophylline for children with severe or life-threatening asthma unresponsive to maximal doses of bronchodilators and steroids.**

A 5 mg/kg loading dose should be given over 20 minutes (omit in those receiving maintenance oral theophyllines) with ECG monitoring followed by a continuous infusion at 1 mg/kg/hour. Measure serum theophylline levels in patients already receiving oral treatment and in those receiving prolonged treatment.

9.9.3 Intravenous magnesium sulphate

Intravenous magnesium sulphate is a safe treatment for acute asthma in children not responding to first-line treatment.[676] Doses of up to 75 mg/kg/day (maximum 2 g) have been used. One additional trial (n=34 receiving magnesium sulphate) reported that the potential side effect of hypotension with a single dose of IV magnesium sulphate is rare.[671]

1++
1+

B **In children who respond poorly to first-line treatments, consider the addition of intravenous magnesium sulphate as first-line intravenous treatment (40 mg/kg/day).**

9.9.4 Other therapies

Heliox

There is no evidence to support the use of heliox for the treatment of acute asthma in childhood.

9.9.5 Critical care settings

In children with acute asthma and a poor response to standard therapy (inhaled bronchodilators, steroids, oxygen and intravenous bronchodilators) other therapies may be considered in the appropriate critical care setting with the appropriate available expertise. There is little high-quality evidence to guide treatment at this stage of an acute asthma attack and it is important to involve a clinician with the appropriate skills in airway management and critical care support as early as possible.

Ketamine

A systematic review of the use of ketamine for the management of acute asthma attacks in children found only one small study (n=68), among non-intubated children, suitable for inclusion. No benefit from ketamine compared with placebo in terms of respiratory rate, oxygen saturation, hospital admission rate, need for mechanical ventilation, or need for other adjuvant therapy was found.[677]

1++
2-

Sevoflurane

A small (n=7) non-comparative study of sevoflurane in children with life-threatening asthma reported that sevoflurane inhalation corrects high levels of $PaCO_2$ and provides clinical improvement in mechanically ventilated children.[678] Use of this agent is, however, limited to areas with appropriate scavenging facilities to extract gas in order to protect healthcare staff.

3

Extracorporeal membrane oxygenation

There is no good quality evidence on the use of ECMO in children, probably reflecting, in part, the low number of children who would be suitable for this approach. Extracorporeal membrane oxygenation has, however, been used successfully in other forms of critical respiratory failure in children for a number of years and there are four paediatric ECMO centres in the UK that would consider treating children with near-fatal asthma who are not responding to conventional treatment (Glenfield Hospital, Leicester; The Freeman Hospital, Newcastle; The Royal Hospital for Children, Glasgow; and Great Ormond Street Hospital, London).

Recombinant human deoxyribonuclease

There is no evidence to support the use of recombinant human deoxyribonuclease in acute asthma in children.

✓ Children with asthma not responding to standard treatment should be evaluated by a specialist with the appropriate experience and skills to use and assess medication familiar to those in critical care settings.

9.9.6 Non-invasive ventilation

A systematic review of NIV for acute asthma in children included two RCTs (n=40) comparing NIV as add-on therapy to usual care versus usual care in children under 18 years of age hospitalised for an acute asthma attack. Both included studies used bilevel positive airway pressure only. Both included studies reported improvements in asthma symptom scores. This finding is, however, based on a small number of participants and on trials assessed as having a high risk of bias.[679] | 1++

A further, observational, study reported that NIV is feasible in children with severe asthma within the paediatric intensive care unit setting, but did not include a control group for comparison of clinical outcomes.[680] | 3

Although there is some evidence that NIV is safe and feasible for use in this population, there is little evidence of its effectiveness and insufficient evidence on which to base a recommendation.

Future trials, including measurable clinical outcomes such as respiratory parameters, physiological variables and blood gases, are needed to assess the role of NIV in treating children with *status asthmaticus*.

9.9.7 Discharge planning

Children can be discharged when stable on 3–4 hourly inhaled bronchodilators that can be continued at home.[681] Peak expiratory flow and/or FEV_1 should be >75% of best or predicted and SpO_2 >94%. An asthma care bundle developed by BTS is also available from the BTS website (www.brit-thoracic.org.uk). Adult studies show that optimal care comprising self monitoring, regular review and a written PAAP can improve outcomes.[166] Acute asthma attacks should be considered a failure of preventive therapy and thought should be given about how to help families avoid further severe episodes.

Discharge plans should address the following:

- the diagnosis – clearly document the criteria used to diagnose asthma
- check inhaler technique
- consider the need for preventer treatment or optimising/adjusting previously prescribed preventer treatments
- provide a written PAAP for subsequent asthma attacks with clear instructions about the use of bronchodilators and the need to seek urgent medical attention in the event of worsening symptoms not controlled by up to 10 puffs of salbutamol 4 hourly

- assess exposure to environmental tobacco smoke or actual smoking in older children and refer to suitable agencies where appropriate
- identify the trigger of the acute attack and discuss future management plans for exposure
- arrange follow up by primary care services within two working days
- arrange follow up in a paediatric asthma clinic at about one month after admission
- arrange referral to a paediatric respiratory specialist if there have been life-threatening features.

Many children with recurrent episodes of wheeze triggered by viruses do not go on to develop atopic asthma. The need for regular preventer treatment may depend on the severity and frequency of episodes. Many may not require inhaled corticosteroids.

It is essential that the patient's primary care practice is informed within 24 hours of discharge from the emergency department or hospital following an asthma attack. Ideally this communication should be directly with a named individual responsible for asthma care within the practice, by means of fax or email.

10 Difficult asthma

10.1 Defining and assessing difficult asthma

The term difficult asthma generally refers to a clinical situation where a prior diagnosis of asthma exists, and asthma-like symptoms and asthma attacks persist, despite prescription of high-dose asthma therapy. There is no definition of difficult asthma in children or adults that is universally agreed, and specifically at what level of treatment prescription or asthma attack frequency the term difficult asthma should apply. Consequently there are no precise data on the prevalence of this clinical problem. Previous consensus studies have suggested failure to achieve symptom control despite prescribed high-dose ICS as a minimum requirement, or have stipulated a treatment level equivalent to at least high-dose ICS (adults) or medium-dose ICS (children) plus a LABA or LTRA *(see section 7.5.2)* before labelling as 'difficult'.[682, 683]

In this guideline difficult asthma is defined as persistent symptoms and/or frequent asthma attacks despite treatment with high-dose ICS (adults) or medium-dose ICS (children) plus a LABA (age 5 and over) or LTRA; or medium-dose ICS (adults) or low-dose ICS (children) plus a LABA (age 5 and over) and an appropriate additional therapy *(see section 7.5.2);* or continuous or frequent use of oral steroids *(see section 7.5.3).*

Observational uncontrolled studies in participants with difficult asthma, using multidisciplinary assessment models have identified high rates of alternative or coexistent diagnoses and psychological comorbidity.[97, 684-686] These uncontrolled studies, using systematic multidisciplinary assessment and management, have suggested improved outcomes in adults and children, but controlled clinical trials are required. Within this broadly defined group of participants with difficult asthma, a proportion will have refractory disease, which is relatively resistant to currently available therapies. This group can only be identified after detailed evaluation, including exclusion of alternative causes of persistent symptoms, management of other comorbidities and confirmation of adherence with therapy. | 3

D

Patients with difficult asthma should be systematically evaluated, including:

- **confirmation of the diagnosis of asthma, and**
- **identification of the mechanism of persisting symptoms and assessment of adherence to therapy.**

D

This assessment should be facilitated through a dedicated multidisciplinary difficult asthma service, by a team experienced in the assessment and management of difficult asthma.

10.2 Factors contributing to difficult asthma

10.2.1 Poor adherence

Poor adherence with asthma medication is associated with poor asthma outcome in adults and children (*see section 5.4*). Two UK studies in adults attending specialist difficult asthma services documented high levels of poor adherence identified by low prescription filling. A study of 182 patients in the Northern Ireland Regional Difficult Asthma Service found that 63 patients (35%) filled 50% or fewer inhaled LABA/ICS prescriptions and 88% admitted poor adherence with inhaled therapy after initial denial; 23 of the 51 patients (45%) prescribed oral steroids were found to be non-adherent using serum prednisolone/cortisol testing.[687] In another study, 75 of 115 (65%) patients filled prescriptions for <80% of ICS medication and had significantly worse lung function, higher sputum eosinophil counts and prior ventilation compared to adherent patients.[688] A study of 71 school-aged children with persistent symptoms, despite high-dose treatment or continuous or frequent use of oral steroids, attending one hospital in London, found that 56 (79%) had potentially modifiable risk factors, the two most common of which were psychosocial factors (59%) and medication issues | 2^+ | 3

including adherence (48%). In 39 children (55%) the factors identified and the interventions recommended meant that further escalation of treatment was avoided.[689] In a paediatric case-control series, poor adherence based on prescription records was identified in 22% of children with difficult to control asthma, although adherence was not reported in the stable controls.[690] In a descriptive study of 100 adult participants with a physician diagnosis of 'severe asthma', 28 patients were on >15 mg prednisolone and of these nine (32%) were found to be non-adherent with prednisolone.[685]

There is a need to identify patients who have poor control solely as a result of poor adherence to simple therapies that are currently available. In theory, improving adherence through monitoring and intervention could potentially reduce asthma attacks, target resources for genuine therapy-resistant cases and reduce overall health costs by minimising asthma attacks, hospitalisation and health resource use.

Monitoring adherence is likely to be beneficial to asthma control and there is some evidence that it can improve lung function and quality of life.[691] Adherence monitoring based on self assessment is unlikely to be accurate and objective measures are therefore needed. An ancillary study to an RCT showed that there was very poor agreement between objective (doses remaining in Turbohaler device) and subjective (self-reported) measurements of adherence in children aged 5–12 years with mild or moderate asthma and airway hyper-responsiveness to methacholine, and that self reporting failed to detect poor adherence.[234] Objective measurement of non-adherence based on FeNO suppression in adults with difficult asthma was demonstrated in one study although further validation of this test is required.[244] Some other objective measures such as prescription filling are problematical because patients may fill prescriptions but not take the medication. 1+

C **Healthcare professionals should always consider poor adherence to maintenance therapy before escalating treatment in patients with difficult asthma.**

10.2.2 Psychosocial factors

Fatal and near-fatal asthma have been associated with adverse psychosocial factors *(see section 9.1.3)*. Most observational studies[97, 685, 692-695] and a case-control study[696] in patients with difficult asthma have also suggested a high level of psychological morbidity, though this observation has not been universal.[697, 698] 2+ 3

A meta-analysis of behavioural adjustment in children suggested increasing asthma severity, defined on the basis of treatment requirements, was associated with greater behavioural difficulties.[699] The core issue of cause and effect remains unclear; specifically the extent to which persistent asthma symptoms, despite aggressive treatment, results in psychological morbidity or whether pre-existing psychological morbidity makes asthma difficult to control. 2++

There is a lack of evidence that interventions specifically targeting psychological morbidity in patients with difficult asthma are of benefit. A small proof of concept study targeting treatment of depression demonstrated a reduction in oral steroid use,[700] and an observational study in high-risk children with asthma suggested potential benefit from joint consultation with a child psychiatrist, with an improvement in symptom scores and adherence to therapy.[701] However, a non-blinded randomised intervention study in adults with difficult asthma showed no benefit from a six-month nurse-delivered psychoeducational programme.[702] A meta-analysis of psychoeducational interventions in patients with difficult asthma concluded that many of the studies were of poor quality, although there was some evidence of a positive effect from psychosocial educational interventions on hospital admissions in adults and children and on symptoms in children. There was not enough evidence to warrant significant changes in clinical practice and little information available on cost effectiveness.[703] 1+ 3

C **Healthcare professionals should be aware that difficult asthma is commonly associated with coexistent psychological morbidity.**

D	**Assessment of coexistent psychological morbidity should be performed as part of a difficult asthma assessment. In children this may include a psychosocial assessment of the family.**

10.2.3 Dysfunctional breathing

Observational uncontrolled studies in patients with difficult asthma have identified high rates of dysfunctional breathing as an alternative or concomitant diagnosis to asthma. The dysfunctional breathing may cause symptoms that mimic asthma or coexist with asthma, worsening symptoms.[97, 685] It remains unclear what is the best mechanism of identifying and managing this problem. | 3

D	**Dysfunctional breathing should be considered as part of the assessment of patients with difficult asthma.**

10.2.4 Allergy

Acute asthma has been associated with IgE-dependent sensitisation to indoor allergens.[704] In case-control studies, mould sensitisation has been associated with recurrent admission to hospital and oral steroid use[705, 706] and with intensive care unit admissions and respiratory arrest.[707, 708] There is no published evidence of any intervention study in this patient group. Research in this area is required. | 2++ 3

C	**In patients with difficult asthma and recurrent hospital admission, allergen testing to moulds should be performed.**

10.2.5 Monitoring airway response

Two blinded RCTs and one open randomised study have supported the use of titrating steroid treatment against sputum eosinophilia in adults with moderate to severe asthma, with greatest benefit seen in patients receiving higher doses of ICS therapy.[709-711] In the study with the largest number of patients receiving high-dose ICS treatment, patients who were considered to be poorly adherent with treatment, or had inadequately controlled aggravating factors, such as rhinitis or gastro-oesophageal reflux were specifically excluded.[709] Case series have suggested that sputum induction is safe in patients with difficult to control asthma.[67, 712-715] | 1+ 1- 3

Controlled studies using FeNO to target treatment have not specifically targeted adults or children with difficult asthma.[716, 717] | 1+

B	**In patients with difficult asthma, consider monitoring induced sputum eosinophil counts to guide steroid treatment.**

