

## Age-dependent inaccuracy of asthma death certification in Northern England, 1991–1992

D.W.E.C. Reid\*, V.J. Hendrick\*, T.C. Aitken\*, W.T. Berrill\*\*, S.C. Stenton\*, D.J. Hendrick\*

*Age-dependent inaccuracy of asthma death certification in Northern England, 1991–1992. D.W.E.C. Reid, V.J. Hendrick, T.C. Aitken, W.T. Berrill, S.C. Stenton, D.J. Hendrick. ©ERS Journals Ltd 1998.*

**ABSTRACT:** Asthma mortality appeared to increase two-fold in the UK from the mid-1970s to the early 1990s, but there is evidence of inaccuracy in asthma death certification and so a region-wide investigation was undertaken to assess whether this recorded statistical trend might have been partly or wholly artefactual.

A total of 35 respiratory physicians, distributed in panels of three, systemically reviewed the hospital and general practice records of 210 subjects with physician-diagnosed asthma who died in 1991 and 1992. The death certificates indicated that asthma was considered to be the primary cause of death in 103 (group 1), a contributory cause in 70 (group 2) and not relevant in 37 (group 3).

There was agreement within the panels that 43% of the subjects had probably never suffered from asthma. Discordance between the panels and the certifying physicians over the correct death certification category was high for group 1 (45% for those aged <65 yrs, 75% for those aged ≥65 yrs and 64% overall) and group 2 (67%), but much less for group 3 (22%).

This study concludes that asthma death certification provides a markedly inaccurate picture of asthma mortality, particularly in elderly subjects. Thus, it is speculated that if the magnitude of this source of inaccuracy has increased over the last two decades, the apparent recent increase in asthma mortality may be largely artefactual. *Eur Respir J 1998; 12: 1079–1083.*

\*Dept of Respiratory Medicine and Regional Unit for Occupational Lung Disease, Royal Victoria Infirmary, University of Newcastle upon Tyne, Newcastle upon Tyne, UK. \*\*Dept of Medicine, West Cumberland Hospital, Whitehaven, Cumbria, UK.

Correspondence: D.J. Hendrick  
Royal Victoria Infirmary  
Queen Victoria Road  
Newcastle upon Tyne  
NE1 4LP  
UK  
Fax: 44 1912275224

Keywords: Asthma  
asthma epidemiology  
asthma mortality  
death certification

Received: July 28 1997  
Accepted after revision June 30 1998

Asthma morbidity in England and Wales appears to have increased in recent decades, despite advances in therapy, and this is widely attributed to increasing asthma prevalence. This increase has not, however, been fully reflected by mortality trends, and in children and young adults, there have been no clear changes. In adults aged ≥45 yrs (in whom >85% of current asthma deaths are recorded), mean annual mortality doubled between the mid-1970s and the early 1990s in both sexes [1, 2]. The rate of change and the degree of annual fluctuation increased with age, and the apparent increase was most evident in those aged ≥65 yrs.

The cause of the marked increase in recorded asthma deaths in this age group is uncertain. If correct, it could reflect improved diagnostic recognition, an increase in asthma prevalence, an increase in disease severity or an adverse effect of medication. The 1979 and 1984 changes in international coding practice (International Classification of Diseases (ICD) 9, implementation of rule 3) artificially increased the mortality rate in those aged <45 yrs and >75 yrs, respectively, but this provides insufficient explanation for the observed trends [2–4].

Alternatively, the increase may be largely artefactual. The accuracy of death certification is known to decline with advancing age, and there is concern that recent trends, especially in the elderly, may be attributable to diagnostic transfer [5, 6]. An audit investigation in the period 1980–

1989 in one district of the Northern Health Region of England suggested that the majority of certified "asthma deaths" had occurred in elderly smokers who had neither died from asthma nor suffered from it [7]. Other studies have suggested that asthma death certification for the whole population may overestimate the number of true asthma deaths by 13–47%, with the degree of inaccuracy in certification rising in the elderly to 39–80% [8–10].

The recorded asthma mortality rates of 3.94 and 3.64 per 100,000 for the Northern Health Region (population 3.07 million) for the years 1991 and 1992, respectively, closely reflect the national figures for England and Wales of 3.67 and 3.48 (total population 51 million). Therefore, experience within the northern region as a whole is likely to be representative of the national picture. The aim of this study was, consequently, to estimate the magnitude of any inaccuracy in death certification for asthma within this region, and hence, to assess whether the apparent increase in asthma mortality in the elderly could have occurred, at least partly, as a result of diagnostic transfer.

