Evidence based guidelines for the prevention, identification, and management of occupational asthma


Background: Occupational asthma is the most frequently reported work related respiratory disease in many countries. This work was commissioned by the British Occupational Health Research Foundation to assist the Health and Safety Executive in achieving its target of reducing the incidence of occupational asthma in Great Britain by 30% by 2010.

Aim: The guidelines aim to improve the prevention, identification, and management of occupational asthma by providing evidence based recommendations on which future practice can be based.

Methods: The literature was searched systematically using Medline and Embase for articles published in all languages up to the end of June 2004. Evidence based statements and recommendations were graded according to the Royal College of General Practitioner’s star system and the revised Scottish Intercollegiate Guidelines Network grading system.

Results: A total of 474 original studies were selected for appraisal from over 2500 abstracts. The systematic review produced 52 graded evidence statements and 22 recommendations based on 223 studies.

Discussion: Evidence based guidelines have become benchmarks for practice in healthcare and the process used to prepare them is well established. This evidence review and its recommendations focus on interventions and outcomes to provide a robust approach to the prevention, identification, and management of occupational asthma, based on and using the best available medical evidence. The most important action to prevent cases of occupational asthma is to reduce exposure at source. Thereafter surveillance should be performed for the early identification of symptoms, including occupational rhinitis, with additional functional and immunological tests where appropriate. Effective management of workers suspected to have occupational asthma involves the identification and investigation of symptoms suggestive of asthma immediately they occur. Those workers who are confirmed to have occupational asthma should be advised to avoid further exposure completely and early in the course of their disease to offer the best chance of recovery.

Methods
We systematically searched Medline and Embase from 1966 and 1974 respectively to the end of June 2004. Pairs of working group members reviewed over 2500 abstracts independently to select 474 papers for further, independent critical review; single case studies and narrative reviews were excluded. Data from 223 papers were entered into evidence tables and contributed to the evidence statements.

Criteria for grading evidence and recommendations were developed primarily to guide inferences about treatment; questions about disease frequency, aetiology, diagnosis, and prognosis require other hierarchies. There are few meta-analyses and randomised controlled trials (RCTs) related to OA, and so little Scottish Intercollegiate Guidelines Network (SIGN) grading system level 1 evidence. Therefore we graded evidence statements (ES) and recommendations using both the revised SIGN grading system 2000 for levels of evidence (table 1) and recommendations (table 2), and the modified 1995 Royal College of General Practitioners (RCGP) three star system used in the BOHRF Occupational Health Guidelines for the Management of Low Back Pain at Work (table 3). In accordance with current opinion, recommendations appear in behaviourally specific terms.

RESULTS AND DISCUSSION

Background
OA is the most frequently reported occupational respiratory disorder in westernised industrialised populations. Where mining is common, for example, South Africa and the Czech Republic, OA is the second commonest occupational respiratory disorder after pneumoconiosis.

Abbreviations: BOHRF, British Occupational Health Research Foundation; ES, evidence statement; HMW, high molecular weight; LMW, low molecular weight; OA, occupational asthma; PEFR, peak expiratory flow; RCT, randomised controlled trial; RCP, Royal College of General Practitioners; RPE, respiratory protective equipment; SIGN, Scottish Intercollegiate Guidelines Network; SBPT, specific bronchial provocation testing
Main messages

- Reducing airborne exposure reduces the number of workers who develop occupational asthma.
- Occupational rhinitis may indicate an increased risk of a worker developing occupational asthma, particularly when IgE associated and especially in the year after the onset of rhinitis. 
- Health surveillance can detect occupational asthma at an earlier stage of disease and contribute to improved clinical outcome.
- Asking workers about symptoms that improve regularly when away from work is more sensitive than enquiring about symptoms that deteriorate when at work.
- Outcome is better in workers who have shorter duration of symptoms prior to diagnosis, relatively normal lung function at diagnosis, and no further exposure to the causative agent after diagnosis.