11 Asthma in adolescents

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

12 Asthma in pregnancy

12.1 Natural history and management of stable asthma

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

12.2 Management of acute asthma in pregnancy

The management of acute asthma in pregnancy may be affected by concerns about harmful effects of medication on the fetus. In a prospective controlled study of 51 pregnant women and 500 non-pregnant women presenting with acute asthma to an emergency department in Boston, USA, pregnant patients with asthma were less likely to receive appropriate treatment with steroids and, as a result, were more likely to experience ongoing asthma attacks at two weeks.[806] Available studies give little cause for concern regarding treatment side effects and the maternal and fetal risks of uncontrolled asthma are much greater than the risks from using conventional asthma medications for management of acute asthma. In five confidential enquiries into maternal deaths in the UK (covering 1994–2008) there were 22 deaths from asthma.[807-811] A report from the Intensive Care National Audit and Research Centre on female admissions to adult critical care units in England, Wales and Northern Ireland between 2009 and 2012 found that of 1,188 currently pregnant women, 94 (8%) were admitted with acute asthma and of 5,605 postpartum women, 32 (0.6%) were admitted with acute asthma.[812] 2+

Oxygen should be delivered to maintain saturation 94–98% in order to prevent maternal and fetal hypoxia.[578] `When interpreting arterial blood gases in pregnancy it should be remembered that the progesterone-driven increase in minute ventilation may lead to relative hypocapnia and a respiratory alkalosis, and higher PaO_2[813, 814] but oxygen saturations are unaltered.[815] Acidosis is poorly tolerated by the fetus. 4

Drug therapy should be given as for a non-pregnant patient with acute asthma, including nebulised β_2 agonists and early administration of steroid tablets *(see section 9)*.[788, 794, 795, 798, 799] In severe cases, intravenous β_2 agonists, aminophylline or intravenous bolus magnesium sulphate can be used as indicated.[816] 2+

Continuous fetal monitoring should be performed when asthma is uncontrolled or severe, or when fetal assessment on admission is not reassuring. Consideration should be given to early referral to critical care services as impaired ventilatory mechanics in late pregnancy can lower functional residual capacity and may result in earlier oxygen desaturation.[817] Pregnant women may be more difficult to intubate due to anatomical changes especially if they have pre-eclampsia.[818]

C **In pregnant patients, give drug therapy for acute asthma as for non-pregnant patients including systemic steroids and magnesium sulphate.**

D **In pregnant patients with acute asthma, deliver high-flow oxygen immediately to maintain saturation 94–98%.**

D **Acute severe asthma in pregnancy is an emergency and should be treated vigorously in hospital.**

✓ Continuous fetal monitoring is recommended for pregnant women with acute severe asthma.

✓ For women whose asthma is poorly-controlled during pregnancy there should be close liaison between the respiratory physician and obstetrician, with early referral to critical care physicians for women with acute severe asthma.

12.3 Drug therapy in pregnancy

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

12.4 Management during labour

Acute attacks of asthma are very rare in labour, perhaps due to endogenous steroid production. In women receiving steroid tablets there is a theoretical risk of maternal hypothalamic-pituitary-adrenal axis suppression. Women with asthma may safely use all forms of usual labour analgesia.

In some studies there is an association between asthma and an increased Caesarean section rate,[797, 851, 852] but this may be due to planned Caesarean sections or inductions of labour rather than due to any direct effect of asthma on intrapartum indications.[795] A large prospective cohort study comparing women with moderate and severe asthma with women without asthma found the only significant difference was an increased Caesarean section rate (OR 1.4, 95% CI 1.1 to 1.8).[789] 2+

Data suggest that the risk of postpartum asthma attacks is increased in women having Caesarean sections.[851] This may relate to the severity of their asthma rather than to the Caesarean section, or to factors such as postoperative pain with diaphragmatic splinting, hypoventilation and atelectasis. Prostaglandin E2 may safely be used for labour inductions.[841] Prostaglandin F2α (carboprost/hemobate®) used to treat postpartum haemorrhage due to uterine atony may cause bronchospasm.[841] Although ergometrine may cause bronchospasm particularly in association with general anaesthesia,[841] this is not a problem encountered when syntometrine (syntocinon/ergometrine) is used for postpartum haemorrhage prophylaxis. 2-3

Although suppression of the fetal hypothalamic-pituitary-adrenal axis is a theoretical possibility with maternal systemic steroid therapy, there is no evidence from clinical practice or the literature to support this.[853]

✓ Advise women that an acute asthma attack is rare in labour.

✓ Advise women to continue their usual asthma medications in labour.

✓ In the absence of an acute severe asthma attack, reserve Caesarean section for the usual obstetric indications.

✓ If anaesthesia is required, regional blockade is preferable to general anaesthesia in women with asthma due to the potential risk of bronchospasm with certain inhaled anaesthetic agents.

✓ Women receiving steroid tablets at a dose exceeding prednisolone 7.5 mg per day for more than two weeks prior to delivery should receive parenteral hydrocortisone 100 mg 6–8 hourly during labour.

D **Use prostaglandin F2α with extreme caution in women with asthma because of the risk of inducing bronchoconstriction.**

12.5 Drug therapy for breastfeeding mothers

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

13 Occupational asthma

13.1 Incidence

The true frequency of occupational asthma is not known, but underreporting is likely. Published reports, which come from surveillance schemes, compensation registries or epidemiological studies, estimate that occupational asthma may account for about 9–15% of adult onset asthma.[858-860] It is now the commonest industrial lung disease in the developed world with over 400 reported causes.[861-863] 2++

The diagnosis should be suspected in all adults with symptoms of airflow limitation, and positively searched for in those with high-risk occupations or exposures. Patients with pre-existing asthma aggravated non-specifically by dust and fumes at work (work-aggravated asthma) should be distinguished from those with pre-existing asthma who become additionally sensitised to an occupational agent.

B **In patients with adult onset, or reappearance of childhood asthma, healthcare professionals should consider that there may be an occupational cause.**

13.2 At-risk populations

Several hundred agents have been reported to cause occupational asthma and new causes are reported regularly in the medical literature.

The most frequently reported causative agents include isocyanates, flour and grain dust, colophony and fluxes, latex, animals, aldehydes and wood dust.[864-872]

The workers most commonly reported to occupational asthma surveillance schemes include paint sprayers, bakers and pastry makers, nurses, chemical workers, animal handlers, welders, food processing workers and timber workers.[864, 865, 867, 869-875] 2++

Workers reported to be at increased risk of developing asthma include bakers, food processors, forestry workers, chemical workers, plastics and rubber workers, metal workers, welders, textile workers, electrical and electronic production workers, storage workers, farm workers, waiters, cleaners, painters, dental workers and laboratory technicians.[876-879] 2+

13.3 Diagnosis

Occupational asthma should be considered in all workers with symptoms of airflow limitation *(see Annex 10)*. The best screening question to ask is whether symptoms improve on days away from work. This is more sensitive than asking whether symptoms are worse at work, as many symptoms deteriorate in the hours after work or during sleep. The use of non-leading questions is advocated.[880] Asthma symptoms reported by the use of a questionnaire to be better on days away from work have been shown to have a sensitivity of 58–100% for subsequently validated occupational asthma and specificities of 45–100%, with wheeze and shortness of breath the symptoms most commonly reported.[881] There is also some evidence that free histories taken by experts may have a higher sensitivity than patient questionnaires administered by experts, but their specificity may be lower for a diagnosis of occupational asthma.[881] 4

One study notes a relatively low positive predictive value of work related symptoms.[882] 3

✓ Adults with suspected asthma or unexplained airways obstruction should be asked:

- Are you the same, better, or worse on days away from work?
- Are you the same, better, or worse on holiday?

Those with positive answers should be investigated for occupational asthma.

Occupational asthma can be present when tests of lung function are normal, limiting their use as a screening tool. Asthmatic symptoms improving away from work can produce false negative diagnoses, so further validation is needed.

Serial measurement of peak respiratory flow is the most readily available initial investigation, and the sensitivity and specificity of serial peak-flow measurement in the diagnosis of occupational asthma are high.[883-890] 3

Although skin-prick tests or blood tests for specific IgE are available, there are few standardised allergens commercially available which limits their use. A positive test denotes sensitisation, which can occur with or without disease. The diagnosis of occupational asthma can usually be made without specific bronchial provocation testing, considered to be the gold standard diagnostic test. The availability of centres with expertise and facilities for specific provocation testing is very limited in the UK and the test itself is time consuming.

As a general observation, the history is more useful in excluding occupational asthma than in confirming it. A significant proportion of workers with symptoms that improve on days away from work or on holiday have been shown by objective tests not to have occupational asthma.[891] 3

D **In suspected work-related asthma, the diagnosis of asthma should be confirmed using standard objective criteria.**

13.3.1 Sensitivity and specificity of serial peak-flow measurements

In a meta-analysis of 31 studies in which a variety of reference standards were used, the pooled sensitivity and specificity of serial PEF measurements were 75% and 79% respectively. Higher values (82% and 88%) were obtained from pooling studies where more complete series of measurements had been made, achieved by 61% of the analysed population. Visual analysis was more sensitive (78% *v* 71%) but less specific (69% *v* 91%) than computer-based methods.[890] 2^-

There are several validated methods for interpreting serial PEF records for a diagnosis of occupational asthma which differ in their minimal data requirements. The original discriminant analysis method requires:

- at least three days in each consecutive work period
- at least four evenly spaced readings per day
- at least three series of consecutive days at work with three periods away from work (usually about three weeks).[892]

Shorter records without the requirement for three consecutive days at work can be analysed using the area between curves score. This requires at least eight readings a day on eight work days and three rest days.[893] A statistical method using the addition of timepoint analysis requires the waking time to be similar on rest and work days.[894] 2^+ 3

The analysis is best done with the aid of a criterion-based expert system. Suitable record forms and support are available from www.occupationalasthma.com

D **Objective diagnosis of occupational asthma should be made using serial peak-flow measurements, with at least four readings per day.**

13.3.2 Diagnosis of validated cases of occupational asthma using Ige testing

A review by the British Occupational Health Research Foundation states that, "...the respective sensitivities and specificities of the ability of skin-prick or serological tests to detect specific IgE vary between allergens and depend on the setting of positive cut-offs".[881] The sensitivities and specificities of serum-specific IgE antibodies to low molecular weight agents depends on whether the antibodies have been properly characterised and the availability of 4

appropriate hapten conjugates. The presence of specific IgE confirms sensitisation but alone does not confirm the presence of occupational asthma, nor necessarily its cause.[881] The review concluded that skin-prick testing or tests for specific IgE should be used in the investigation of occupational asthma caused by high molecular weight agents but are less sensitive for detecting specific IgE and occupational asthma caused by low molecular weight agents. In neither case are the tests specific for diagnosing asthma.[881]

D **Skin-prick testing or tests for specific IgE should be used in the investigation of occupational asthma caused by high molecular weight agents.**

D **Skin-prick testing or tests for specific IgE should not be used in the investigation of occupational asthma caused by low molecular weight agents.**

13.3.3 Non-specific reactivity

Studies of non-specific reactivity are confounded by the different methods used, different cut-offs for normality and the interval between last occupational exposure and the performance of the test (an increase in time interval may allow recovery of initial hyper-reactors). A single measurement of non-specific reactivity has been shown to have only moderate specificity and sensitivity for the validation of occupational asthma and changes in non-specific reactivity at and away from work alone have only moderate sensitivity and specificity for diagnosis.[881, 895]

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D **A single measurement of non-specific reactivity should not be used for the validation of occupational asthma.**

13.3.4 Specific bronchial provocation testing

Specific inhalation challenges (SIC) with occupational agents should only be carried out in hospitals with expertise in using occupational agents, and should always include: a control challenge on a separate day; a gradual increase of exposure to the suspected occupational agent; close monitoring of airway calibre during the challenge and for at least six hours after the end of the exposure.[896] When carrying out specific challenge testing, an increased duration of allergen exposure may increase the overall diagnostic sensitivity of the tests.[897]

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A positive SIC is one in which the FEV_1 falls by ≥15% from baseline; either within the first hour after exposure (an immediate reaction) or later (a late reaction) or both. Alternatively for late reactions, two measurements below the 95% CI for three days away from exposure have been validated as a positive test.[898] Equivocal reactions can sometimes be clarified by finding changes in non-specific bronchial responsiveness, sputum eosinophils or exhaled nitric oxide. Specific inhalation challenge is generally a safe procedure; excessive reactions are rare with <3% of patients needing repeated doses of a bronchodilator and steroid treatment.

The sensitivity and specificity of SIC are high but not easily quantified as the method is usually used as the reference standard for the diagnosis of occupational asthma. False negative tests also occur, and SIC testing may be of less value where complex workplace exposures cannot be replicated in the laboratory. SIC remains the gold standard for making a diagnosis of occupational asthma.

13.3.5 Sputum eosinophilia

Eosinophilic bronchial inflammation can be assessed by cell counts in fresh sputum, induced by inhaling hypertonic saline.[881, 895, 899] Studies have shown that induced sputum eosinophilia is not sufficiently sensitive or specific to help in the diagnosis of occupational asthma although it may help in the interpretation of equivocal SIC reactions.[881] In the clinical setting the absence of sputum eosinophilia does not exclude a diagnosis of occupational asthma.[881]

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13.3.6 Exhaled nitric oxide

The 2010 review by the British Occupational Health Research Foundation states that, "...the measurement of exhaled nitric oxide produced by inflammatory and epithelial cells in the respiratory tract is non-invasive and has been studied extensively in non-occupational asthma, although it has not been fully validated as an effective diagnostic test for occupational asthma". The review concluded that the role of exhaled nitric oxide measurements in the diagnosis of occupational asthma in this setting is not established.[881] 4

13.3.7 Exhaled breath condensate

Exhaled breath condensate may offer assistance in those undergoing diagnostic testing for occupational asthma. Its definitive utility is not yet understood.[900, 901] 3

13.4 Management of occupational asthma

The aim of management is to identify the cause, remove the worker from exposure, and for the worker to have worthwhile employment.