### Methods

#### Subjects

Permission was obtained from 13 of the 16 local Health Authorities for a review of death certificates for the years

1991–1992. Those that included the word "asthma", either as the direct cause of death (part 1 of the certificate) or as a contributory cause (part 2 of the certificate), were identified. In addition, a random sample was sought from Regional Health Authority records of patients who had died within these districts over the same period and who had a diagnosis of asthma recorded in their hospital records, but whose death certificate did not mention asthma. Hospital and general practice records were sought for all cases.

We identified 375 relevant death certificates and for 215 of these the full hospital and general practice records were obtained. There was additional information from *post mortem* examinations for 41 of these cases. The failure to retrieve both hospital and general practice records in 160 cases was not associated with any obvious bias of relevance to death certification with regard to age or sex, although those included were more likely to have died in hospital than the 160 who were not included (69 *versus* 37%). In 67% of these 160 cases, either the hospital records or the general practice records were available for review, but not both, and so we decided to investigate only those for which there were full records from both sources. As a consequence, an unknown number of cases were excluded because there had been no hospital referrals and hence no hospital records.

#### *Study groups, case batches, and sentinel cases*

Of the 215 cases with both hospital and general practice records, the initial 210 were classified into three groups: group 1, asthma certified as the direct cause of death (103 cases, 49%); group 2, asthma certified as a contributory but not direct cause of death (70 cases, 33%); and group 3, asthma not mentioned on death certificate but recorded in hospital records as an active problem (37 cases, 18%). Of these 210 cases, 204 were drawn together into 17 batches of 12, each batch containing at least one case from each death certification group. The six other cases, two from each death certification group, had been selected at random as "sentinel cases" to assess consistency and repeatability among the reviewers. They were distributed in two sets of three cases (one from each certification group). One set was included in all odd numbered batches, and the other in all even numbered batches, so that each reviewed batch of 15 cases contained 12 regular cases for single review and three sentinel cases for multiple review. The remaining five of the 215 cases were insufficient to form a batch and so were not included in the investigation.

#### *Reviewer panels*

Each batch of 15 cases was reviewed by a panel of three respiratory physicians, two trained consultants and a registrar trainee. New panels were constituted as each case batch was prepared, so that the task was shared as evenly as possible. All regional consultants and trainee registrars were invited to participate and almost all did so, *i.e.* 23 consultants and 12 registrars, each reviewing one to three (usually two) batches of cases. Each physician reviewed the data independently without seeing the death certificates, and without knowledge of the distribution of cases by certification group or sentinel status. It was known, however, that all three death certification groups would be represented.

#### *Systematic reviews*

A standardized questionnaire was used to aid the physicians summarize their reviews of the hospital and general practice records. They were then asked to conclude whether: the subject had asthma, asthma directly caused death or asthma contributed to death if it was not the direct cause; they were also asked to identify the level of probability associated with each conclusion: most unlikely, *i.e.* <10; probably not, *i.e.* 10–29%; conceivable but unlikely, *i.e.* 30–49%; more likely than not, *i.e.* 50–69%; probably, *i.e.* 70–89%; or almost certainly, *i.e.* ≥90%. They were also invited to identify any other disorder that they considered was the direct or a contributory cause of death.

#### *Analytical methods*

The primary method of analysis, leading to a "consensus" conclusion, was based on the categorical result from each reviewer; *i.e.* was the answer to a given question probably yes (≥50% probability) or probably no (<50% probability)? The agreement of at least two of the three reviewers was required for each nonsentinel case, and a majority of at least two thirds among the many reviewers for each sentinel case. As an alternative method of analysis, the mid-points within each probability range (*i.e.* 5, 20, 40, 60, 80, 95%) were used to obtain a score from each reviewer, thereby taking account of the reviewer's individual levels of confidence. Providing that at least two panel physicians were able to offer a score, the panel conclusion for each question was then expressed by the "mean panel score". A mean score ≥50% indicated a positive (yes) answer to the question posed.

### **Results**

#### *Demographic data*

Of the 210 cases, 91 were males and 119 were females. Of the males, 35 (38%) were aged <65 years, and 56 (62%) ≥65 yrs. Of the females, 33 (28%) were aged <65 yrs, and 86 (72%) ≥65 yrs.