There are no complete registries of OA so the true frequency of the disease is unknown. Published frequencies come from surveillance schemes, compensation registries, or epidemiological studies of the relation between asthma and occupation. The incidence, predominant causative agents, and jobs most commonly reported to incur risk depend on the methodology of data collection, case definition, and predominant work sectors and occupations. Studies generally do not distinguish between hypersensitivity and irritant causes. One systematic review showed an attributable risk of 9%, while the highest scoring studies showed an attributable risk of 15%, a figure supported by another review.

ES1*** SIGN 2++
Occupational factors are estimated to account for 9–15% of cases of asthma in adults of working age, including new onset or recurrent disease.

ES2*** SIGN 2++
The annual population incidence of occupationally related asthma ranges from an estimated 12–170 cases per million workers with an estimated mean of 47 cases per million workers. 

ES3* SIGN 3
The population incidence of OA may be underestimated by as much as 50%.

ES4* SIGN 3
The reported incidence of OA has not decreased in recent years.

Policy implications

- Employers should implement programmes to prevent occupational asthma by removing or reducing exposure to its causes.
- Employers and their health and safety personnel should provide regular health surveillance (respiratory questionnaire with functional and immunological tests, where appropriate) to workers where a risk of occupational asthma is identified.
- Employers and their health and safety personnel should ensure that measures are taken to ensure that workers diagnosed as having of occupational asthma avoid further exposure to its cause in the workplace.

ES5*** SIGN 2++
The most frequently reported agents include isocyanates, flour and grain dust, colophony and fluxes, latex, animals, aldehydes, and wood dust.

ES6*** SIGN 2++
The workers most commonly reported to surveillance schemes of OA include paint sprayers, bakers and pastry makers, nurses, chemical workers, animal handlers, welders, food processing workers, and timber workers.

ES7** SIGN 2+
The workers reported from population studies 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, plastic workers, dental workers, and laboratory technicians.

Four main risk factors have been identified for OA: the causative factor of exposure to an agent at work; the predisposing factors of atopy and genetic predisposition; and the contributing factor of cigarette smoking. A direct relation between OA and exposure to an agent at work occurs with acid anhydrides, cimetidine, colophony, enzymes, green coffee and castor bean, flour allergens, crab, isocyanates, laboratory animal allergens, piperazine, platinum salts, prawns, and western red cedar. Most studies also showed a positive exposure-response relation for sensitisation. Studies limited to sensitisation showed a relation with exposure to acid anhydrides, enzymes, laboratory animals, and platinum salts.

ES8*** SIGN 2++
The risk of sensitisation and OA is increased by higher exposures to many workplace agents.

Table 1 Revised SIGN grading system for levels of evidence

<table>
<thead>
<tr>
<th>Level of evidence</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1++</td>
<td>High quality meta-analyses, systematic reviews of RCTs, or RCTs with a very low risk of bias</td>
</tr>
<tr>
<td>1+</td>
<td>Well conducted meta-analyses, systematic reviews of RCTs, or RCTs with a low risk of bias</td>
</tr>
<tr>
<td>1−</td>
<td>Meta-analyses, systematic reviews of RCTs, or RCTs with a high risk of bias</td>
</tr>
<tr>
<td>2++</td>
<td>High quality systematic reviews of case-control or cohort studies. High quality case-control or cohort studies with a very low risk of confounding, bias, or chance, and a high probability that the relation is causal</td>
</tr>
<tr>
<td>2+</td>
<td>Well conducted case-control or cohort studies with a low risk of confounding, bias, or chance and a moderate probability that the relation is causal</td>
</tr>
<tr>
<td>2−</td>
<td>Case-control or cohort studies with a high risk of confounding, bias, or chance and a significant risk that the relation is not causal</td>
</tr>
<tr>
<td>3</td>
<td>Non-analytical studies, e.g. case reports, case series</td>
</tr>
<tr>
<td>4</td>
<td>Expert opinion</td>
</tr>
</tbody>
</table>
Smoking increases the risk of OA in workers exposed to: isocyanates,\textsuperscript{47} 64 82 83 85 86 88 111 salmon,\textsuperscript{65} 68 69 snow crab,\textsuperscript{86} and wheat flour.\textsuperscript{44} Co-morbid rhinitis or rhino-conjunctivitis is reported in 45–90% of subjects suffering from IgE associated OA attributable to acid anhydrides,\textsuperscript{105} 116 laboratory animals,\textsuperscript{50} 68 69 snow crab,\textsuperscript{86} and wheat flour.\textsuperscript{44}