Complete avoidance of exposure may or may not improve symptoms and bronchial hyper-responsiveness. Both the duration of continued exposure following the onset of symptoms and the severity of asthma at diagnosis may be important determinants of outcome. Early diagnosis and early avoidance of further exposure, either by relocation of the worker or substitution of the hazard offer the best chance of complete recovery. Workers who remain in the same job and continue to be exposed to the same causative agent after diagnosis are unlikely to improve and symptoms may worsen. The likelihood of improvement or resolution of symptoms or of preventing deterioration is greater in workers who have no further exposure to the causative agent.[885, 902-910] 2^{++}

Several studies have shown that the prognosis for workers with occupational asthma is worse for those who remain exposed for more than one year after symptoms develop, compared with those removed earlier.[911-913]

D **Relocation away from exposure should occur as soon as diagnosis is confirmed, and ideally within 12 months of the first work-related symptoms of asthma.**

There is consistent evidence from clinical and workforce case series that about one third of workers with occupational asthma are unemployed after diagnosis. It is unclear whether this risk is higher than that for other adults with asthma.[914-916] The risk of unemployment may fall with increasing time after diagnosis.[917] There is consistent evidence that loss of employment following a diagnosis of occupational asthma is associated with loss of income. Adults with occupational asthma may find employment more difficult than adults with non-occupational asthma.[915, 916] Approximately one third of workers with occupational asthma have been shown to be unemployed up to six years after diagnosis.[913-921] 2^{-}

14 Organisation and delivery of care

14.1 Care pathways

Clinical care pathways are "...structured multidisciplinary care plans used by health services to detail essential steps in the care of patients with a specific clinical problem. They aim to link evidence to practice and optimise clinical outcomes whilst maximising clinical efficiency."[922]

There is little high-quality evidence from randomised trials addressing the impact of care pathways for asthma. Pathways have usually been implemented through a training session or programme. Two interventions, one to establish pathways for the management of people with high-risk asthma in UK primary care, the other to establish pathways for children with acute and chronic asthma in New Zealand primary care, led to non-significant reductions in ED attendance and hospitalisation.[923, 924] Pathways for inpatient care can improve processes of care, such as prescription of oral prednisolone and use of written asthma action plans in children,[925] and can reduce length of stay for children,[646, 926] but have not improved follow up in general practice after discharge.[927]

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Further well-conducted studies are needed to define the benefits of care pathways for asthma. These should include large studies suitably powered to clarify the impact of pathways promoting systematic management of people with high-risk asthma in UK primary care, and pathways integrating asthma care across the primary/secondary care interface.

14.2 Educating clinicians

There is strong evidence that educating clinicians can improve health outcomes for patients. Two large Cochrane systematic reviews (covering all clinical conditions, not just asthma) found that:

- educational outreach visits (for example training visits to general practices) lead to small to moderate improvements in outcomes[928]
- mixed interactive and didactic education is more effective than either alone.[929]

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Several models of clinician education specifically for asthma have been tested in randomised trials and these broadly support the conclusions of the two Cochrane reviews. The most consistently effective of these for asthma comprises educational outreach visits which deliver multifaceted training, based on theoretical models of behaviour change, including training in consultation styles and delivery of key messages. Several studies have tested the American-developed Physician Asthma Care Education (PACE) paediatric asthma programme,[189, 930] or adaptations of it for Australian and UK practice,[217, 931] and have shown reductions in ED visits,[930] improved symptom control,[217] and increased use of written asthma action plans.[931] The PACE intervention has not been tested for adult populations and there is little experience of its use in the UK.

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In the USA, peer education comprising intensive training of a 'practice asthma champion' who in turn trained and supported colleagues, led to fewer asthma attacks in children.[932] Practice asthma champions were trained in pharmacotherapy and physician behaviour change techniques, and received ongoing support for their role as a 'change agent'. They received guideline summaries, key targets for their physician colleagues and feedback on their colleagues' performance along with monthly support from a nurse co-ordinator. When this peer education programme was combined with intensively trained outreach nurses implementing patient reviews (the Planned Care Model), children experienced fewer asthma symptoms and fewer asthma attacks.

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These interventions illustrate that, to effect change, interventions need to be of sufficient intensity to engage with, and change, the way practices are organised.

Less intensive educational interventions, such as brief outreach visits comprising simple group education are less effective, showing no impact on symptoms, quality of life, or healthcare use.[933-936] 1+ 1-

Remote IT educational interventions, such as remote spirometry training,[937] may be effective but have not been widely tested.

Further large-scale studies, carried out in the UK, are needed to test the impact of intensive educational interventions, such as adapted PACE and peer education programmes

B **Training for primary care clinicians should include educational outreach visits using multifaceted programmes that include consultation training including goal setting**

14.3 Asthma clinics

14.3.1 Structured review

This section has been superseded by Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and is included in the Asthma pathway (SIGN 244).

14.3.2 Primary care asthma clinics

Primary care asthma clinics can be defined as a "...proactive system of care sited in primary care (for example GP clinic) which occupies a defined and often regular clinical session for the routine review of patients with asthma".[945]

Within primary care, structured reviews may be delivered as appointments in routine surgeries, or within dedicated asthma clinics.

One systematic review which included three small studies of the asthma clinic model, showed no evidence of improvement in important outcomes such as hospitalisation, ED attendances, or quality of life, although there was a reduction in night-time waking, and no evidence that clinics were cost effective.[945] The poor quality of the included studies led the review to conclude that there was a lack of evidence to inform the best way to organise structured asthma care in practice. 1++

There is, however, no evidence that these clinics do harm. Asthma reviews in primary care may best be carried out, however, during routine surgeries rather than a dedicated asthma clinic.

14.3.3 Specialist asthma clinics

The evidence for whether specialist asthma clinics improve outcomes for people with severe or difficult asthma was limited to one systematic review, including 17 studies, many of poor quality and underpowered.[172] The review focused on psychoeducational interventions mostly for adults and adolescents (age 16 or older) with difficult or severe asthma, so provided incomplete evidence on the ideal content of such clinics. The review found that these interventions reduced hospitalisations (but not ED attendances) in adults and children, and improved symptoms in children. The authors concluded that the strength of evidence was insufficient to change practice. 2+

Further trials testing the impact of clinics run by specialists in asthma care are needed.

C **Consider including psychoeducational interventions in clinics for adults and children with difficult asthma.**

14.4 Telehealthcare

Telehealthcare is evolving rapidly and terminology is changing and is used inconsistently in the literature and in practice. In this guideline, 'telehealthcare' is used as an overarching term for all technology-enabled healthcare. Within this, telemonitoring implies collection and transfer of patient data; teleconsultation is the use of technology to enable remote consultation between a patient and a clinician; and telemedicine is interprofessional consultation.

14.4.1 Supporting self management

Telehealthcare embraces a range of functionalities which target different aspects of self-management behaviour including automated medication reminders to improve adherence,[946] educational games to improve knowledge[170, 181, 266, 947] or effect behavioural change,[201, 948, 949] and telemonitoring with various levels of professional oversight to support self management.[212, 950-955] These functions may use different IT modalities (text messaging,[171, 956] automated telephone calls,[267] 'apps',[953] computer games,[170, 181, 266] cloud-based electronic health records,[953-955]) and may be delivered in different contexts (primary/community care,[212, 267, 952, 953] hospital outpatients,[947] school based[181, 201, 266, 949]) which may influence their impact. In the fast moving context of telehealthcare, the aim of the intervention and the theoretical underpinning is likely to be more important to interpreting the evidence than details of the mode of delivery.

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Automated reminders to improve adherence

In the short term, and in the context of a clinical trial, automated reminders (delivered by text messaging, alarms, or automated telephone calls) can improve adherence to medication, but do not have an impact on clinical outcomes.[946] As part of more complex telehealthcare interventions, reminders may contribute to improved adherence to monitoring or medication use.[171, 954-956]

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Computer-based educational games to improve knowledge or affect behaviour

Educational games improved asthma knowledge in most, but not all participants in school-based interventions,[170, 181, 266] and children attending a UK outpatients clinic.[947] The latter study showed reduced school absenteeism and the number of steroid courses,[947] but overall there is an inconsistent effect on clinical outcomes,[170, 181, 266] and no impact on use of healthcare resources.[181, 266, 947]

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Games based on behavioural change theories have resulted in some improvement in self-management skills, although impact on symptoms and use of healthcare resources is variable. A generic health behaviour game which targeted teenagers with specific behavioural traits (such as rebelliousness, poor emotional support or low self esteem), improved asthma control, reduced absenteeism, and reduced admissions, but did not reduce ED attendances.[201, 949]

1+

Telemonitoring to support self management

Telemonitoring, the transmission of monitoring data from a patient to an electronic health record which can be shared with (or monitored by) healthcare professionals, is promoted as having the potential to improve outcomes.

Some studies have demonstrated improvement in at least one clinical outcome, such as measures of asthma control,[952, 955] lung function,[212] quality of life, reduced risk of activity limitation,[212] and school absenteeism, exacerbations, and use of unscheduled care.[212] Other trials, however, have shown no impact on asthma control or use of healthcare resources.[951, 953]

These interventions are heterogeneous, and the impact of the telemonitoring is likely to be strongly influenced by the demographic context (deprivation status and cultural background[212, 952]), and the level of professional support provided (frequency of monitoring,[212, 954] personalisation of feedback,[954] access to case-management support[952]).

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People with poorly-controlled asthma have the potential to gain more by engaging with telemonitoring than those whose control is already optimal.[955] Telehealthcare-supported self management offered no clinical benefits over care delivered in traditional ways that was already guideline standard.[953]

Despite the heterogenous interventions, the overarching findings from the systematic reviews are consistent and show that telehealthcare:

- can improve process outcomes, such as knowledge,[170, 181, 957] adherence to monitoring,[171] self-efficacy/self-management skills,[181, 948, 957] and increased use of preventer medication,[946, 956, 957] at least in the short term[946]
- has an inconsistent effect on clinical outcomes, such as symptoms,[170, 171, 181, 948, 950, 951, 956, 957] SABA use,[170] lung function,[170, 171, 950, 956, 957] school absenteeism,[181, 957] activity limitation,[950, 957] quality of life,[181, 950, 951, 957] and oral steroid courses[948]
- generally has no effect on unscheduled use of healthcare resources (such as hospitalisations and ED attendances),[170, 951, 956, 957] out-of-hours consultations,[951] and GP consultations[951, 957]
- has cost implications relating to providing and supporting telehealthcare services[171, 951]
- has no identified harms and whilst the telehealthcare intervention was often no better than usual care, there were no instances in which it was less effective.

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Telehealthcare is a means of delivering care, not a panacea. Overall, clinical outcomes with telehealthcare are at least as good as, though not consistently superior to, traditionally delivered care. Information technology-based approaches may, therefore, be considered where organisational/clinical/social circumstances or clinician and patient preferences or convenience suggest they may be appropriate.

C **Telehealthcare may be considered as an option for supporting self management.**

14.4.2 Remote consulting

Remote consulting can be either asynchronous, with information exchanged sequentially, for example via email, text or web, or synchronous, with information exchange by, for example, telephone.

Evidence to support either approach in patients with asthma is very limited. Two systematic reviews of asynchronous remote consulting covering 15 RCTs and 52 other studies, most of them observational, included only four studies addressing asthma, two of them RCTs, one of which was of poor quality.[958, 959] Although both reviews suggest that asynchronous telehealthcare led to significant reductions in healthcare use and some improvement in disease status (for example HbA1c in diabetes), the evidence relating to asthma is limited and of low quality and no conclusions can be drawn about its effectiveness in this patient group.

1^+

Evidence to support synchronous consulting in patients with asthma is also limited and, in general, did not address major outcomes of importance. Of four RCTs identified,[213, 267, 960, 961] two were considered to be of low methodological quality.[213, 267] There is some evidence to suggest that synchronous consulting can lead to improvements in parental QoL,[960] and equivalent health status to people reviewed in 'traditional' face-to-face consultations.[961]

1^{++} 1^-

14.4.3 Computerised decision support systems

Computerised decision support systems (CDSS) can broadly be divided into systems targeted at healthcare professionals and integrated within the electronic health record, and web-based systems that are used by patients (and their healthcare professionals) to support self management.

A systematic review of eight RCTs considering the impact on asthma control of CDSS used by healthcare practitioners found little effect on patient outcomes because the healthcare

1^+

practitioners rarely used the CDSS being evaluated and when used, rarely followed the advice given. Future CDSS need to align better with professional workflows so that pertinent and timely advice is easily accessible within the consultation. The authors concluded that integration of CDSS into electronic health records is cumbersome and a major factor in their ineffectiveness.[962]

A second review of 19 RCTs concluded that CDSS can improve chronic disease processes and outcomes. This conclusion, however, reflects the inclusion of four trials of systems used by patients to promote self management, three of which reported improved asthma control or QoL, although one, with a high risk of bias, improved symptoms and QoL but led to increased unscheduled care.[963] 1++

A **Computerised decision support systems for patient use can be considered as an approach to supporting self management.**

14.5 School-based interventions

Most school-based asthma interventions focus on education delivered by adults (usually healthcare professionals) to school children.[181] Other approaches include peer education, whereby students are trained and then, in turn, train their peers,[772, 964] web-based programmes,[201] or directly-observed therapy with ICS medication,[787] which may additionally include education of parents (see also section 11.11.2).[965] One study tested a multifaceted intervention combining education of schoolchildren with additional training of their doctor, including provision of self-management plans.[966] Most evaluations have been based in the USA, often involving minority ethnic groups not directly applicable to the UK.

Education for children in schools generally led to improvements in symptom control and quality of life, but had no impact on healthcare use.[181] Peer education was effective for adolescents[772] but not preteens.[964] In two studies, directly observed therapy improved symptom control.[787, 965] Of all the school-based interventions tested, Bruzzese's multifaceted programme had the most impact, improving symptoms, quality of life, emergency department use and hospitalisation.[966] 1+ 1- 2+

B **Consider a multifaceted approach to school-based asthma education programmes targeting children's healthcare professionals as well as the children themselves.**

14.6 Ethnicity/culture-based interventions

The majority of studies examining ethnicity and culture-based interventions that tailor asthma education for people from minority ethnic groups have been carried out in the USA. Further details on the aspects of tailoring can be found in section 5.3.5.

