Respiratory Medicine (2013) 107, 1172–1177

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Time trends in 30 day case-fatality following hospitalisation for asthma in adults in Scotland: A retrospective cohort study from 1981 to 2009

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Received 24 July 2012; accepted 5 April 2013
Available online 3 May 2013

KEYWORDS
Asthma mortality;
Asthma trends;
Hospitalisations;
Epidemiology

Summary
Background: The risk of case-fatality following hospitalisation for asthma has not been well characterised. We describe trends in 30 day case-fatality following hospitalisation for asthma in adults in Scotland from 1981 to 2009.
Methods: Using the Scottish Morbidity Record Scheme (SMR01) with all asthma hospitalisations for adults (≥18 years) with ICD9 493 and ICD10 J45–J46 in the principal diagnostic position at discharge (1981–2009). These data were linked to mortality data from the General Register Office for Scotland (GROS), with asthma case-fatality defined as death within 30 days of asthma admission (in or out of hospital). Logistic regression was used to explore the impact of age, sex, previous asthma admission (in the 12 months prior to hospitalisation), socioeconomic deprivation, year of admission and co-morbidity on 30-day case-fatality.
Results: There were a total of 116 457 asthma hospitalisations; a total of 1000 (0.9%) hospitalisations resulted in a post-admission death (within 30 days of admission). Odds ratios for unadjusted and adjusted case-fatality showed a decreased risk of case-fatality from the mid-1990s onwards when compared to case-fatality in 1981. Advancing age and co-morbid diagnoses of respiratory failure, cancer, renal failure, cor pulmonale, coronary heart disease and respiratory infection were associated with increased likelihood of death.
Conclusions: 30 day case-fatality has declined over the last three decades, comparable to

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0954-6111/$ - see front matter
http://dx.doi.org/10.1016/j.rmed.2013.04.004

case-fatality reported in other parts of the UK. This decline may be in part due to improved guidelines, protocols and disease management for asthma over the last 30 years. The likelihood of death 30 days following an asthma admission increased with age group and was associated with respiratory failure, renal failure and cancer.

Background

Asthma affects approximately 300 million people worldwide.[1] In 2007 the World Health Organisation estimated that there were 250 000 asthma-related deaths per year.[2] Compared to other chronic diseases asthma can be considered to have a low mortality risk. Improvement in clinical management and the advent of inhaled corticosteroids have improved asthma control and reduced morbidity and mortality. Asthma mortality has declined over the last two decades in most developed nations.[3–5] Mackay et al. in Scotland showed stable mortality in the 5—44 age group for both males and females in the 1970s and 80s[6] and Campbell et al. showed that since the late 1980s asthma mortality has dropped (except for those over 85) in England and Wales.[7] Some studies have shown an increased risk of mortality in asthma patients despite the overall decline in asthma mortality.[8,9]

Watson et al.[10] examined the mortality rate of 250 043 asthma admissions and examined the mortality levels after admission (0.43%). Women and those aged over 45 had the highest levels of mortality. Patients with severe asthma account for the majority of asthma hospitalisations[11] and asthma severity has been shown to be the strongest independent risk factor for hospital readmission.[12] Severe asthma is a significant burden to patients in terms of morbidity and potential mortality, as well as being a financial burden to the health service, in terms of cost from managing hospitalisations of severe exacerbations.

It is generally accepted that asthma mortality rates are generally much lower in well-designed clinical studies where patients are monitored more meticulously than in routine care. There is little published literature about current case-fatality after an admission for asthma and it is important to know mortality rates among severe asthmatics in routine practice, and the case-fatality for asthma patients admitted to hospital with an exacerbation. Patients with inadequately controlled unstable severe asthma are at a higher risk of exacerbation, as well as hospitalisation and mortality.[13,14]

This study describes trends in short-term case-fatality following hospitalisation for asthma in adults in Scotland from 1981 through to 2009.