Table 3 Modified RCGP three star system

<table>
<thead>
<tr>
<th>Source of evidence</th>
<th>Strength of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>** Strong evidence</td>
<td>Provided by generally consistent findings in multiple, high quality scientific studies</td>
</tr>
<tr>
<td>** Moderate evidence</td>
<td>Provided by generally consistent findings in fewer, smaller, or lower quality scientific studies</td>
</tr>
<tr>
<td>* Limited or contradictory evidence</td>
<td>Provided by one scientific study or inconsistent findings in multiple scientific studies</td>
</tr>
<tr>
<td>– No scientific evidence</td>
<td>Based on clinical studies, theoretical considerations, and/or clinical consensus</td>
</tr>
</tbody>
</table>

Prevention

With any study of preventive measures, it is difficult to distinguish the relative effect of one measure against another, since they are usually implemented as a composite programme. Studies show that reducing exposure leads to fewer cases of OA from acid anhydrides,\textsuperscript{31} 124 detergent enzymes,\textsuperscript{34} 36 isocyanates,\textsuperscript{95} laboratory animals,\textsuperscript{64} 125 and latex.\textsuperscript{126} 128

ES16** SIGN 2+

Reducing airborne exposure reduces the number of workers who become sensitised and who develop OA.\textsuperscript{31} 34 36 49 60 125-128

Table 2 Revised SIGN grading system for recommendations

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Source of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>A At least one meta-analysis, systematic review, or RCT rated as 1++, and directly applicable to the target population; or a systematic review of RCTs or a body of evidence consisting principally of studies rated as 1+, directly applicable to the target population, and showing overall consistency of results</td>
<td>Strong evidence</td>
</tr>
<tr>
<td>B A body of evidence including studies rated as 2++, directly applicable to the target population, and showing overall consistency of results; or extrapolated evidence from studies rated as 1++ or 1+</td>
<td>Moderate evidence</td>
</tr>
<tr>
<td>C A body of evidence including studies rated as 2+, directly applicable to the target population and showing overall consistency of results; or extrapolated evidence from studies rated as 2++</td>
<td>Limited or contradictory evidence</td>
</tr>
<tr>
<td>D Evidence level 3 or 4; or extrapolated evidence from studies rated as 2+</td>
<td>No scientific evidence</td>
</tr>
</tbody>
</table>
Respiratory protective equipment (RPE) only offers protection when worn properly, removed safely, and either replaced or maintained regularly. Studies are few and small; one observed a significant association between symptoms and even brief removal of RPE.46

ES17* SIGN 3
The use of RPE reduces the incidence of, but does not completely prevent, OA.48 85 129

Pre-placement examinations should be used to establish a baseline for periodic health surveillance rather than to detect and exclude susceptible individuals from workplaces. Little is known about host susceptibility factors, except for atopy in those exposed predominantly to high molecular weight agents. The efficiency of screening out susceptible job applicants depends partly on the frequency of the trait in the general population.