A review of system-level interventions concluded that the most effective at reducing further healthcare use were those targeted at people who had attended emergency care or had been hospitalised.[186] Interventions were usually intensive, multisession clinic-based programmes. They were nurse-led or used experts including pharmacists or allergy specialists.[186] These findings mirror the little work published in the UK, which showed that a clinic based in primary care was ineffective,[206] while a specialist nurse-led intervention targeted at those attending emergency care reduced further unscheduled care, albeit less in people from ethnic minority groups than in those from white populations.[207] 1+

Further studies examining the impact of interventions on people from minority ethnic groups in the UK are needed.

C **Establish intensive clinic-based programmes for people from ethnic minority groups who have attended emergency care.**

14.7 Lay-led interventions

Educational interventions led by lay, rather than healthcare professionals, have become popular in the last decade. The NHS Expert Patient Programme, a six-week group education programme, is an example. Programmes are usually generic; people attending may have a range of conditions, not specifically asthma.

A systematic review including 17 RCTs of lay-led self-management education programmes was identified.[967] Only two of the included trials specifically addressed people with asthma, and these found no improvements in breathlessness, health-related quality of life, healthcare use, days/nights spent in hospital, and no change in disease-specific knowledge. Overall, lay-led self-management interventions may lead to small, short-term improvements in participants' self efficacy, self-rated health, cognitive symptom management, and frequency of aerobic exercise. There is, however, currently no evidence to suggest that these interventions alter healthcare use or are cost effective. 1+

A **Lay-led self-management programmes for people with asthma are not recommended.**

14.8 Pharmacist-led interventions

Pharmacists have opportunities to provide education for people with asthma, and furthermore, may be able to identify those with poor asthma control. The body of evidence for pharmacy-based interventions is, however, methodologically weak or of limited relevance. Two systematic reviews were assessed. One review addressed interventions in low and middle income countries, while another addressed pharmacy interventions more generally.[968, 969]

Interventions generally involved educating community pharmacists to, in turn, educate patients.[970-972] Other models or elements included follow-up reviews for newly prescribed medication,[973] identifying those with poor control by using questionnaires such as the Asthma Control Test,[972] searching prescribing databases for patients using large numbers of reliever inhalers,[974] and targeting reviews or referral to general practitioners.

Overall, the most consistent improvements in outcomes were seen in inhaler technique,[970-972] with a few studies showing improvements in reduced dispensing of, or need for, reliever inhalers.[972, 974] There was no convincing evidence of reduction in healthcare use. 1+ 1-

Further high-quality randomised trials testing pharmacist-led interventions to improve asthma outcomes are needed.

✓ Consider training pharmacists to provide education for people with asthma.

15 Provision of information

The provision of accurate information to patients and carers is of great importance in order to achieve good adherence to treatment and improved patient outcomes. Specific recommendations and good practice points relating to provision of information by healthcare professionals to patients and carers are found throughout this guideline. In addition, supported self management is covered in detail in section 5, including sections on personalised asthma action plans *(see section 5.2.2 and Table 11)* and adherence and concordance *(see section 5.4)*.

Patient versions of this guideline, in booklet form are available on the SIGN website (www.sign.ac.uk, *see section 15.2*) or directly from SIGN and could be a useful addition to the patient's PAAP. Healthcare professionals are encouraged to inform patients and carers that these booklets are available. The patient versions are reviewed and updated in line with the clinical guideline. In addition to information on care and treatment, the booklets include contact details for, and brief information about, a number of organisations that provide information for patients *(see section 15.3).*

15.1 Checklist of information for patients and carers

This section gives examples of the information patients/carers may find helpful at the key stages of the patient journey. The checklist was designed by members of the guideline development group based on their experience and their understanding of the evidence base. In developing the checklist, consideration was given to what patients and carers valued. The checklist is neither exhaustive nor exclusive.

Assessment and diagnosis
• Fully explain symptoms and triggers, giving examples to help. Ask the patient questions to ensure they understand. • Explain to the patient that diagnosing and managing asthma is not straightforward, and that they might be trying a few different tests and medicines. Explain to the patient that the results of tests or medicine trials may mean more tests and trying different medicines. • Explain the different tests using clear, concise, jargon-free language. Show the materials that will be used in these tests, for example a spirometer. • Ensure patients are kept informed about which tests will be performed, when they are likely to be carried out, and what the results mean. • Explain and show equipment (inhalers and spacers), how it is used, how often the patient should use it, where they will get these from. • Encourage patients and their families to discuss their questions and concerns during appointments and reviews. This will help patients to get the most from their appointments or reviews.
Ongoing care (monitoring)
• Advise patients and their families of the need to work in partnership with them to allow a holistic approach to managing their asthma. • Ensure the patient is aware that they do not have to wait until their regular review if they have concerns that they need to discuss with their healthcare professional sooner. • Encourage people to take a notebook to appointments to allow them to record key information. • Offer a summary of discussions at the end of every appointment and check the patient's understanding. • Ensure appropriate information is given to patients to encourage them to take responsibility for their asthma, for example making sure that they are familiar with personal asthma action plans and filling these in with them if they do not have one.

• Be sensitive to and aware of how culture and beliefs affect a patient's asthma and lifestyle. For example offer action plans in different language as appropriate. • Listen carefully to the needs and priorities of patients and carers. • Explain what happens if the patient reaches a crisis point of an asthma attack.
Medicines (pharmacological management)
• Inform patients of side effects from medication when prescribing and reviewing medication and reassure them that these are normal. Listen to any concerns. • Explain in clear, jargon-free language, any new medicines, and reasons for changing medicines. • Check and optimise inhaler technique.
Non-pharmacological management
• Remain open minded and open to discussing things that may help manage symptoms alongside medicines. Different things might help different people.
Self management
• Ask patients to think about asthma triggers, for example perfumes, cleaning products, smoke, etc. • Ask patients what they do to help them to manage their asthma, for example do they keep a diary, notebook, use an app, peak-flow meter, etc. • Provide and explain a personal asthma action plan (PAAP).
Asthma attacks
• Introduce yourself. • Discuss with the patient their personal asthma action plan before they leave hospital. • Discuss with the patient and their family or carer what happens after they leave the hospital, for example explain that they need to make an appointment with their doctor or asthma nurse.
Asthma in pregnancy
• Communicate with the labour team to ensure they are aware of any at-risk patients. • Discuss with the patient any changes to their asthma action plan and make sure the patient understands any changes.
Asthma in young people
• Involve children and young people from the start and encourage them to take responsibility for managing their asthma. Listen to and address their needs fully and ask children and young people the following questions. - Have you had any asthma attacks? What were you doing at the time? - Have you been breathless? - Have you been taking your medication? If not, what were the reasons for this?
Work-related asthma
• Explain that people may find they have issues at work, for example triggers may be present. • Discuss what can be done to help at work.

15.2 Publications from sign

SIGN patient versions of guidelines are documents that 'translate' guideline recommendations and their rationales, originally developed for healthcare professionals, into a form that is more easily understood and used by patients and the public. They are intended to:

- help patients and carers understand what the latest evidence supports around diagnosis, treatment and self care
- empower patients to participate fully in decisions around management of their condition in discussion with healthcare professionals
- highlight for patients where there are areas of uncertainty.

SIGN patient versions for asthma can be accessed at: www.sign.ac.uk/patient-publications.html

15.3 Sources of further information

15.3.1 National organisations for people who have asthma

Asthma UK
18 Mansell Street, London, E11 8AA
Tel: 0300 222 5800
Asthma UK's Helpline nurses: 0300 222 5800 (9am-5pm, Mon-Fri) – nurses provide advice for people with asthma and for healthcare professionals.
www.asthma.org.uk • General enquiries: info@asthma.org.uk

Asthma UK is a charity dedicated to improving the health and wellbeing of people who are affected by asthma. The charity provides a wide range of information and resources on their website, including downloadable asthma action plans. Printed information booklets and other resources are available on request and bulk copies are available for purchase by healthcare professionals.

Asthma + Lung UK
The White Chapel Building, 10 Whitechapel High Street, London, E1 8QS
Tel: 020 7688 5555
Asthma + Lung UK

Asthma and Lunk UK support people to understand and live with lung disease. They run the Breathe Easy support network which offers information, support and friendship to anyone affected by lung disease.

15.3.2 Other organisations

Allergy UK
Planwell House, Lefa Business Park, Edgington Way, Sidcup, Kent, DA14 5BH
Helpline: 01322 619898
www.allergyuk.org

Allergy UK is a charity which aims to increase people's understanding and awareness of allergies, and helps people manage their allergies.

ASH (Action on Smoking and Health)
First Floor, 144–145 Shoreditch High Street, London, E1 6JE
Tel: 020 7739 4732
www.ash.org.uk

ASH is the leading voluntary organisation campaigning for effective tobacco-control legislation and providing an expert information service.

NHS 111
Freephone: 111

This is a 24-hour helpline for people in England and Wales. It is led by nurses who provide confidential healthcare advice and information 24 hours, 365 days a year.

NHS 24
Freephone: 111
www.nhs24.scot

This is a 24-hour helpline for people in Scotland. It is led by nurses who provide confidential healthcare advice and information 24 hours, 365 days a year.

Department of Work and Pensions (DWP)
www.dwp.gov.uk

The website gives details of state benefits patients may be entitled to.

16 The evidence base

16.1 Systematic literature review

The evidence base for this guideline was synthesised in accordance with SIGN methodology. A systematic review of the literature was carried out using an explicit search strategy devised by a SIGN Evidence and Information Scientist. Databases searched include Medline, Embase, Cinahl, PsycINFO and the Cochrane Library. Internet searches were carried out on various websites. The main searches were supplemented by material identified by individual members of the development group. Each of the selected papers was evaluated by two members of the group using standard SIGN methodological checklists before conclusions were considered as evidence.

The evidence base builds on the reviews carried out for the original (2003) version of the guideline and subsequent updates. Annex 2 provides details of the time period covered for each topic. A copy of the search narrative, including listings of strategies, is available on the SIGN website as part of the supporting material for this guideline.

16.2 Recommendations for research (2019)

The guideline development group was not able to identify sufficient evidence to answer all of the key questions asked in this update of the guideline *(see Annex 1)* The following areas for further research have been identified:

- Clinical prediction models for quantifying risk need to be developed and prospectively validated in adults, children aged 5–12 and children under five years of age. Does risk assessment based on these factors improve outcomes when used prospectively in routine clinical practice?
- In monitoring asthma, what level of risk is associated with factors where evidence is currently limited or equivocal *(see Tables 9 and 10)*?
- Does incorporation of assessment of risk of future asthma attacks (potentially using a risk score) into routine care improve outcomes?
- What is the utility of FeNO measurement in guiding asthma treatment to improve asthma outcomes, such as reduced asthma attacks or increased asthma control, in different patient groups?
- What is the impact of poverty, urban/rural living, ethnicity and different rates of state/private/no medical insurance on asthma outcomes in the UK setting?
- In children under five years of age, what factors are associated with increased risk of acute asthma/wheezing attacks? Do risk factors in this age group differ from those in older children?
- What features of available apps lead to improvements in adherence to medication and which have any impact on clinical outcomes?
- Which approaches to improving medication adherence are most effective and sustainable in patients with asthma?
- How effective are house dust mite and other allergen reduction measures in asthma? A systematic review/meta-analysis is required including only high-quality trials that i) use interventions that are documented to reduce allergen exposure, ii) follow up participants for a sufficient time for important clinical outcomes to become apparent, iii) provides separate analyses for children and adults, and iv) accounts for any changes in asthma medication over the course of the trial.
- What are the potential beneficial effects of vitamin D supplementation in people with asthma, particularly children and people with frequent severe asthma exacerbations, with different baseline vitamin D levels?

- How effective are breathing exercises in children with asthma?
- What components of individualised multicomponent allergen reduction strategies are effective at improving asthma control and reducing exacerbations?
- Do strategies to reduce environmental allergens improve asthma control and reduce exacerbations in specific subgroups of people with asthma, eg children?
- How effective is montelukast in patients without allergic rhinitis and/or atopic dermatitis?
- Development of an agreed universal definition of 'asthma exacerbation' to allow comparison of this outcome between studies?
- Classification of asthma-related and non-asthma related adverse events to allow comparison of adverse events between studies?
- Which, if any, subgroups of children benefit most from addition of LTRA as compared with LABA as additional add-on therapy to ICS alone?
- What are the short- and long-term steroid-sparing effects of monoclonal antibody therapies in adults and children on different treatment regimens?
- Does the effectiveness of treatment with monoclonal antibodies decrease over time and/or does clinically relevant antibody sensitisation occur, and if so, at what point does/do these occur?
- What markers of response are there to enable targeting of monoclonal antibody therapy?
- Does suppression of IgE or IL-5 have any long-term effects on the recipient's immune function?
- What is the short- and long-term effectiveness and safety of subcutaneous and sublingual immunotherapy in asthma in studies with optimal design and patient-centric endpoints, such as asthma control and exacerbations? Does effectiveness differ between different products or between patients with different characteristics?
- Which patients with asthma might benefit most from bronchial thermoplasty and what are the long-term outcomes and safety of this treatment?
- What is the place of bronchial thermoplasty in the management of severe asthma compared with other options such as biological treatments?
- What is the relative clinical effectiveness and safety of bronchial thermoplasty compared with monoclonal antibody treatments?
- What is the role of non-invasive ventilation and high-flow oxygen therapy in treating children with severe exacerbations of asthma, and what is their effect on measurable outcomes including respiratory parameters, physiological variables and blood gases?
- In considering treatment with extracorporeal membrane oxygenation (ECMO) what is the definition of life-threatening or standard care?
- What is the clinical effectiveness and safety of ECMO treatment in patients with asthma taking anticoagulants?