Methods

The National Health Service (NHS) provides virtually all elective and emergency hospital care in Scotland free at point of access. Hospital discharge data are routinely recorded in the Scottish Morbidity Record (SMR01). Up to six discharge diagnoses, one principal and five co-morbid, are recorded using the International Classification of Diseases (ICD) system in SMR01 at the time of discharge. SMR01 data are routinely linked to mortality records collected by the General Registry Office for Scotland (GROS). We identified all hospitalisations in adults ($\geq$18 years of age) in which asthma was coded in the principal diagnostic position at discharge (ICD9 493; ICD10 J45—J46) from 1st January 1981 to 31st December 2009.[15]

From the SMR01 dataset explanatory variables were collected including demographic characteristics such as age, sex, and co-morbidities. Age was grouped into the following categories for analysis (18—24 years, 25—34 years, 35—44 years, 45—54 years, 55—64 years, and 65 years and over). Co-morbid diagnoses were identified from secondary diagnoses recorded during the index asthma hospitalisation, and principal or secondary diagnoses during all prior hospitalisation in the 5 years preceding the index asthma hospitalisation. Co-morbid diagnoses included diabetes, cancer, coronary heart disease, essential hypertension, cerebrovascular disease, renal failure, respiratory infections, cor pulmonale, and respiratory failure. Asthma hospitalisations within 12 months of the index asthma hospitalisation were identified. Socioeconomic deprivation was defined using the Carstairs—Morris index of deprivation,[16] an area-based measure based on postcode sector of residence.

Statistical analysis

All subjects were followed from the date of hospital admission for 30 days. Crude case-fatality at 30 days (from date of admission) was calculated. Logistic regression was used to model case-fatality at 30 days and explore the impact of age group, sex, asthma hospitalisation within 12 months of the index asthma hospitalisation, socioeconomic deprivation, year of hospitalisation and co-morbidity. To account for the fact that one individual might contribute multiple hospitalisations; the logistic regression was performed specifying clustering at patient level to ensure appropriate estimation of standard errors. The dataset was examined for interactions between sex, age and comorbidities. The data were analysed for the association of cohort, age and period with mortality, using the intrinsic estimator approach[17]; the model presented is the best fitting model. A significance level of 0.05 was used throughout. Analyses were conducted using STATA (Version 10; STATA Corp, College Station, Texas).

Results

Baseline characteristics of patients hospitalised with asthma (n = 116 457)

There were 116 457 admissions for asthma during the study period, there were significantly more women (76 198,

65.4%) admitted for asthma compared with men (40 259, 34.6%). The baseline characteristics of the cohort are outlined in Table 1. The mean (SD) age at admission was 46 ± 18 years, and a quarter were in the most socioeconomically deprived group.

Baseline characteristics according to vital status at 30 days (n = 115 457)

Ninety-nine percent of the admissions were alive after 30 days of a hospital admission. The mean (SD) age at admission was 46 ± 18 years, with similar proportions of males and females compared with those who died within 30 days. The most commonly associated co-morbidities for those who were still alive after 30 days were respiratory infections (15.1%), coronary heart disease (12.1%), essential hypertension (6.7%), diabetes (4.5%) and respiratory failure (2.4%).

Crude case-fatality within 30 days of a hospital admission for asthma (n = 1000)

Overall crude case-fatality at 30 days was 0.9% (n = 1000). Those who died within 30 days of admission were older (66 ± 15.6 years). The likelihood of fatality increased with increasing age group. Just over 60% of the case fatalities were aged over 65 years. The most commonly associated co-morbidities for all case fatalities were coronary heart disease (35.9%), respiratory infections (23.2%), respiratory failure (11.6%) and essential hypertension (9.4%).

Adjusted case-fatality at 30 days

Table 2 shows the results from the logistic model with unadjusted and adjusted odds ratios (adjusted for age, sex, year, socioeconomic deprivation and comorbidities). The odds of mortality 30 days post-admission increased with advancing age group. Co-morbid diagnoses of respiratory failure, cancer, renal failure, cor pulmonale, coronary heart disease and respiratory infection were associated with an increased odds of mortality at 30 days.

On testing, the only statistically significant interactions were between sex and co-morbid respiratory infections. Here the adjusted odds ratio (OR) for case-fatality within 30 days (respiratory infections *vs* no respiratory infections) was 1.75 (95% CI 1.35—2.27) for women and 1.08 (95% CI 0.75—1.56) for men. Fig. 1 shows unadjusted and adjusted odds ratios for each year of the study period. The overall trend was towards a decline in the odds of 30 day case-fatality from the mid-1990s relative to the start of the study period, although the 95% confidence intervals crossed unity indicating that the difference was not statistically significant.