#### *Asthma diagnosis*

The panels agreed by consensus with the diagnosis of asthma in 120 (57%) of the 210 cases (unanimously in 78, by majority in 42), and disagreed in 89 (unanimously in 52, by majority in 37). In one case, there was insufficient information to permit a consensus conclusion, two reviewers disagreeing with each other and one abstaining because the data were considered inadequate. The percentage of subjects thought to have had asthma was similar in all death certification groups: group 1, 55%; group 2, 57%; and group 3, 59%. However, the percentages differed significantly between those aged <65 yrs and those who were older (70 *versus* 50% respectively;  $\chi^2=5.986$ ;  $p<0.05$ ).

#### *Asthma mortality*

The reviewing panels were able to reach a conclusion about the cause of death in 191 of the 210 cases (unanimously in 61% and by majority in 39%). Their conclusions, by the consensus method, are shown in table 1. The

Table 1. – Conclusions by consensus on relevance of asthma to death, by certification group

Panel conclusion	Death certification			Total
	Group 1 direct	Group 2 contributory	Group 3 irrelevant	
All subjects	86	67	37	190
Direct	31	1	4	36
Contributory	13	5	4	22
Not relevant	42	61	29	132
Subjects aged <65 yrs	31	15	14	60
Direct	17	0	3	20
Contributory	5	2	2	9
Not relevant	9	13	9	31
Subjects aged ≥65 yrs	55	52	23	130
Direct	14	1	1	16
Contributory	8	3	2	13
Not relevant	33	48	20	101

Values are numbers of cases.

panels agreed with the certifying physicians that asthma was the direct cause of death in only 31 of the 86 (36%) cases so certified in group 1, and that it was of some relevance (*i.e.* direct or contributory cause) in only 50 of the 153 (33%) cases in which the word "asthma" appeared on the death certificate (groups 1 and 2 combined). They agreed with the certifying physician that asthma was not relevant to death in 29 of the 37 (78%) group 3 cases.

There was a high level of agreement among the reviewing physicians over the relevance of asthma to death in the six randomly chosen sentinel cases (table 2). Agreement was almost unanimous (>95%) in five of the six cases and by a clear majority (70%) in the other. Despite this, there was agreement between the panels and the certifying physicians in only half of these cases.

Five panel physicians unknowingly reviewed a set of three sentinel cases twice, thereby providing 15 duplicated reviews. Identical results were obtained for all but two of the 15 pairs. One reviewer considered that asthma was not relevant to death initially, but decided that there was insufficient information to judge when the case was reviewed the second time. Another initially considered asthma to be a contributory cause of death, but the direct cause at the second review.

Almost all of the group 3 subjects had died in hospital (this had no doubt helped the Health Authority to identify

Table 2. – Sentinel cases: number of respiratory physicians recording the relevance of asthma to death in each possible diagnostic category, by certification group

Physicians' conclusions	Death certification		
	Group 1 direct	Group 2 contributory	Group 3 irrelevant
Odd batches	Case O1	Case O2	Case O3
Direct cause	24	0	26
Contributory cause	0	0	0
Not relevant	0	24	1
Even batches	Case E1	Case E2	Case E3
Direct cause	1	16	0
Contributory cause	0	4	0
Not relevant	23	3	24

For odd batches, there were 27 reviews and for even batches, 24. In some cases, the individual reviewer did not consider that there was sufficient evidence to offer an opinion.

them), but the sites of death (hospital or community) of the group 1 and 2 subjects were distributed much more evenly. The independent importance of place of death and age to the likelihood of discordance between panels and certifying physicians was assessed using logistic regression analysis. Discordance over the cause of death in the group 1 cases was significantly more likely with increasing age (75% for those aged ≥65 yrs *versus* 45% for those aged <65 yrs, the odds of disagreement increasing by 3.6% per year of age difference;  $p=0.028$ ) and there was more discordance over the group 1 and 2 cases together than over the group 3 cases (67% *versus* 22%, odds ratio=11.7;  $p<0.001$ ). Whether death occurred in the community or hospital (*i.e.* whether the certifying physician was a general practitioner or junior hospital doctor) exerted no influence (odds ratio=1.12;  $p=0.8$ ). The internal disagreement between panel physicians was also greater for the group 1 and 2 cases than for the group 3 cases ( $p<0.001$ , one-way analysis of variance (ANOVA)), but the age at death did not exert any influence on their ability to reach a conclusion or on the level of internal disagreement.