17 Development of the guideline

17.1 Introduction

SIGN is a collaborative network of clinicians, other healthcare professionals and patient organisations and is part of Healthcare Improvement Scotland. SIGN guidelines are developed by multidisciplinary groups of practising clinicians using a standard methodology based on a systematic review of the evidence. Further details about SIGN and the guideline development methodology are contained in 'SIGN 50: A guideline developer's handbook', available at **www.sign.ac.uk.** This guideline was developed according to the 2011 edition of SIGN 50.

SIGN and BTS have worked in partnership since 2001 to produce the British Guideline on the Management of Asthma. Governance arrangements including a Memorandum of Understanding between SIGN and BTS approved by Healthcare Improvement Scotland, SIGN Council and the BTS Board of Trustees, are in place. These arrangements cover production of each update and appointment of members to each of the groups that comprise the overall Guideline Development Group.

17.2 Guideline development group

Dr James Paton (Co-chair)	*Reader and Honorary Consultant Paediatrician, Royal Hospital for Sick Children, Glasgow*
Dr John White (Co-chair)	*Consultant Respiratory Physician, York District Hospital*
Mr Joe Annandale	*Respiratory Nurse Specialist, Prince Philip Hospital, Llanelli*
Dr Anne Boyter	*Senior Lecturer, Strathclyde Institute of Pharmacy and Biomedical Sciences, Glasgow*
Ms Juliet Brown	*Evidence and Information Scientist, Healthcare Improvement Scotland*
Ms Beatrice Cant	*Programme Manager, SIGN Executive*
Dr Toby Capstick	*Consultant Pharmacist, St James' University Hospital, Leeds*
Dr Richard Chavasse	*Consultant in Respiratory Paediatrics, St George's Hospital, London*
Dr Luke Daines	*Academic Clinical Fellow, Asthma UK Centre for Applied Research, Usher Institute of Population Health Sciences and Informatics, University of Edinburgh, and General Practitioner, Craiglockhart Medical Group, Edinburgh.*
Dr Andrew Deacon	*ST4 Adult Respiratory Medicine, Manchester Royal Infirmary*
Dr Rebecca Devaney	*ST6 Paediatric Respiratory Medicine, Queen's Medical Centre, Nottingham*
Dr Sinan Eccles	*Consultant Adult Respiratory Medicine, Royal Glamorgan Hospital, Pontyclun*
Mrs Sheila Edwards	*Chief Executive, British Thoracic Society*
Professor David Fishwick	*Consultant Respiratory Physician, Brearley Chest Clinic, Northern General Hospital, Sheffield*
Professor Chris Griffiths	*Professor of Primary Care, Centre for Primary Care and Public Health, London*

Ms Karen Gibson	*Asthma Nurse Specialist, Norfolk and Norwich University Hospital, Norwich*
Mrs Toni Gibson	*Lay Representative*
Dr Nicola Littlewood	*Consultant in Emergency Medicine, Queen Elizabeth University Hospital, Glasgow*
Dr David Lo	*ST8 Paediatric Respiratory Medicine, Leicester Royal Infirmary*
Dr Kenneth MacLeod	*Consultant in Paediatric Respiratory Medicine, Royal Hospital for Sick Children, Edinburgh*
Dr Alexander Mathioudakis	*NIHR Academic Clinical Fellow and Honorary Lecturer in Respiratory Medicine, University of Manchester*
Ms Tina Morrow	*Lay representative*
Dr Rob Niven	*Senior Lecturer in Respiratory Medicine, Whythenshawe Hospital, Manchester*
Dr Rebecca Normansell	*Joint Co-ordinating Editor Cochrane Airways, Population Health Research Institute, London*
Professor Hilary Pinnock	*Professor of Primary Care Respiratory Medicine, Asthma UK Centre for Applied Research, Usher Institute of Population Health Sciences and Informatics, University of Edinburgh, and General Practitioner, Whitstable Medical Practice, Kent*
Professor Graham Roberts	*Professor and Honorary Consultant Paediatrician, University of Southampton*
Dr Stephen Scott	*Consultant in Respiratory Medicine, Countess of Chester Hospital, Chester*
Dr Diana Slim	*Respiratory Registrar, Bristol Royal Infirmary*
Mrs Lynne Smith	*Evidence and Information Scientist, Healthcare Improvement Scotland*
Dr Fatimazahra Tharoo	*General Practitioner, Birmingham*
Professor Steve Turner	*Professor and Honorary Consultant Paediatrician, Department of Child Health, University of Aberdeen*
Ms Sally Welham	*Deputy Chief Executive, British Thoracic Society*
Dr Sarah Winfield	*Consultant Obstetrician, Leeds Teaching Hospitals NHS Trust*
Mr Alex Woodward	*Respiratory Physiotherapist, Leicestershire Parternship NHS Trust*

The membership of the guideline development group was confirmed following consultation with the member organisations of SIGN. All members of the guideline development group made declarations of interest. A register of interests is available in the supporting material section for this guideline at **www.sign.ac.uk**

Guideline development and literature review expertise, support and facilitation were provided by the SIGN Executive.

All members of the SIGN Executive make yearly declarations of interest. A register of interests is available on the contacts page of the SIGN website **www.sign.ac.uk**

Euan Bremner	*Project Officer*
Karen Graham	*Patient Involvement Advisor*
Aimie Little	*Administrative Officer*

Domenico Romano	*Publications Designer*
Gaynor Rattray	*Guideline Co-ordinator*

17.3 Acknowledgements

SIGN would like to acknowledge the guideline development group responsible for the development of SIGN 153: British guideline on the management of asthma, on which this guideline is based.

SIGN would like to acknowledge the PRISMS group who kindly provided the searches, quality assessment and data extraction for the implementation studies in asthma self-management *(see section 5.5)* based on their systematic review of self-management support interventions for people with long-term conditions conducted as part of a project funded by the National Institute for Health Research Health Services and Delivery Research programme (project number 11/1014/04).(Taylor SJC, Pinnock H, Epiphaniou E, et al. A rapid synthesis of the evidence on interventions supporting self-management for people with long-term conditions. (PRISMS Practical Systematic Review of Self-Management Support for long-term conditions). *Health Serv Deliv Res* 2014;2:54). The considered judgement and recommendations (in section 5.5) were developed by the self-management Evidence Review Group in accordance with SIGN methodology. The views and opinions expressed therein are those of the SIGN/BTS guideline development group and do not necessarily reflect those of the PRISMS authors, NIHR, NHS or the Department of Health.

17.4 Consultation and peer review

17.4.1 Consultation

Selected changes to this guideline were presented for discussion in draft form at the Winter Meeting of the British Thoracic Society in December 2018. All questions and comments raised at the meeting were addressed on the day and were also summarised and considered separately by the guideline development group. The draft guideline was also available on the SIGN and BTS websites for five weeks to allow all interested parties to comment. A total of eighteen organisations and seven individuals submitted formal responses as part of the open consultation. A report of the consultation and peer review comments and responses is available in the supporting material section for this guideline on the SIGN website. All expert referees and other contributors made declarations of interest and further details of these are available on request from the SIGN Executive.

17.4.2 Specialist review

This guideline was also reviewed in draft form by the following independent expert referees, who were asked to comment primarily on the comprehensiveness and accuracy of interpretation of the evidence base supporting the recommendations in the guideline. The guideline group addresses every comment made by an external reviewer, and must justify any disagreement with the reviewers' comments. All expert referees made declarations of interest and further details of these are available on request from the SIGN Executive.

SIGN and BTS are very grateful to these experts for their contribution to the guideline.

Dr Bernard Higgins	*Consultant Respiratory Physician, Newcastle Upon Tyne Hospitals NHS Trust*
Professor Richard Beasley	*Director, Medical Research Institute of New Zealand and Adjunct Professor, University of Otago and Physician, Capital and Coast District Health Board, Wellington*

17.4.3 Editorial group

As a final quality-control check, the guideline is reviewed by an editorial group comprising the relevant specialty representatives on SIGN Council and members of the Governance Committee for the BTS/SIGN British guideline on the management of asthma to ensure that the specialist reviewers' comments have been addressed adequately and that any risk of bias in the guideline development process as a whole has been minimised. The editorial group for this guideline was as follows. All members of SIGN Council make yearly declarations of interest. A register of interests is available on the SIGN Council Membership page of the SIGN website www.sign.ac.uk.

Mrs Margaret Ryan	*Royal Pharmaceutical Society representative on SIGN Council*
Mrs Sheila Edwards	*Chief Executive, British Thoracic Society*
Dr Luke Howard	*Chair, BTS Standards of Care Committee*
Dr Roberta James	*Programme Lead, SIGN; Co-Editor*
Professor John Kinsella	*Chair of SIGN; Co-Editor*
Dr Karen Ritchie	*Head of Knowledge and Information, Healthcare Improvement Scotland*
Ms Sally Welham	*Deputy Chief Executive, British Thoracic Society*

17.4.3 2024 revision

A revision to the guideline was made in November 2024 to ensure alignment with Asthma: diagnosis, monitoring and chronic asthma management (SIGN 245) and the Asthma pathway (SIGN 244).

Alan Bigham	*Programme Manager, SIGN*
Dr Tom Fardon	*Consultant Physician in Respiratory and General Internal Medicine at NHS Tayside*
Dr Roberta James	*Programme Lead, SIGN*
Dr Safia Qureshi	*Director of Evidence and Digital, Healthcare Improvement Scotland*
Professor Angela Timoney	*Chair of SIGN*

Abbreviations

	ACT	Asthma Control Test	
	ACQ	Asthma Control Questionnaire	
	anti-IL5	anti-interleukin-5 monoclonal antibody	
	AOR	adjusted odds ratio	
	Apgar score	A number expressing the physical condition of a newborn infant (a score of ten representing the best possible condition).	
	AQLQ	Asthma Quality of Life Questionnaire	
	BCG	Bacillus Calmette-Guérin	
	BDP	beclometasone dipropionate	
	BHR	bronchial hyper-reactivity	
	BMI	body mass index	
	BNF	British National Formulary	
	BTS	British Thoracic Society	
	CAM	complementary and alternative medicine	
	CDSS	computerised decision support systems	
	CFC	chloroflurocarbon	
	C-ACT	Childhood Asthma Control Test	
	CI	confidence interval	
	COPD	chronic obstructive pulmonary disease	
	DPI	dry powder inhaler	
	ECG	electrocardiogram	
	ECMO	extracorporeal membrane oxygenation	
	ED	emergency department	
	ETS	environmental tobacco smoke	
	FeNO	fractional exhaled nitric oxide	
	FEV_1	forced expiratory volume in one second	
	FVC	forced vital capacity	
	GMC	General Medical Council	
	GORD	gastro-oesophageal reflux disease	
	GP	general practitioner	
	HbA1c	glycated haemoglobin	
	HDM	house dust mite	
	HFA	hydrofluoroalkane	
	ICS	inhaled corticosteroids	
	ICU	intensive care unit	
	IgE	immunoglobulin E	

	IM	intramuscular	
	IT	information technology	
	IU	international unit	
	IV	intravenous	
	kU/L	kilounits of antibody per litre	
	kPa	kilopascals	
	LABA	long-acting β_2 agonist	
	LAMA	long-acting muscarinic antagonist	
	LTRA	leukotriene receptor antagonists	
	MA	marketing authorisation	
	MART	maintenance and reliever therapy	
	MDI	metered dose inhaler	
	MHRA	Medicines and Healthcare products Regulatory Agency	
	n-3PUFA	omega-3 polyunsaturated fatty acid	
	NICE	National Institute for Health and Care Excellence	
	NIV	non-invasive ventilation	
	NPV	negative predictive value	
	NRAD	National Review of Asthma Deaths	
	OR	odds ratio	
	PAAP	personalised asthma action plan	
	PACE	Physician Asthma Care Education	
	$PaCO_2$	partial arterial pressure of carbon dioxide	
	PaO_2	partial arterial pressure of oxygen	
	PAQLQ	Paediatric Asthma Quality of Life Questionnaire	
	PC_{20}	the provocative concentration of bronchoconstrictor (eg methacholine) required to cause a 20% fall in FEV_1	
	PD_{20}	the provocative dose of bronchoconstrictor (eg methacholine) required to cause a 20% fall in FEV_1	
	PEF	peak expiratory flow	
	pMDI	pressurised metered dose inhaler	
	ppb	parts per billion	
	PPV	positive predictive value	
	QoL	quality of life	
	RCT	randomised controlled trial	
	RR	risk ratio	
	SABA	short-acting β_2 agonist	
	SCIT	subcutaneous immunotherapy	
	SIC	specific inhalation challenge	

	SIGN	Scottish Intercollegiate Guidelines Network	
	SLIT	sublingual immunotherapy	
	SMC	Scottish Medicines Consortium	
	SpO_2	oxygen saturation measured by a pulse oximeter	
	TNF	tumour necrosis factor	
	V_{Emax}	ventilation at maximal exercise capacity	

Annex 1
Key questions addressed in this update

This guideline is based on a series of structured key questions that define the target population, the intervention, diagnostic test, or exposure under investigation, the comparison(s) used and the outcomes used to measure efficacy, effectiveness, or risk. These questions form the basis of the systematic literature search.