ES18* SIGN 3
The positive predictive values of screening criteria are too poorly discriminating for screening out potentially susceptible individuals, particularly in the case of atopy where the trait is highly prevalent.67 77 111 123 130–132

ES19* SIGN 3
A previous history of asthma is not significantly associated with OA.67 68

Periodic health surveillance aims to identify sensitised workers or cases of OA at early and reversible stages of disease. There are few, and no concurrent comparison studies of the efficacy of health surveillance for OA. The only study from which valid conclusions can be drawn is of isocyanate workers, in whom health surveillance was linked to a mandatory programme of control of exposure. Workers with isocyanate induced asthma were diagnosed sooner after symptoms began, had better lung function and better outcome than workers who had asthma attributable to other workplace agents135 although the results might partly be attributable to concomitant reduction in exposure. Few studies have evaluated the separate components of health surveillance, questionnaires, spirometry, and identification of specific IgE. In one, all true cases of OA were identified by questionnaire, spirometry producing many false positives due to poor inspiratory effort and no additional cases of OA.134 Skin prick or blood tests for specific IgE are available for most HMW agents and a few LMW agents but few standardised assays are commercially available. OA can usually be diagnosed without specific bronchial provocation testing (SBPT).

ES20* SIGN 3
Health surveillance can detect OA at an earlier stage of disease and outcome is improved in workers who are included in a health surveillance programme.131

ES21* SIGN 3
Screening questionnaires may lead to an underestimate of the prevalence of asthmatic symptoms.136 137

ES22* SIGN 3
Spirometry detects few cases of OA that would not otherwise be detected by respiratory questionnaire.134 135

ES23** SIGN 2+
Skin prick testing and blood sampling of exposed workers to conduct immunological tests is feasible in the workplace.138–140

ES24** SIGN 2+
Prospective surveillance for the development of specific IgE antibodies can be used as part of a broader risk management programme to reduce the incidence of OA.36 90

Identification and evaluation of OA
Most evidence relating to the diagnosis of OA emanates from specialist settings where the prior probability of disease and positive predictive values of tests may be high. History alone produces false positive diagnoses, requiring further validation. Serial measurement of peak expiratory flow (PEF) is the simplest initial investigation. When performed and interpreted to validated standards there are few false positive results, but about 20% false negatives. Skin prick or blood tests for specific IgE are available for most HMW agents and a few LMW agents but few standardised assays are commercially available. OA can usually be diagnosed without specific bronchial provocation testing (SBPT).

The symptoms of any type of asthma have high sensitivity but lower specificity, whereas the question “have you been told by a doctor that you have asthma” has a higher specificity but lower sensitivity.141 Asking about deterioration at work is an insensitive method of diagnosing OA. Questioning about symptoms that are better on days away from work has a sensitivity of 58–100% for validated OA and is enhanced by asking about symptoms improving on holiday. Work related symptoms are common in those with negative SBPT.

ES25** SIGN 2+
In the clinical setting questionnaires that identify symptoms of wheeze and/or shortness of breath that improve on days away from work or on holiday have a high sensitivity, but relatively low specificity for OA.136 142–147

ES26* SIGN 3
Free histories taken by experts have high sensitivity, but their specificity may be lower.137 142 143 144 148–150

No good studies compare cross-shift changes with SBPT. Such testing is unlikely to be either sensitive or specific since measures of airflow obstruction show diurnal variation in most normal workers that is increased in most asthmatics. In one study a fall in FEV₁ of >10% post-shift was found in 5% of asymptomatic workers and 32% of those with work related asthma symptoms.

ES27* SIGN 3
Pre- to post-shift changes in lung function cannot be recommended for the validation or exclusion of OA.151 152