#### Mean panel scores

The supplementary analysis using the mean panel scores gave almost identical results to those obtained categorically by consensus. Of 209 cases for which both methods could be used to assess the diagnosis of asthma, only eight gave a positive outcome for one but a negative outcome for the other. For 191 cases, at least two panel physicians were able to offer a score for the cause of death (table 3), and for 190 of these, the results could be compared with the results of the consensus method of assessment. Inconsistencies were noted in only three, all from group 3. In one, asthma was considered a "contributory" cause of death by consensus but "not relevant" by mean score, and in another the converse occurred. In the third case, asthma was considered a "contributory" cause by consensus but the "direct" cause by mean score.

#### Cause of death identified by panels

In the 55 group 1 cases where the panels disagreed with the certifying physician that asthma was the direct cause

Table 3. – Conclusions by mean score on relevance of asthma to death, by certification group

Panel conclusion	Death certification			Total
	Group 1 direct	Group 2 contributory	Group 3 irrelevant	
All subjects	87	67	37	191
Direct	31	1	5	37
Contributory	13	5	3	21
Not relevant	43	61	29	133
Subjects aged <65 yrs	31	15	14	60
Direct	17	0	3	20
Contributory	5	2	1	8
Not relevant	9	13	10	32
Subjects aged ≥65 yrs	56	52	23	131
Direct	14	1	2	17
Contributory	8	3	2	13
Not relevant	34	48	19	101

Values are numbers of cases.

of death, the true cause was thought to be smoking-related chronic obstructive pulmonary disease (COPD) in 28 (51%), both COPD and cardiovascular disease in six (11%), cardiovascular disease alone in six (11%), an alternative respiratory disorder in three (sarcoidosis 2%, pulmonary embolism 4%) and a variety of other diseases in 10 (18%). In two cases, the panels were unable to identify the probable direct cause of death, although in one, asthma probably contributed.

### Discussion

It is well recognized that death certificates may be inaccurate, the degree of inaccuracy being greatest in the elderly, for whom there are often multiple pathologies and a natural reluctance to obtain a necroscopic diagnosis. Despite this, mortality trends derived from asthma death certifications have exerted a considerable influence during recent decades, and the apparent steady rise in older age groups has led to fears that treatment may be ineffective or may have unsuspected dangers [11–14].

Our investigation suggests that inaccuracies in attributing death to asthma are likely to be substantial, although it should be recognized that the physicians certifying death may have possessed additional information of relevance to that available to the reviewing panels. Differences in opinion between certifying physicians and panel physicians do not necessarily mean, therefore, that the errors lay with the former rather than the latter. Furthermore, approximately one third of the panels' conclusions were reached by majority, not unanimous, verdict, and by corresponding mean scores in the most uncertain probability range, *i.e.* 30–69%. This implies that diagnosing asthma and assessing its relevance to death are often difficult tasks, although the panel physicians did not appear to find this more difficult in the older subjects, despite the frequency of other disorders of possible relevance. We consequently assessed the overall concordance between panels and certifying physicians by considering whether asthma was likely to have been relevant to death (*i.e.* direct or contributory case), since this would minimize differences of opinion over quantitative issues, while still allowing an assessment of the fundamental qualitative issues.

In fact, the levels of concordance were of a similar order, whether asthma was assessed specifically as the direct cause of death (*i.e.* group 1 cases only) or more widely as a factor of relevance (*i.e.* groups 1 and 2 combined). Thus, concordance proved to be poor for group 1 and 2 cases where asthma was certified to be relevant, but good for group 3 cases where the death certificates did not mention asthma. Although panel conclusions were not always clear cut, the six randomly selected sentinel cases usefully indicated that the panel physicians as a group showed a high level of consistency in assessing the cause of death, as did the five individual panel physicians who provided duplicate reviews. This was despite the poor level of concordance (merely 50%) between the panels and the certifying physicians for these sentinel cases. There was also a high level of consistency between the consensus conclusions of the panel physicians and their conclusions derived from mean probability scores. This suggests that the results did fairly reflect the considered opinions of practising respiratory physicians rather than the method of ana-

lysis. Almost every respiratory physician in the region contributed to the investigation and no one physician contributed to excess. Furthermore, all three possible death certification groupings were known to be represented in each batch of cases, although in unknown proportions. It is doubtful, therefore, whether any important systematic biases were operating, and we think it is likely that the findings do indicate a substantial "false positive" inaccuracy in asthma death certification.