Guideline section	Key question	
4.3	2	In people with asthma (<5, 5–12, >12), which individual, or combination of, characteristic/s effectively predict/s future loss of control and/or future risk of attacks? Population: people with asthma Interventions: symptom pattern, asthma control, asthma severity, previous history of attacks, atopy (including sensitisation, comorbid allergic conditions, family history), treatment adherence, behaviours (including smoking), social deprivation, biomarkers, polypharmacy Comparisons: none Outcomes: number of asthma attacks, frequency of asthma attacks
6.2	4	What interventions (avoidance or reduction of exposure to environmental factors) in the home/school/outdoor environment improve asthma control and prevent or reduce severity of asthma attacks? Population: people with asthma Interventions: avoidance of exposure to environmental factors, reduction of exposure to environmental factors, eg use of mattress covers for house dust mites Comparisons: no intervention to reduce exposure to environmental factors. Outcomes: asthma symptom control, number of asthma attacks, severity of asthma attacks
6.2.14	5	In people aged 12 and over with asthma, is breathing training in addition to usual care effective at reducing asthma attacks, improving symptoms, reducing side effects, improving treatment adherence or improving lung function? Population: people with asthma aged 12 and over Interventions: breathing training Comparisons: no breathing training (ie usual care) Outcomes: asthma attacks, asthma symptom control, adverse side effects, treatment adherence, lung function
7.4, 7.5	7	In people with asthma whose symptoms are not adequately controlled by low-dose (>12 years) or very low-dose (<5, 5–12 years) ICS plus a LABA, is adding an LTRA, LAMA, theophylline or slow-release β2 agonist tablets, more effective than increasing the dose of ICS at reducing asthma attacks,

		improving symptoms, reducing side effects, improving treatment adherence or improving pulmonary/lung function? Population: people with asthma taking low-dose (>12 years) or very low-dose (<5, 5–12 years) ICS plus a LABA Interventions: LTRA, LAMA, theophylline, slow-release β2 agonist tablets Comparisons: increasing ICS dose above low-dose (>12 years) or very low-dose (<5, 5–12 years) Outcomes: asthma attacks, asthma symptom control, adverse side-effects, treatment adherence, pulmonary/lung function
7.5.4	8	In people with asthma who are not adequately controlled on high-dose ICS plus LABA or on oral corticosteroids, does addition of monoclonal antibodies (eg omalizumab, mepolizumab, reslizumab) reduce use of oral steroids, unscheduled care, side effects, or improve symptoms, treatment adherence or lung function? Population: people with asthma inadequately controlled on high-dose ICS plus a LABA or on oral corticosteroids Interventions: monoclonal antibodies (including omalizumab, mepolizumab, reslizumab, etc) Comparisons: no use of monoclonal antibodies Outcomes: reduction in unscheduled care (reduced asthma attacks, reduced steroid courses, reduced unplanned hospital/GP visits), adverse side effects, asthma symptom control, lung function, treatment adherence, reductions in treatment (ICS reduction, oral steroid reduction)
7.5.7	9	In people with asthma who are not adequately controlled on high-dose ICS plus a LABA or oral corticosteroids, does addition of bronchial thermoplasty reduce use of oral steroids, unscheduled care, side effects, or improve symptoms, treatment adherence or lung function? Population: people with asthma inadequately controlled on high-dose ICS plus a LABA or on oral corticosteroids Interventions: bronchial thermoplasty Comparisons: no bronchial thermoplasty Outcomes: reduction in unscheduled care (reduced asthma attacks, reduced steroid courses, reduced unplanned hospital/GP visits), adverse side effects, asthma symptom control, lung function, treatment adherence, reductions in treatment (ICS reduction, oral steroid reduction)
7.5.6	10	In people with asthma who are poly- or mono-sensitised, is sublingual immunotherapy compared to standard therapy effective at reducing asthma attacks, improving asthma control, improving treatment adherence or improving lung function? Population: people with asthma mono- or poly-sensitised Interventions: sublingual immunotherapy (SLIT) Comparisons: standard therapy

		Outcomes: asthma attacks, asthma symptom control, treatment adherence, lung function
9.3.12, 9.9.5	12	In the immediate treatment of people with life-threatening or near-fatal asthma, does extracorporeal membrane oxygenation (ECMO) or other potentially life-saving therapies, compared to usual care, improve patient survival or other outcomes? Population: people experiencing a life-threatening or near-fatal asthma attack Interventions: extracorporeal membrane oxygenation (ECMO), ketamine, other rescue therapies Comparisons: usual care Outcomes: survival, morbidity
6.2.8	13	In people with asthma, is supplementation with vitamin D compared to placebo effective at reducing asthma attacks, reducing side effects or improving lung function? Population: people with asthma Interventions: vitamin D supplementation Comparisons: usual care Outcomes: asthma attacks, side effects, lung function

Annex 2
Summary of search histories by section

This guideline is based on a series of structured key questions that define the target population, the intervention, diagnostic test, or exposure under investigation, the comparison(s) used and the outcomes used to measure efficacy, effectiveness, or risk. These questions form the basis of the systematic literature search.

Literature searches to support the various sections of this guideline are conducted on a rolling basis. This summary indicates the currency of the searches supporting each section. Searches in all databases began with the earliest year available at that time, which varied from database to database; for example, searches in Embase extended back to 1980 and in CINAHL to 1982. Specific date coverage is provided for Medline.

The 2019 revision saw updating of multiple sections of the guideline identified as priority areas by the guideline development group. Literature searches were conducted in Medline, Embase, CINAHL and the Cochrane Library for all topics to identify systematic reviews published between 2012 and March 2018. Additional literature search coverage for the specific topics considered in this update is described below.

Detailed search strategies are available on the SIGN website in the supplementary material section.

Section 4 Monitoring asthma

Monitoring current asthma symptom control

A broad search was carried out in May 2018 covering 2014–2018. No study design filter was applied.

Predicting future risk of asthma attacks

A broad search was carried out in May 2018 with no date limit. No study design filter was applied.

Section 5 Supported self management

Components of a self-management programme

A broad search was carried out in April 2018 with no date limit to identify studies which looked at people with asthma increasing the dose of ICS or adding an LTRA, compared to usual care, at the onset of an asthma attack and as part of a self-management plan. No study design filter was applied.

Section 6 Non-pharmacological management

Secondary non-pharmacological prevention

A broad search was carried out to identify studies which looked at what interventions (avoidance or reduction of exposure to environmental factors) in the home/school/outdoor environment improve asthma control and prevent or reduce severity of asthma attacks. The search covered 2014–2018 on Medline. No study design filter was applied.

A search was conducted in April 2018 to identify studies on breathing training. The search covered 2013–2018 in Medline, Embase, the Cochrane Library and CINAHL. An RCT filter was applied.

A search was conducted in May 2018 to identify studies on vitamin D supplementation. The search covered 2016–2018 in Medline, Embase, the Cochrane Library and CINAHL. An RCT filter was applied.

Section 7 Pharmacological management

The 2019 revision updated searches for inhaled steroids, long-acting β_2 agonists, theophyllines, leukotriene receptor antagonists, frequency and dose of inhaled steroids, monoclonal antibodies, sublingual immunotherapy and bronchial thermoplasty.

The Cochrane Library, Medline and Embase were searched from 2012–2018. SIGN systematic review and RCT filters were applied.

Section 9 Management of acute asthma

Broad searches were carried out in May/June 2018 with no date limit to identify studies which looked at extracorporeal membrane oxygenation (ECMO) or other potentially life-saving therapies for people with life-threatening or near-fatal asthma. No study design filter was applied.

Annex 3

Management of acute asthma in adults in general practice

Many deaths from asthma are preventable. Delay can be fatal. Factors leading to poor outcome include:

- Clinical staff failing to assess severity by objective measurement
- Patients or relatives failing to appreciate severity
- Under use of corticosteroids

Regard each emergency asthma consultation as for acute severe asthma until shown otherwise.

Assess and record:

- Peak expiratory flow (PEF)
- Symptoms and response to self treatment
- Heart and respiratory rates
- Oxygen saturation (by pulse oximetry)

Caution: *Patients with severe or life-threatening attacks may not be distressed and may not have all the abnormalities listed below. The presence of any should alert the doctor.*

Moderate asthma	Acute severe asthma	Life-threatening asthma
INITIAL ASSESSMENT		
PEF>50–75% best or predicted	**PEF 33–50% best or predicted**	**PEF<33% best or predicted**
FURTHER ASSESSMENT		
• SpO_2 ≥92% • Speech normal • Respiration <25 breaths/min • Pulse <110 beats/min	• SpO_2 ≥92% • Can't complete sentences • Respiration ≥25 breaths/min • Pulse ≥110 beats/min	• SpO_2 <92% • Silent chest, cyanosis or poor respiratory effort • Arrhythmia or hypotension • Exhaustion, altered consciousness
MANAGEMENT		
Treat at home or in surgery and ASSESS RESPONSE TO TREATMENT	**Consider admission**	**Arrange immediate ADMISSION**
TREATMENT		
• β_2 bronchodilator: – via spacer* If no improvement: – via nebuliser (preferably oxygen-driven), salbutamol 5 mg • Give prednisolone 40–50 mg • Continue or increase usual treatment If good response to first treatment (symptoms improved, respiration and pulse settling and PEF >50%) continue or increase usual treatment and continue prednisolone	• Oxygen to maintain SpO_2 94–98% if available • β_2 bronchodilator: – via nebuliser (preferably oxygen-driven), salbutamol 5 mg – or if nebuliser not available, via spacer* • Prednisolone 40–50 mg or IV hydrocortisone 100 mg • **If no response in acute severe asthma: ADMIT**	• Oxygen to maintain SpO_2 94–98% • β_2 bronchodilator with ipratropium: – via nebuliser (preferably oxygen-driven), salbutamol 5 mg and ipratropium 0.5mg – or if nebuliser and ipratropium not available, β_2 bronchodilator via spacer* • Prednisolone 40–50 mg or IV hydrocortisone 100 mg immediately
Admit to hospital if any: • Life-threatening features • Features of acute severe asthma present after initial treatment • Previous near-fatal asthma Lower threshold for admission if afternoon or evening attack, recent nocturnal symptoms or hospital admission, previous severe attacks, patient unable to assess own condition, or concern over social circumstances	**If admitting the patient to hospital:** • Stay with patient until ambulance arrives • Send written asssessment and referral details to hospital • β_2 bronchodilator via oxygen-driven **nebuliser in ambulance**	**Follow up after treatment or discharge from hospital:** • Continue prednisolone until recovery (minimum 5 days) • **GP review within 2 working days** • Monitor symptoms and PEF • Check inhaler technique • **Written asthma action plan** • Modify treatment according to guidelines for chronic persistent asthma • Address potentially preventable contributors to admission

*** β_2 bronchodilator via spacer given one puff at a time, inhaled separately using tidal breathing; according to response, give another puff every 60 seconds up to a maximum of 10 puffs**

Annex 4

Management of acute asthma in adults in the emergency department

Time

Measure peak expiratory flow and arterial saturations

PEF >50–75% best or predicted **Moderate asthma**	PEF 33–50% best or predicted **Acute severe asthma**	PEF <33% best or predicted **Life-threatening asthma**
SpO_2 ≥92% PEF >50–75% best or predicted No features of acute severe asthma	Features of severe asthma • PEF<50% best or predicted • Respiration ≥25/min • SpO_2 ≥92% • Pulse ≥110 beats/min • Cannot complete sentence in one breath	• SpO_2<92% • Silent chest, cyanosis, poor respiratory effort • Arrhythmia, hypotension • Exhaustion, altered consciousness
Give β_2 bronchodilator via spacer (give one puff at a time; according to response, give another puff every 60 seconds up to maximum of 10 puffs)	Give β_2 bronchodilator (salbutamol 5 mg) by oxygen-driven nebuliser	**Obtain senior/ICU help now if any life-threatening features are present**

5 mins

Clinically stable AND PEF >75%	Clinically stable AND PEF <75%	No life threatening features AND PEF 50–75%	Life threatening features OR PEF <50%

IMMEDIATE MANAGEMENT
- Oxygen to maintain SpO_2 94–98%
- β_2 bronchodilator with ipratropium
  - via nebuliser (preferably oxygen-driven), salbutamol 5 mg and ipratropium 0.5 mg
- Prednisolone 40–50 mg orally or IV hydrocortisone 100 mg

15-20 mins

Repeat salbutamol
5 mg nebuliser
Give prednisolone
40–50 mg orally

Measure arterial blood gases
Markers of severity:
- **'Normal' or raised $PaCO_2$** ($PaCO_2$>4.6 kPa; 35 mmHg)
- **Severe hypoxia** (PaO_2 <8 kPa; 60 mmHg)
- **Low pH** (or high H^+)

60 mins

Patient recovering AND PEF >75%	No signs of severe asthma AND PEF 50-75%	Signs of severe asthma OR PEF <50%

- Give/repeat salbutamol 5 mg with ipratropium 0.5 mg by oxygen-driven nebuliser after 15 minutes
- Consider continuous salbutamol nebuliser 5–10 mg/hr
- Consider IV magnesium sulphate 1.2–2 g over 20 minutes
- Correct fluid/electrolytes, especially K^+ disturbances
- Chest X-ray
- Repeat ABG

OBSERVE AND MONITOR
- SpO_2
- heart rate
- respiratory rate

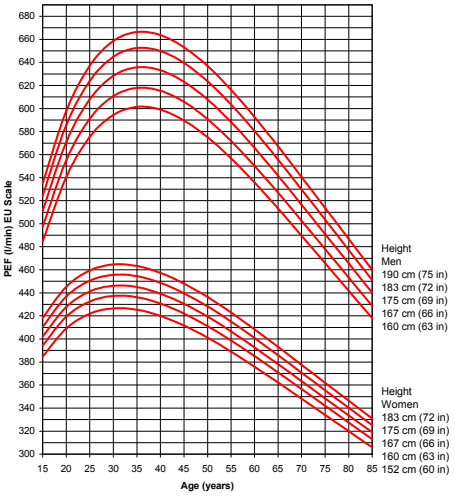
120 mins

Patient stable AND PEF >50%	Signs of severe asthma OR PEF <50%

ADMIT
Patient accompanied by a nurse or doctor at all times

POTENTIAL DISCHARGE
- In all patients who received nebulised β_2 bronchodilator prior to presentation, consider an extended observation period prior to discharge
- If PEF<50% on presentation, give prednisolone 40–50 mg/day until recovery (minimum 5 days)
- In all patients ensure treatment supply of inhaled steroid and β_2 bronchodilator and check inhaler technique
- Arrange GP follow up within 2 working days postdischarge
- Fax or email discharge letter to GP
- Refer to asthma liaison nurse/chest clinic

Peak Expiratory Flow Rate – Normal Values



Adapted by Clement Clarke for use with EN13826 / EU scale peak flow meters from Nunn AJ Gregg I, Br Med J 1989:298;1068-70

Annex 5

Management of acute asthma in adults in hospital

Features of acute severe asthma

- Peak expiratory flow (PEF) 33–50% of best (use % predicted if recent best unknown)
- Can't complete sentences in one breath
- Respiration ≥25 breaths/min
- Pulse ≥110 beats/min

Life-threatening features

- PEF <33% of best or predicted
- SpO_2 <92%
- Silent chest, cyanosis, or poor respiratory effort
- Arrhythmia or hypotension
- Exhaustion, altered consciousness

If a patient has any life-threatening feature, measure arterial blood gases. No other investigations are needed for immediate management.