Serial PEF was studied in small case series of patients attending specialist clinics or workplace surveys. Over 70% of subjects in four clinical series and each of the workforce populations returned acceptable records. A single case series of 74 patients attending a specialist clinic reports the highest combination of sensitivity and specificity with PEF measured at least four times daily. Less frequent readings produced higher specificity but lower sensitivity. Six series report high levels of agreement (averaging 80%) between expert assessors. A single series, using non-expert assessors, reports much lower inter-observer agreement. Eight case series report direct and blinded comparisons of serial PEF measurement and either SBPT or an expert diagnosis based on a combination of other evidence. Sensitivities and specificities were consistently high, averaging 80% and 90% respectively. Three case series compare visual inspection of PEF records by experts with a variety of statistical indices. One computed analysis reported sensitivity of 75% and specificity of 94%
Many studies show that non-specific bronchial hyper-reactivity is normal in 5–40% of SBPT positive workers. Testing with higher concentrations of methacholine or histamine at which some non-asthmatics react reduces the number of, but still leaves some, non-reacting asthmatics. A large number of concordant studies from different centres using different methodologies showed that increased non-specific reactivity is often found in workers with OA. There are however many reports of normal methacholine or histamine reactivity within 24 hours of exposure in workers with confirmed OA. Changes in non-specific reactivity at and away from work may persist for many years after avoidance of various agents. The symptoms and functional impairment of OA caused by complex platinum salts are limited to small studies in provocation chambers or limited case reports. The risk of unemployment may vary or may not. There is higher than in other adult asthmatics and may fall with increasing time from diagnosis. No studies make direct comparisons between different systems of rehabilitation. There is one small RCT of the effect of inhaled corticosteroids on recovery from OA after ceasing exposure. The symptoms and functional impairment of OA caused by complex platinum salts are limited to small studies in provocation chambers or limited case reports. The risk of unemployment may vary or may not. There is higher than in other adult asthmatics and may fall with increasing time from diagnosis. No studies make direct comparisons between different systems of rehabilitation. There is one small RCT of the effect of inhaled corticosteroids on recovery from OA after ceasing exposure.

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. The symptoms and functional impairment of OA caused by various agents may persist for many years after avoidance of further exposure to the causative agent. 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.
Table 4  Principal recommendations