The discordance between panel physicians and certifying physicians in assessing the direct cause of death in the group 1 cases was much greater (and significantly so) in the older subjects, being 75% in those aged  $\geq 65$  yrs but 45% for the remainder. However, internal disagreement within panels was not related to age (or place of death). This suggests that the increasing discordance between panels and certifying physicians with increasing age was a consequence of differences in diagnostic opinion rather than a lack of information.

The effect of patient age on agreement about the cause of death is important as most certified deaths from asthma (about 60%) occur in this older population, and national statistics are unduly weighted by them. If the false positive certification rate was of the order of 75% nationally in this older population in the early 1990s, there would have been 800–900 false positive certifications annually in England and Wales, enough to account for the apparent overall increase in asthma mortality since the mid-1970s. The recent trend in this older group may consequently have been entirely artefactual. For this to be so, there would have been about 300 true asthma deaths among the total of 1,100–1,200 certified in the early 1990s in subjects aged  $\geq 65$  yrs, and also about 300 among the total of 500–600 certified annually in the mid-1970s. This would imply an increase in the false positive rate of asthma death certifications from about 50% (approximately the rate that we have found in 1991–1992 for subjects aged  $< 65$  yrs) to 75%, which seems plausible though is entirely speculative. It would imply, in addition, that if asthma prevalence has increased without any increase in overall mortality, the risk of death in an affected individual must have decreased. Recently developed management strategies may, therefore, have been more successful than has been suggested.

Diagnostic transfer from COPD appeared to be responsible for many of the false positive asthma death certifications, a phenomenon noted in other studies [5, 6, 10, 15]. There is an increasing tendency to treat patients suffering from fixed airflow obstruction (which may occasionally be a consequence of long-standing asthma) with the same medications that are used for asthma, and as such patients may perceive some benefit from this treatment, it may be that the diagnostic terms COPD and asthma have come to be used interchangeably, at least in some subjects. This is especially likely in patients who are not referred to respiratory medicine clinics and who do not, consequently, undergo adequate diagnostic tests of lung function. During an era in which there has been increasing awareness of asthma by public and physicians alike, it may have become the preferred diagnosis and so have appeared subsequently, though erroneously, on death certificates. For the particular population in the present study, the panels concluded that there was insufficient evidence from either the general practice records or the hospital records to sustain a

diagnosis of asthma in a substantial proportion (42%). Again, this percentage was significantly greater in subjects aged  $\geq 65$  yrs (50%) than in those who were younger (30%).

The investigation was aimed primarily at assessing the accuracy of group 1 and 2 death certifications, *i.e.* an assessment of false positive inaccuracy. The group 3 cases were included to lessen the possibility of bias during the reviewing process. Reviewers might have been prejudiced by suspecting that asthma mortality had been exaggerated or underestimated. However, they would have known that any individual case could have come from any one of the possible death certification groups, and that other reviewers would also assess each case. The number of group 3 cases was insufficient for a meaningful assessment of false negative inaccuracy in asthma death certification, and they were not selected from any particular death certification grouping. We cannot estimate, therefore, how many true asthma deaths are hidden among the statistics relating to death from COPD, cardiovascular disease, or any other causes. We noted, nevertheless, that of the 37 group 3 cases, the panels concluded that asthma was the direct cause of death in four and a contributory cause in a further four. By coincidence, a very recent investigation of asthma mortality in the 16–64 yr age group suggested that false negative certifications had occurred in four of 22 cases (18%; 95% confidence interval 5–40) [16].

In view of the high prevalence of asthma within the population at large and the large number of deaths attributed to COPD (or to alternative diagnostic terms) and cardiovascular disease, the cumulative potential for false negative certification of asthma deaths is formidable. Underestimation of asthma mortality through this phenomenon is, consequently, likely to counteract, to some degree, the probable error towards overestimation that we have identified in this investigation. Unrecognized asthma deaths are not, however, likely to invalidate our suggestion that recent trends of increasing asthma mortality in the elderly may be, primarily, a consequence of artefact (increased "false positive" certification) because it is improbable that there would have been increases in diagnostic transfer in opposite direction simultaneously.