Blood gas markers of a life-threatening attack:

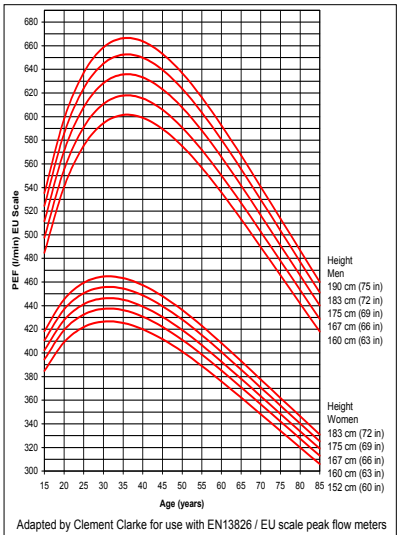
- 'Normal' (4.6–6 kPa, 35–45 mmHg) $PaCO_2$
- Severe hypoxia: PaO_2 <8 kPa (60 mmHg) irrespective of treatment with oxygen
- A low pH (or high H^+)

Caution: Patients with severe or life-threatening attacks may not be distressed and may not have all these abnormalities. The presence of any should alert the doctor.

Near-fatal asthma

- Raised $PaCO_2$
- Requiring mechanical ventilation with raised inflation pressures

Peak Expiratory Flow Rate - Normal Values



Adapted by Clement Clarke for use with EN13826 / EU scale peak flow meters from Nunn AJ Gregg I, Br Med J 1989:298;1068-70

IMMEDIATE TREATMENT

- Oxygen to maintain SpO_2 94–98%
- β_2 bronchodilator (salbutamol 5 mg) via an oxygen-driven nebuliser
- Ipratropium bromide 0.5 mg via an oxygen-driven nebuliser
- Prednisolone tablets 40–50 mg or IV hydrocortisone 100 mg
- No sedatives of any kind
- Chest X-ray if pneumothorax or consolidation are suspected or patient requires mechanical ventilation

IF LIFE-THREATENING FEATURES ARE PRESENT:

- Discuss with senior clinician and ICU team
- Consider IV magnesium sulphate 1.2–2 g infusion over 20 minutes (unless already given)
- Give nebulised β_2 bronchodilator more frequently eg salbutamol 5 mg up to every 15-30 minutes or 10 mg per hour via continuous nebulisation (requires special nebuliser)

SUBSEQUENT MANAGEMENT

IF PATIENT IS IMPROVING continue:

- Oxygen to maintain SpO_2 94–98%
- Prednisolone 40–50mg daily or IV hydrocortisone 100 mg 6 hourly
- Nebulised β_2 bronchodilator with ipratropium 4–6 hourly

IF PATIENT NOT IMPROVING AFTER 15–30 MINUTES:

- Continue oxygen and steroids
- Use continuous nebulisation of salbutamol at 5–10 mg/hour if an appropriate nebuliser is available. Otherwise give nebulised salbutamol 5 mg every 15–30 minutes
- Continue ipratropium 0.5 mg 4–6 hourly until patient is improving

IF PATIENT IS STILL NOT IMPROVING:

- Discuss patient with senior clinician and ICU team
- Consider IV magnesium sulphate 1.2–2 g over 20 minutes (unless already given)
- Senior clinician may consider use of IV β_2 bronchodilator or IV aminophylline or progression to mechanical ventilation

MONITORING

- Repeat measurement of PEF 15–30 minutes after starting treatment
- Oximetry: maintain SpO_2 >94–98%
- Repeat blood gas measurements within 1 hour of starting treatment if:
  - initial PaO_2 <8 kPa (60 mmHg) unless subsequent SpO_2 >92% or
  - $PaCO_2$ normal or raised or
  - patient deteriorates
- Chart PEF before and after giving β_2 bronchodilator and at least 4 times daily throughout hospital stay

Transfer to ICU accompanied by a doctor prepared to intubate if:

- Deteriorating PEF, worsening or persisting hypoxia, or hypercapnia
- Exhaustion, altered consciousness
- Poor respiratory effort or respiratory arrest

DISCHARGE

When discharged from hospital, patients should have:

- Been on discharge medication for 12–24 hours and have had inhaler technique checked and recorded
- PEF >75% of best or predicted and PEF diurnal variability <25% unless discharge is agreed with respiratory physician
- Treatment with **oral steroids (prednisolone 40–50 mg until recovery - minimum 5 days) and inhaled steroids** in addition to bronchodilators
- Own PEF meter and **written asthma action plan**
- GP follow up arranged within **2 working days**
- Follow-up appointment in respiratory clinic **within 4 weeks**

Patients with severe asthma (indicated by need for admission) **and adverse behavioural or psychosocial features are at risk of further severe or fatal attacks.**

- Determine reason(s) for exacerbation and admission
- Send details of admission, discharge and potential best PEF to GP

Management of acute asthma in children in general practice

Age 2–5 years

ASSESS AND RECORD ASTHMA SEVERITY

Moderate asthma	Acute severe asthma	Life-threatening asthma
• SpO_2 ≥92% • Able to talk • Heart rate ≤140/min • Respiratory rate ≤40/min	• SpO_2 <92% • Too breathless to talk • Heart rate >140/min • Respiratory rate >40/min • Use of accessory neck muscles	SpO_2 <92% plus any of: • Silent chest • Poor respiratory effort • Agitation • Confusion • Cyanosis
	• Oxygen via facemask to maintain SpO_2 94–98% if available	
• β_2 bronchodilator: - via spacer ± facemask* • Consider oral prednisolone 20 mg	• β_2 bronchodilator - via nebuliser (preferably oxygen-driven), salbutamol 2.5 mg - *or*, if nebuliser not available, via spacer* • Oral prednisolone 20 mg	• β_2 bronchodilator with ipratropium: - via nebuliser (preferably oxygen-driven), salbutamol 2.5 mg and ipratropium 0.25 mg every 20 minutes - *or*, if nebuliser and ipratropium not available, β_2 bronchodilator via spacer* • Oral prednisolone 20 mg *or* IV hydrocortisone 50 mg if vomiting
	Assess response to treatment 15 mins after β_2 bronchodilator	
IF POOR RESPONSE ARRANGE ADMISSION	**IF POOR RESPONSE REPEAT** β_2 BRONCHODILATOR **AND ARRANGE ADMISSION**	**REPEAT** β_2 BRONCHODILATOR **VIA OXYGEN-DRIVEN NEBULISER WHILST ARRANGING IMMEDIATE HOSPITAL ADMISSION**

GOOD RESPONSE

- Continue β_2 bronchodilator via spacer or nebuliser, as needed but not exceeding 4 hourly
- **If symptoms are not controlled repeat** β_2 bronchodilator **and refer to hospital**
- Continue prednisolone until recovery (minimum 3-5 days)
- Arrange follow-up clinic visit within 48 hours
- Consider referral to secondary care asthma clinic if 2nd attack within 12 months.

POOR RESPONSE

- Stay with patient until ambulance arrives
- Send written assessment and referral details
- Repeat β_2 bronchodilator via oxygen-driven nebuliser in ambulance

LOWER THRESHOLD FOR ADMISSION IF:

- Attack in late afternoon or at night
- Recent hospital admission or previous severe attack
- Concern over social circumstances or ability to cope at home

NB: If a patient has signs and symptoms across categories, always treat according to their most severe features

Age >5 years

ASSESS AND RECORD ASTHMA SEVERITY

Moderate asthma	Acute severe asthma	Life-threatening asthma
• SpO_2 ≥92% • Able to talk • Heart rate ≤125/min • Respiratory rate ≤30/min • PEF ≥50% best or predicted	• SpO_2 <92% • Too breathless to talk • Heart rate >125/min • Respiratory rate >30/min • Use of accessory neck muscles • PEF 33–50% best or predicted	SpO_2 <92% plus any of: • Silent chest • Poor respiratory effort • Agitation • Confusion • Cyanosis • PEF <33% best or predicted
	• Oxygen via facemask to maintain SpO_2 94–98% if available	
• β_2 bronchodilator: - via spacer* • Consider oral prednisolone 30–40 mg	• β_2 bronchodilator - via nebuliser (preferably oxygen-driven), salbutamol 5 mg - *or*, if nebuliser not available, via spacer* • Oral prednisolone 30–40 mg	• β_2 bronchodilator with ipratropium: - via nebuliser (preferably oxygen-driven), salbutamol 5 mg and ipratropium 0.25 mg every 20 minutes - *or*, if nebuliser and ipratropium not available, β_2 bronchodilator via spacer* • Oral prednisolone 30–40 mg *or* IV hydrocortisone 100 mg if vomiting
	Assess response to treatment 15 mins after β_2 bronchodilator	
IF POOR RESPONSE ARRANGE ADMISSION	**IF POOR RESPONSE REPEAT** β_2 BRONCHODILATOR **AND ARRANGE ADMISSION**	**REPEAT** β_2 BRONCHODILATOR **VIA OXYGEN-DRIVEN NEBULISER WHILST ARRANGING IMMEDIATE HOSPITAL ADMISSION**

GOOD RESPONSE

- Continue β_2 bronchodilator via spacer or nebuliser, as needed but not exceeding 4 hourly
- **If symptoms are not controlled repeat** β_2 bronchodilator **and refer to hospital**
- Continue prednisolone until recovery (minimum 3-5 days)
- Arrange follow-up clinic visit within 48 hours
- Consider referral to secondary care asthma clinic if 2nd attack within 12 months.

POOR RESPONSE

- Stay with patient until ambulance arrives
- Send written assessment and referral details
- Repeat β_2 bronchodilator via oxygen-driven nebuliser in ambulance

LOWER THRESHOLD FOR ADMISSION IF:

- Attack in late afternoon or at night
- Recent hospital admission or previous severe attack
- Concern over social circumstances or ability to cope at home

NB: If a patient has signs and symptoms across categories, always treat according to their most severe features

* β_2 bronchodilator via spacer given one puff at a time, inhaled separately using tidal breathing; according to response, give another puff every 60 seconds up to a maximum of 10 puffs

Management of acute asthma in children in emergency department

Age 2–5 years

ASSESS AND RECORD ASTHMA SEVERITY

Moderate asthma
- SpO_2 ≥92%
- No clinical features of severe asthma

NB: If a patient has signs and symptoms across categories, always treat according to their most severe features

Acute severe asthma
- SpO_2 <92%
- Too breathless to talk or eat
- Heart rate >140/min
- Respiratory rate >40/min
- Use of accessory neck muscles

Life-threatening asthma

SpO_2 <92% plus any of:
- Silent chest
- Poor respiratory effort
- Agitation
- Confusion
- Cyanosis

First line treatments

- β_2 bronchodilator:
  - via spacer ± facemask*
- Consider oral prednisolone 20 mg

Oxygen via face mask/nasal prongs to achieve SpO_2 94–98%

- β_2 bronchodilator
  - via nebuliser (preferably oxygen-driven), salbutamol 2.5 mg
  - *or*, if nebuliser not available, via spacer*
- Oral prednisolone 20 mg or IV hydrocortisone 4 mg/kg if vomiting
- **If poor response** add 0.25 mg nebulised ipratropium bromide to every nebulised β_2 bronchodilator and repeat every 20 minutes for 2 hours according to response

- β_2 bronchodilator with ipratropium:
  - via nebuliser (preferably oxygen-driven), salbutamol 2.5 mg and ipratropium 0.25 mg
- Repeat bronchodilators every 20–30 minutes
- Oral prednisolone 20 mg or IV hydrocortisone 4 mg/kg if vomiting

Discuss with senior clinician, PICU team or paediatrician

Reassess within 1 hour

Second line treatments

- Consider 2nd line treatments – see Annex 8
- Admit all cases if features of severe attack persist after initial treatment
- Arrange transfer to PICU/HDU if poor response to treatment as per local guidelines

DISCHARGE PLAN
- Continue β_2 bronchodilator 4 hourly as necessary
- Continue prednisolone 20 mg daily until recovery (minimum 3–5 days)
- Advise to contact GP if not controlled on above treatment
- Provide a written asthma action plan
- Review regular treatment
- Check inhaler technique
- Arrange GP follow up within 48 hours
- Arrange hospital asthma clinic follow up in 4–6 weeks if 2nd or subsequent attack in past 12 months.

Age >5 years

ASSESS AND RECORD ASTHMA SEVERITY

Moderate asthma
- SpO_2 ≥92%
- PEF ≥50% best or predicted
- No clinical features of severe asthma

NB: If a patient has signs and symptoms across categories, always treat according to their most severe features

Acute severe asthma
- SpO_2 <92%
- PEF 33–50% best or predicted
- Heart rate >125/min
- Respiratory rate >30/min
- Use of accessory neck muscles

Life-threatening asthma

SpO_2 <92% plus any of:
- PEF<33% best or predicted
- Silent chest
- Poor respiratory effort
- Altered consciousness
- Cyanosis

First line treatments

- β_2 bronchodilator:
  - via spacer*
- Oral prednisolone 30–40 mg

Oxygen via face mask/nasal prongs to achieve SpO_2 94–98%

- β_2 bronchodilator
  - via nebuliser (preferably oxygen-driven), salbutamol 5 mg
  - *or*, if nebuliser not available, via spacer*
- Oral prednisolone 30–40 mg or IV hydrocortisone 4 mg/kg if vomiting
- **If poor response** add 0.25 mg nebulised ipratropium bromide to every nebulised β_2 bronchodilator and repeat every 20 minutes for 2 hours according to response

- β_2 bronchodilator with ipratropium:
  - via nebuliser (preferably oxygen-driven), salbutamol 5 mg and ipratropium 0.25 mg
- Repeat bronchodilators every 20–30 minutes
- Oral prednisolone 30–40 mg or IV hydrocortisone 4 mg/kg if vomiting

Discuss with senior clinician, PICU team or paediatrician

Reassess within 1 hour

Second line treatments

- Consider 2nd line treatments – see Annex 8
- Admit all cases if features of severe attack persist after initial treatment
- Arrange transfer to PICU/HDU if poor response to treatment as per local guidelines

DISCHARGE PLAN
- Continue β_2 bronchodilator 4 hourly as necessary
- Continue prednisolone 30–40 mg daily until recovery (minimum 3–5 days)
- Advise to contact GP if not controlled on above treatment
- Provide a written asthma action plan
- Review regular treatment
- Check inhaler technique
- Arrange GP follow up within 48 hours
- Arrange hospital asthma clinic follow up in 4–6 weeks if 2nd or subsequent attack in past 12 months.