Discussion

Comparisons of hospital mortality rates are commonly based on either in-hospital deaths[18,19] or deaths that occur within a fixed time period such as 30 days after admission.[20,21] In-hospital deaths can be easily identified from hospital discharge records, but may be subject to bias due

Table 1 Baseline characteristics of all asthma admissions.

	All asthma admissions		
	All N = 116 457	Men N = 40 259	Women N = 76 198
Mean age at admission, year (SD)	45.9 (18.32)	46.0(17.8)	45.9 (18.6)
Age groups, *N* (%)			
18—24 years	17 173	5686	11 487
25—34 years	20 785	7163	13 622
35—44 years	20 390	6851	13 539
45—54 years	19 856	6996	12 860
55—64 years	16 474	6296	10 178
≥65 + years +	21 779	7267	14 512
Carstairs—Morris index of socioeconomic deprivation, *N* (%)			
1st quintile (least deprived)	13 356	4549	8807
2nd quintile	16 573	5692	10 881
3rd quintile	20 029	6613	13 416
4th quintile	22 878	7756	15 122
Quintile (most deprived)	29 871	10 051	19 820
Asthma hospitalisation in last 12 months *N* (%)	35 624	11 733	23 891
Comorbidity, *N* (%)			
Diabetes	5289 (4.5)	1511 (3.8)	3778 (5.0)
Cancer	2231 (1.9)	910 (2.3)	1321 (1.7)
Coronary heart disease	14 579 (12.5)	5377 (13.4)	9202 (12.1)
Essential hypertension	7837 (6.7)	2100 (5.2)	5737 (7.5)
Cerebrovascular disease	1955 (1.7)	572 (1.4)	1383 (1.8)
Renal failure	999 (0.9)	348(0.9)	651(0.9)
Respiratory infections	17 672 (15.2)	5571 (13.8)	12 101 (15.9)
Cor pulmonale	567 (0.5)	262 (0.7)	305 (0.4)
Respiratory failure	2941 (2.5)	987 (2.4)	1954 (2.6)

Table 2 Logistic regression models for 30 day case-fatality after asthma admission (adjusted for age group, sex, year socioeconomic deprivation, comorbidities).[a]

	Unadjusted odds ratio	Lower 95% CI, upper 95% CI	Adjusted odds ratio	Lower 95% CI, upper 95% CI
Age group 18–24	1.0 (reference)		1.0 (reference)	
Age group 25–34	1.0	0.5, 1.8	1.1	0.6, 2.2
Age group 35–44	1.4	0.8, 2.5	1.4	0.7, 2.7
Age group 45–54	3.1	1.8, 5.2	2.4	1.3, 4.4
Age group 55–64	8.9	5.4, 14.6	6.3	3.6, 11.1
Age group 65+	19.6	12.1, 31.8	12.3	7.1, 21.3
Sex	0.8	0.71, 0.9	0.9	0.8, 1.0
Carstairs–Morris index of Socioeconomic deprivation				
1st quintile (least deprived)	1.0 (reference)		1.0 (reference)	
2nd quintile	1.3	0.2, 1.7	1.4	1.1, 1.9
3rd quintile	1.1	0.2, 1.4	1.3	1.0, 1.8
4th quintile	0.9	0.1, 1.2	1.1	0.8, 1.4
5th quintile (most deprived)	1.0	0.1, 1.2	1.1	0.9, 1.5
Emergency admission	0.9	0.7, 1.1	1.2	0.9, 1.6
Asthma hospitalisation in last 12 months	0.9	0.7, 1.0	0.9	0.8, 1.1
Comorbidity				
Diabetes	2.1	1.6, 2.6	1.1	0.8, 1.5
Cancer	5.2	4.1, 6.6	2.6	2.0, 3.5
Coronary heart disease	4.1	3.6, 4.7	1.6	1.4, 2.0
Essential hypertension	1.4	1.2, 1.8	0.8	0.6, 1.0
Cerebrovascular disease	3.8	2.9, 4.9	1.5	1.0, 2.1
Renal failure	5.9	4.3, 8.2	2.5	1.7, 3.9
Respiratory infections	1.7	1.5, 2.0	1.5	1.1, 1.8
Cor pulmonale	8.3	5.7, 12.3	1.9	1.1, 3.2
Respiratory failure	5.2	4.2, 6.6	4.0	3.0, 5.3