We conclude that recent statistics of asthma mortality are seriously flawed by false positive certification. This results from diagnostic transfer from other diseases, principally chronic obstructive pulmonary disease, but it is not closely related to whether death occurs in hospital or in the community, and so to whether the death certificate is completed by junior hospital doctors or general practitioners. We speculate that recent trends suggesting an increasing risk of death from asthma in older age groups are partly (or even wholly) artefactual and that, if asthma prevalence is actually increasing, recently developed management strategies (and current medications) have been more successful than has been suggested.

**Acknowledgements:** The following respiratory physicians participated as reviewers: G. Afolabi, T. Aiken, S. Baudouin, W. Berrill, S. Bourke, P. Brown, H. Clague, K. Connolly, R. Convery, P. Corris, A. Gascoigne, J. Gibson, H. Gribbin, R. Harrison; D. Hendrick, B. Higgins, R. Keh-

dia, N. Keane, A. Lishman, A. Leonard, N. Munro, P. Masel, P. Mustchin, S. Pearce, T. Peel, D. Reid, R. Siddiqui, D. Sinclair, C. Stenton, P. Snashall, P. Sutton, I. Taylor, P. Turner, A. Ward, J. White. Many also contributed to the preparation of this manuscript.

We are most grateful to colleagues within the Regional Health Authority, J. Stevenson, A. McNay, and D. Morris, for invaluable assistance and guidance; to clerical staff within Family Health Service Agencies, local hospitals, general practices, and our own department, for their painstaking efforts to recover records; and to our general practitioner and consultant colleagues for permission to study records of patients under their care.

## References

- Office of Population Censuses and Surveys. Mortality Statistics—Cause. Series DH1-20 (1974–1992). London, HMSO, 1977–1994.
- Trends in Asthma Mortality in the Elderly. Factsheet 92/1, Lung & Asthma Information Agency, St George's Hospital Medical School, 1992.
- World Health Organisation. International Classification of Diseases and Related Health Problems. 9th Revision, 1979.
- World Health Organisation. International Classification of Diseases and Related Health Problems Implementation of Rule 3. 9th Revision, 1984.
- Whallet E, Ayres J. Labelling shift from acute bronchitis may be contributing to the recent rise in asthma mortality in the 5–34 age group. *Respir Med* 1993; 87: 183–186.
- Smyth ET, Wright SC, Evans AE, Sinnamon DG, MacMahon J. Death from airways obstruction: accuracy of certification in Northern Ireland. *Thorax* 1996; 51: 293–297.
- Berrill WT. Are asthma deaths exaggerated? An audit from West Cumbria. *BMJ* 1993; 306: 193–194.
- Anonymous. Accuracy of death certificates in bronchial asthma. Accuracy of certification procedures during the confidential inquiry by the British Thoracic Association. *Thorax* 1984; 39: 505–509.
- Jenkins MA, Rubinfield ARR, Robertson CF, Bowes G. Accuracy of asthma death statistics in Australia. *Austral J Pub Health* 1992; 16: 427–429.
- Wright SC, Evans AE, Sinnamon DG, MacMahon J. Asthma mortality and death certification in Northern Ireland. *Thorax* 1994; 49: 141–143.
- Sears M, Taylor D, Print C, Lake D, Li Q, Flannery E. Regular inhaled  $\beta$ -agonist treatment in bronchial asthma. *Lancet* 1990; 336: 1391–1396.
- Spitzer W, Suissa S, Ernst P, Horwitz R, Habbick B, Cockcroft D. The use of  $\beta$ -agonists and the risk of death or near-death from asthma. *N Engl J Med* 1992; 326: 501–506.
- Tattersfield A. Use of  $\beta_2$  agonists in asthma: much ado about nothing? Still cause for concern. *BMJ* 1994; 309: 794–795.
- Crane J, Pearce N, Burgess C, Beasley R. Asthma and the  $\beta$ -agonist debate. *Thorax* 1995; 50: Suppl 1, S5–10.
- Ormerod L, Stableforth D. Asthma mortality in Birmingham 1975–7: 53 deaths. *BMJ* 1980; 280: 687–690.
- Guite HF, Burney PGJ. Accuracy of recording of deaths from asthma in the UK: the false negative rate. *Thorax* 1996; 51: 924–928.