*** β_2 bronchodilator via spacer given one puff at a time, inhaled separately using tidal breathing; according to response, give another puff every 60 seconds up to a maximum of 10 puffs**

Management of acute asthma in children in hospital

Age 2–5 years

ASSESS AND RECORD ASTHMA SEVERITY

Moderate asthma	Acute severe asthma	Life-threatening asthma
• SpO_2 ≥92% • No clinical features of severe asthma **NB: If a patient has signs and symptoms across categories, always treat according to their most severe features**	• SpO_2 <92% • Too breathless to talk or eat • Heart rate >140/min • Respiratory rate >40/min • Use of accessory neck muscles	SpO_2 <92% plus any of: • Silent chest • Poor respiratory effort • Agitation • Confusion • Cyanosis

First-line treatments

	Oxygen via face mask/nasal prongs to achieve SpO_2 94–98%	
• β_2 bronchodilator: - via spacer ± facemask* • Consider oral prednisolone 20 mg	• β_2 bronchodilator - via nebuliser (preferably oxygen-driven), salbutamol 2.5 mg - *or*, if nebuliser not available, via spacer* • Oral prednisolone 20 mg *or* IV hydrocortisone 4 mg/kg if vomiting • Repeat β_2 bronchodilator up to every 20–30 minutes according to response • **If poor response** add 0.25 mg nebulised ipratropium bromide to every nebulised β_2 bronchodilator every 20 minutes for 1–2 hours	• β_2 bronchodilator with ipratropium: - via nebuliser (preferably oxygen-driven), salbutamol 2.5 mg and ipratropium 0.25 mg • Repeat bronchodilators every 20–30 minutes • Oral prednisolone 20mg or IV hydrocortisone 4mg/kg if vomiting • Consider adding 150 mg magnesium sulphate to each β_2 bronchodilator/ipratropium nebuliser in first hour **Discuss with senior clinician, PICU team or paediatrician**
Reassess within 1 hour		

ASSESS RESPONSE TO TREATMENT
Record respiratory rate, heart rate and oxygen saturation every 1-4 hours

Second-line treatments

RESPONDING	NOT RESPONDING
• Continue bronchodilators 1–4 hours as necessary • Discharge when stable on 4–hourly treatment • Continue prednisolone 20 mg daily until recovery (minimum 3–5 days) **At discharge** • Ensure stable on 4-hourly inhaled treatment • Review the need for regular treatment and the use of inhaled steroids • Review inhaler technique • Provide a written asthma action plan for treating future attacks • Arrange GP follow up within 48 hours • Arrange hospital asthma clinic follow up in 4–6 weeks	• **Continue 20–30 minute nebulisers** • **Consider chest X-ray and blood gases** • **Discuss with senior clinician, paediatrician or PICU** • **Consider admission to HDU/PICU** Consider risks and benefits of: • **Bolus IV infusion of magnesium sulphate** 40 mg/kg (max 2 g) over 20 minutes • **Bolus IV salbutamol** 15 micrograms/kg if not already given • Continuous **IV salbutamol infusion** 1–5 micrograms/kg/min (200 micrograms/ml solution) • **IV aminophylline** 5 mg/kg loading dose over 20 minutes (omit in those receiving oral theophyllines) **followed by** continuous infusion 1mg/kg/hour Assess response before initiating each new treatment

Age >5 years

ASSESS AND RECORD ASTHMA SEVERITY

Moderate asthma	Acute severe asthma	Life-threatening asthma
• SpO_2 ≥92% • PEF >50% best or predicted • No clinical features of severe asthma **NB: If a patient has signs and symptoms across categories, always treat according to their most severe features**	• SpO_2 <92% • PEF 33–50% best or predicted • Heart rate >125/min • Respiratory rate >30/min • Use of accessory neck muscles	SpO_2 <92% plus any of: • PEF <33% best or predicted • Silent chest • Poor respiratory effort • Confusion • Cyanosis

First-line treatments

	Oxygen via face mask/nasal prongs to achieve SpO_2 94–98%	
• β_2 bronchodilator: - via spacer* • Oral prednisolone 30–40 mg	• β_2 bronchodilator - via nebuliser (preferably oxygen-driven), salbutamol 5 mg - *or*, if nebuliser not available, via spacer* • Oral prednisolone 30–40 mg or IV hydrocortisone 4 mg/kg if vomiting • Repeat β_2 bronchodilator up to every 20–30 minutes according to response • **If poor response** add 0.25 mg nebulised ipratropium bromide to every nebulised β_2 bronchodilator every 20 minutes for 1–2 hours	• β_2 bronchodilator with ipratropium: - via nebuliser (preferably oxygen-driven), salbutamol 5 mg and ipratropium 0.25 mg • Repeat bronchodilators every 20–30 minutes • Oral prednisolone 30–40 mg *or* IV hydrocortisone 4mg/kg if vomiting • Consider adding 150 mg magnesium sulphate to each β_2 bronchodilator/ipratropium nebuliser in first hour **Discuss with senior clinician, PICU team or paediatrician**
Reassess within 1 hour		

ASSESS RESPONSE TO TREATMENT
Record respiratory rate, heart rate, oxygen saturation and PEF/FEV every 1-4 hours

Second-line treatments

RESPONDING	NOT RESPONDING
• Continue bronchodilators 1–4 hours as necessary • Discharge when stable on 4-hourly treatment • Continue prednisolone 30–40 mg daily until recovery (minimum 3–5 days) **At discharge** • Ensure stable on 4–hourly inhaled treatment • Review the need for regular treatment and the use of inhaled steroids • Review inhaler technique • Provide a written asthma action plan for treating future attacks • Arrange GP follow up within 48 hours • Arrange hospital asthma clinic follow up in 4–6 weeks	• **Continue 20–30 minute nebulisers** • **Consider chest X-ray and blood gases** • **Discuss with senior clinician, paediatrician or PICU** • **Consider admission to HDU/PICU** Consider risks and benefits of: • **Bolus IV infusion of magnesium sulphate** 40 mg/kg (max 2 g) over 20 minutes • **Bolus IV salbutamol** 15 micrograms/kg if not already given • Continuous **IV salbutamol infusion** 1–5 micrograms/kg/min (200 micrograms/ml solution) • **IV aminophylline** 5 mg/kg loading dose over 20 minutes (omit in those receiving oral theophyllines) **followed by** continuous infusion 1mg/kg/hour Assess response before initiating each new treatment

* β_2 bronchodilator via spacer given one puff at a time, inhaled separately using tidal breathing; according to response, give another puff every 60 seconds up to a maximum of 10 puffs

Annex 9

Management of acute asthma in infants aged <2 years in hospital[1]

ASSESS AND RECORD ASTHMA SEVERITY
NB: If a patient has signs and symptoms across categories, always treat according to their most severe features

Moderate asthma
- SpO_2 ≥92%
- Audible wheezing
- Using accessory muscles
- Still feeding

Acute severe asthma
- SpO_2 <92%
- Cyanosis
- Marked respiratory distress
- Too breathless to feed

Most infants are audibly wheezy with intercostal recession but not distressed
Life-threatening features include apnoea, bradycardia and poor respiratory effort

First-line treatments

Immediate management
Oxygen via close-fitting face mask or nasal prongs to achieve SpO_2 94–98%

Give trial of β_2 bronchodilator:

- via spacer and face mask (given one puff at a time inhaled separately using tidal breathing; according to response, give another puff every 60 seconds up to a maximum of 10 puffs)

- or via nebuliser (preferably oxygen-driven) salbutamol 2.5 mg

Repeat β_2 bronchodilator every 1–4 hours if responding

If poor response:

Add 0.25 mg nebulised ipratropium bromide to each β_2 bronchodilator nebuliser every 20–30 minutes for 1–2 hours

Consider: Oral prednisolone 10 mg daily for up to 3 days

Monitoring

Continuous close monitoring of:

- heart rate
- pulse rate
- pulse oximetry

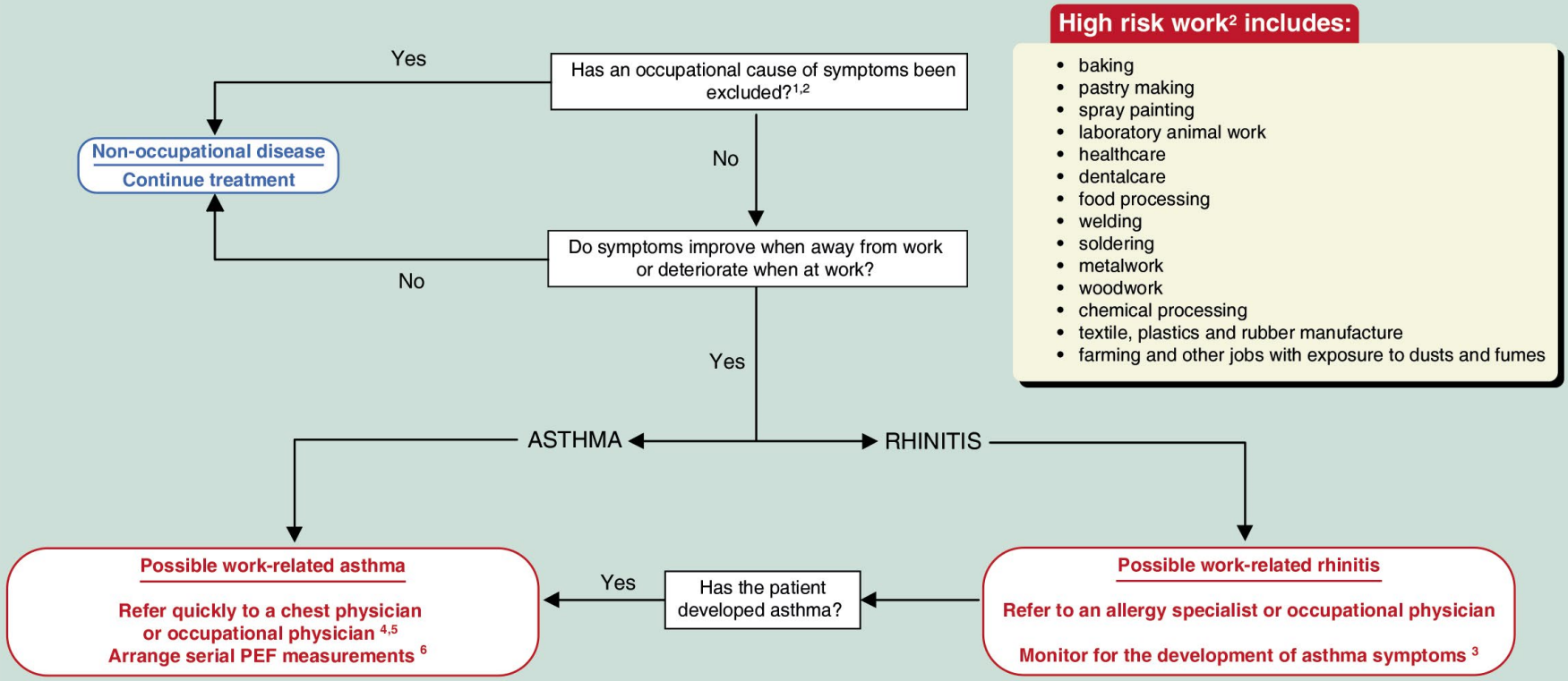
Supportive nursing care with adequate hydration
Consider the need for a chest X-ray

Second-line treatments

- If not responding or has any life-threatening features, discuss with senior paediatriican or PICU team
- Consider alternative diagnoses
- Consider second-line treatments as per Annex 8 with extreme caution

[1] Management of acute asthma in children under 1 year should be under the direction of a respiratory paediatrician.

WORK-RELATED ASTHMA AND RHINITIS: CASE FINDING AND MANAGEMENT IN PRIMARY CARE



High risk work[2] includes:

- baking
- pastry making
- spray painting
- laboratory animal work
- healthcare
- dentalcare
- food processing
- welding
- soldering
- metalwork
- woodwork
- chemical processing
- textile, plastics and rubber manufacture
- farming and other jobs with exposure to dusts and fumes

1. At least 1 in 10 cases of new or reappearance of childhood asthma in adult life are attributable to occupation.
2. Enquire of adult patients with rhinitis or asthma about their job and the materials with which they work.
3. Rhino-conjunctivitis may precede IgE-associated occupational asthma; the risk of developing asthma being highest in the year after the onset of rhinitis.
4. The prognosis of occupational asthma is improved by early identification and early avoidance of further exposure to its cause
5. Confirm a diagnosis supported by objective criteria and not on the basis of a compatible history alone because of the potential implications for employment.
6. Arrange for workers whom you suspect of having work-related asthma to perform serial peak flow measurements at least four times a day.

Guidelines for the identification, Management and Prevention of Occupational Asthma | www.bohrf.org.uk/projects/asthma.html

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Healthcare Improvement Scotland

Edinburgh Office
Gyle Square
1 South Gyle Crescent
Edinburgh
EH12 9EB
0131 623 4300

Glasgow Office
Delta House
50 West Nile Street
Glasgow
G1 2NP
0141 225 6999