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>SIGN</th>
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<tbody>
<tr>
<td>1 Employers, health and safety personnel, and health practitioners should be aware that at least 1 in 10 cases of new or recurrent asthma in adult life are attributable to occupation (ES1)</td>
<td>***</td>
</tr>
<tr>
<td>2 Employers and their health and safety personnel should be aware of the very large number of agents known to cause occupational asthma and the risk of exposure to such agents (ES3)</td>
<td>**</td>
</tr>
<tr>
<td>3 Employers and their health and safety personnel should be aware that the major determinant of risk for the development of occupational asthma is the level of exposure to its causes (ES8)</td>
<td>**</td>
</tr>
<tr>
<td>4 Health practitioners should not use poorly discriminating factors—such as atopy, family or personal history of asthma, cigarette smoking, and HLA phenotype—which increase individual susceptibility to exposure as a reason to exclude individuals from employment (ES18, ES19)</td>
<td>**</td>
</tr>
<tr>
<td>5 Employers should implement programmes to prevent (i.e. reduce the incidence) of occupational asthma by removing or reducing exposure to its causes through elimination or substitution and where this is not possible, by effective control of exposure (ES8, ES16, ES17)</td>
<td>**</td>
</tr>
<tr>
<td>6 Employers and their health and safety personnel should ensure that when respiratory protective equipment is worn, the appropriate type is used and maintained, fit testing is performed and workers understand how to wear, remove and replace their respiratory protective equipment (ES17)</td>
<td>**</td>
</tr>
<tr>
<td>7 Employers and their health and safety personnel should inform workers about any causes of occupational asthma in the workplace and the need to report any relevant symptoms as soon as they develop (ES43, ES44)</td>
<td>**</td>
</tr>
<tr>
<td>8 Employers and their health and safety personnel should be aware that for most causes the risk of developing occupational asthma is greatest during the early years of exposure (ES15)</td>
<td>**</td>
</tr>
<tr>
<td>9 Employers and their health and safety personnel should provide regular health surveillance to workers where a risk of occupational asthma is identified. Surveillance should include a respiratory questionnaire enquiring about work related upper and lower respiratory symptoms, with additional functional and immunological tests, where appropriate (ES20, ES44, ES45)</td>
<td>**</td>
</tr>
<tr>
<td>10 Health practitioners should provide workers at risk of occupational asthma with health surveillance at least annually and more frequently in the first two years of exposure (ES15)</td>
<td>**</td>
</tr>
<tr>
<td>11 Health practitioners should provide more frequent health surveillance to workers who develop rhinitis when working with agents known to cause occupational asthma and ensure that the workplace and working practices are investigated to identify potential causes and implement corrective actions (ES12, ES13, ES14)</td>
<td>**</td>
</tr>
<tr>
<td>12 Health practitioners should provide more frequent health surveillance to any workers who have pre-existing asthma to detect any evidence of deterioration</td>
<td>**</td>
</tr>
<tr>
<td>13 Health practitioners should consider the use of skin prick or serological tests as part of the health surveillance of workers exposed to agents that cause IgE associated occupational asthma to assess the effectiveness of the control of exposure and the risk of occupational asthma among workers (ES24)</td>
<td>**</td>
</tr>
<tr>
<td>14 Health practitioners should enquire of any adult patient with new, recurrent, or deteriorating symptoms of rhinitis or asthma about their job, the materials with which they work and whether their symptoms improve regularly when away from work (ES1, ES5, ES6, ES7, ES25)</td>
<td>**</td>
</tr>
<tr>
<td>15 Employers and their health and safety personnel should assess exposure in the workplace and enquire of relevant symptoms among the workforce when any one employee develops confirmed occupational rhinitis or occupational asthma and identify opportunities to institute remedial measures to protect other workers</td>
<td>**</td>
</tr>
<tr>
<td>16 Health practitioners should be aware that the diagnosis of occupational asthma is improved by early identification and early avoidance of further exposure to its cause (ES45, ES46)</td>
<td>**</td>
</tr>
<tr>
<td>17 Health practitioners who suspect a worker of having occupational asthma should make an early referral to a physician with expertise in occupational asthma</td>
<td>**</td>
</tr>
<tr>
<td>18 Health practitioners who suspect a worker of having occupational asthma should arrange for workers to perform serial peak flow measurements at least four times a day</td>
<td>**</td>
</tr>
<tr>
<td>19 Physicians should confirm a diagnosis of occupational asthma supported by objective criteria (functional, immunological, or both) and not on the basis of a compatible history alone because of the potential implications for future employment (ES25, ES26, ES49, ES50)</td>
<td>**</td>
</tr>
<tr>
<td>20 Employers and their health and safety personnel should ensure that measures are taken to ensure that workers diagnosed as having of occupational asthma avoid further exposure to its cause in the workplace (ES43, ES46, ES47)</td>
<td>**</td>
</tr>
<tr>
<td>21 Physicians treating patients with occupational asthma should follow published clinical guidelines for the pharmacological management of patients with asthma in conjunction with recommendations to avoid exposure to the causative agent</td>
<td>**</td>
</tr>
<tr>
<td>22 Health practitioners should enquire about pre-existing occupational asthma to agents that job applicants might be exposed to in their new job and advise affected applicants that they are not fit to undertake this work (ES43, ES46, ES47)</td>
<td>**</td>
</tr>
</tbody>
</table>

Good practice points appear as † where there is no evidence, and are based on the clinical experience of the authors.

ES46** SIGN 2+  The likelihood of improvement or resolution of symptoms or of preventing deterioration is greater in workers who have shorter duration of symptoms prior to avoidance of exposure.ES18 ES19 205 212 218 219

ES47 SIGN 3  Redeployment to a low exposure area may lead to improvement or resolution of symptoms or prevent deterioration in some workers, but is not always effective.ES20 205 210 215 220 221

ES48* SIGN 3  Air fed helmet respirators may improve or prevent symptoms in some but not all workers who continue to be exposed to the causative agent.ES20 222–226

ES49** SIGN 2–  Approximately one third of workers with OA are unemployed up to six years after diagnosis.ES18 ES19 205 210 227–229

ES50** SIGN 2–  Workers with OA suffer financially.ES18 207 227 228 230

ES51 – SIGN 4  Systems that incorporate retraining may be more effective than those that do not.ES20 231

ES52* SIGN 1+  Inhaled corticosteroids used after cessation of exposure may provide small clinical benefits to workers with OA.ES18

Recommendations

Recommendations appear in table 4 and are followed by references to supporting evidence statements in brackets.

ACKNOWLEDGEMENTS


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