[a] The reference group consisted of men, aged 18–24 in deprivation quintile 1 (least deprived) in 1981, not an emergency admission and no comorbidities.

to variations in length of stay or hospital discharge practices.[22]

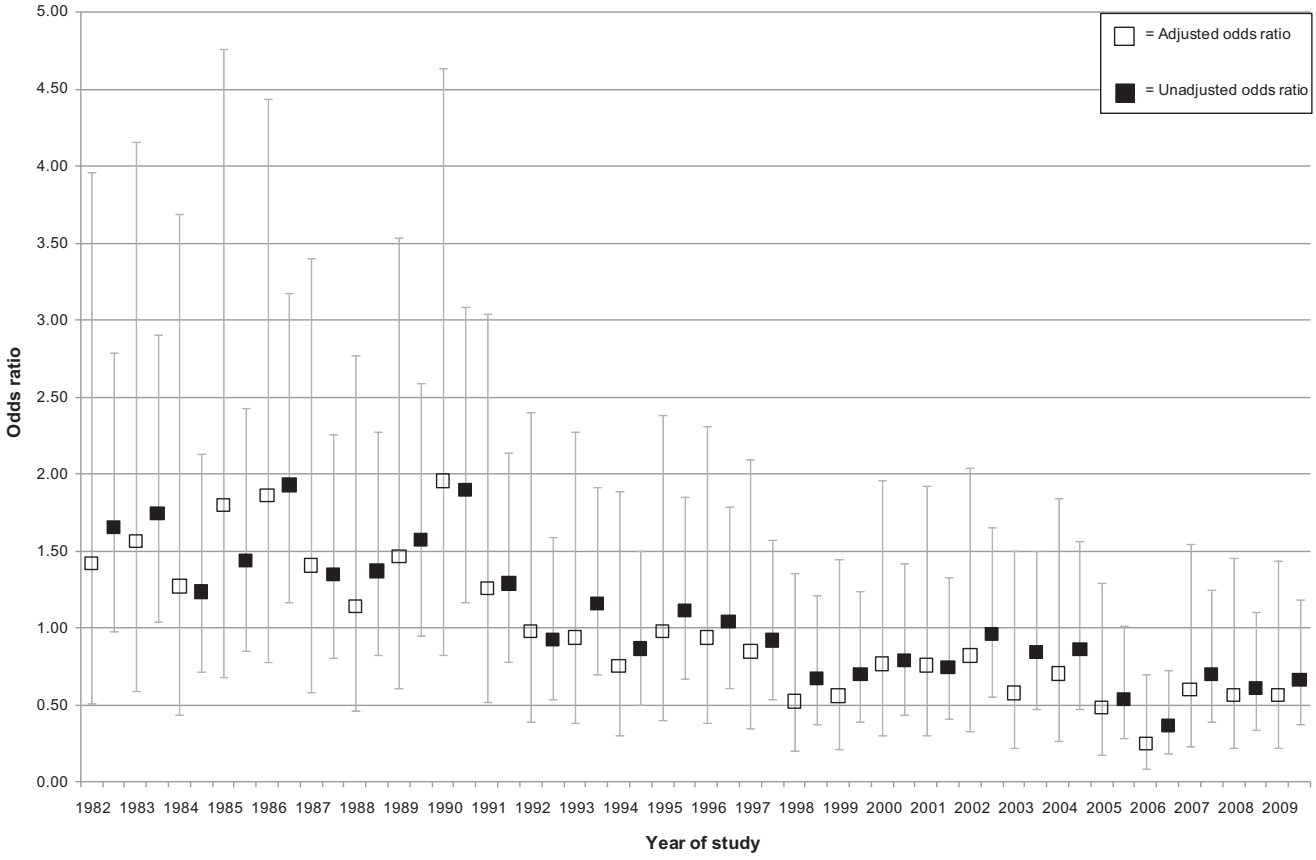
This study set out to investigate mortality rates for adults in Scotland, after a hospitalisation for asthma, from 1981 to 2009. There is little recent population data published on case-fatality after an admission for asthma. Published clinical studies generally have a high level of patient monitoring and such studies report asthma mortality rates, which are very low.

We found that asthma deaths in adults occurred at a low rate; one thousand case fatalities were identified from 116 457 hospital admissions over three decades. Most of the case fatalities were associated with individuals aged over 65 and this was strongly associated with comorbidities such as respiratory and renal failure, and respiratory infections. It is important for respiratory teams to manage other co-morbid diagnoses as well as optimising care for asthma, for example, ensuring provision of seasonal vaccination for those with severe disease. These admissions were similar in terms of ages and sex and comorbidities, and there was no effect of previous asthma admission. The logistic regressions showed that increasing age group increased likelihood of mortality, and there were no differences in mortality between men and women. Other comorbidities, such as cancer and cor pulmonale, were shown to increase the likelihood of case-fatality.

An American study using the nationwide inpatient sample by Krishnan et al.[23] reported in-hospital asthma fatality as 0.5%. In our dataset, asthma fatality was 0.9% at 30 days from date of hospital admission. A study in Spain and Latin America by Rodrigo et al.[24] found levels of mortality approximately 1% and a reduction in in-hospital mortality over the study period (1.0% in 1994 to 0.7% in 2004). The mean (SD) length of stay for those admitted was 7.5 $\pm$ 5.7 days. In this study, deaths occurred more frequently in those aged over 50, however multivariate analysis showed that respiratory failure and respiratory infections were independently associated with a significantly increased mortality risk. Our study investigated case-fatality within 30 days following an asthma admission and included both in-hospital fatalities and out of hospital fatalities.

Strengths and limitations

One of the main strengths of this study was the size of the dataset; we studied a whole population of 5.1 million people over a 27 year period. This study used discharge codes to identify admissions with asthma in the principal position. The Scottish Morbidity Record Scheme is audited routinely and has been shown to be an accurate record of the discharge and diagnosis for each admission.[15] A report from 2004 to 2006 shows the accuracy of the SMR01 database is approximately 88% for the primary diagnosis for inpatients,[15] previous publication has shown an accuracy of



* Adjusted for age, sex, deprivation, year of admission, admission type and comorbidities

Figure 1 Adjusted* and unadjusted odds ratios case-fatality up to 30 days after asthma admission for study period.

89.3% in 1996—1997 for main diagnoses.[25] The aim of this study was to identify case-fatality after a hospital admission for asthma; to ensure robustness we used asthma in the principal diagnostic position to identify asthma admissions. Sensitivity analyses were carried out to identify the proportion of hospitalisations with asthma in a secondary position, including shortness of breath, respiratory infections and COPD in the principal position. In total, only an additional 17 702 admissions were identified, of which COPD were 6.3%. We acknowledge that we do not have access to clinical and therapeutic data from these hospitalisations.

This study described the likelihood of 30 day case-fatality following an asthma hospitalisation according to age group, sex, socioeconomic deprivation and comorbidities using routinely collected linked morbidity and mortality data. Despite significant improvements in the delivery of treatment and care for asthma, this study has shown a case-fatality level of 0.9% with 1000 deaths over the study period. Asthma mortality is relatively rare in comparison to other chronic conditions and the strength of this study lie in the large number of hospitalisations studied in contrast to other smaller studies of hospitalisations with linked primary care data.

The delivery of respiratory care has changed significantly over the last 30 years, which may also have had an impact on hospital admissions including the introduction of evidence-based clinical respiratory guidelines in the early 1990s,[23,24,26] and increasing emphasis on self-management.[27] Earlier studies have suggested that the overall reduction in asthma morbidity seen between the late 1960s and mid 1980s reflects better care, and better use of existing therapies.[28] From the late 1980s there has been increased use of inhaled corticosteroid therapy worldwide,[29,30] and increasing evidence that inhaled corticosteroids reduce the risk of asthma mortality.[31—33] These factors may have contributed to the trend towards a reduction in the odds of 30 day case-fatality observed in our study since the mid-1990s.

Conclusions

Case-fatality at 30 days following a hospitalisation for asthma in Scotland is less than 1%. This is comparable to case-fatality reported in other parts of the UK. The likelihood of death 30 days following an asthma admission increased with age group and was associated with comorbid respiratory failure, cancer, renal failure, cor pulmonale, coronary heart disease, and respiratory infection. Case-fatality at 30 days declined through the study period. Consistent with other studies, this decline may be in part due to improved guidelines and protocols, and disease management for asthma over the last 30 years.

Funding

This study was supported by an unrestricted educational grant from Amgen.

Conflicts of interest

None.

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