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Original Article

A Logistic Regression Analysis of Predictors for Asthma Hospital Re-admissions

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Abstract

In order to identify the risk factors (predictors) of re-hospitalisation for high-risk asthmatic patients, a retrospective logistic regression analysis describing the relationship between the probability of re-admission and possible predictors in hospitalised asthmatics, aged over 5 years, between 1994-1998, was designed. Study setting was a district general hospital in the West Yorkshire, UK. The results obtained showed that there was a 25.5% re-admission rate for 440 patients admitted to the hospital during the period of study. Multivariate logistic regression analysis using the forward stepwise method revealed that only sex (OR=2.65, 95% CI: 1.42, 4.92), Jarman score (OR=2.03, 95% CI: 1.13-3.65) and allergy (OR=1.88, 95% CI: 1.06-3.32) could remain in the model as significant risk factors.

It could be concluded that female patients, patients registered within the practices with a higher workload (higher Jarman score) and those who has a history of allergy were at a higher risk of re-admission. More attention should be paid to these patients who are in a higher risk of hospitalisation.

Keywords: Asthma; Predictors; Re-admission; Gender; Jarman Score; Allergy.

Introduction

Acute exacerbation rates of asthma leading to hospital admissions in asthmatic children and adults, many of which includes re-admissions, are unacceptably high (1, 2). In developed countries up to 50% of all the admissions of asthmatic children are followed with a re-admission in the following 12 months (3). Furthermore, in the UK a 40% probability of re-admission over the next 2 years has been reported for adult asthma patients (1). These high rates of admission and re-admission for asthma deserve more attention to determine the secondary care utilisation by high-risk asthmatic patients and its possible predictors. In this study a regression analysis model has been used to identify if there are any possible predictors for re-admissions in high-risk asthmatics. This analysis has been done using data from individual asthmatic patients' case-notes within the secondary health care sector.

Methods

This study was a retrospective logistic regression analysis describing the relationship between the risk of re-admission and possible predictors of re-admission in hospitalised asthmatics, aged over 5 years. Re-admission was defined as another hospitalisation due to asthma occurring within the period of study (i.e., between 1994-1998). The Airedale Ethics Committee approved the study. All relevant data for asthma admissions [ICD-10 (international classification of diseases, 10th revision) codes J45.0-J45.9] were extracted

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from records in the Airedale General Hospital from 1994-1998.

The predictors were age, sex, ethnicity (South Asian or non-South Asian), smoking habit (smoker, ex-smoker, non-smoker), history of allergy, history of eczema/hay fever, asthma type (childhood, adulthood), drugs regimen on discharge (regimens with salmeterol and/or fluticasone; regimens with traditional anti-asthma medications). The Townsend material deprivation index (TI), and Jarman score (JS: an indicator of a GP's workload) were also entered into the analysis. For each of these two latter predictors, the median was calculated and those below this value was classified as low and those above as high.

Preliminary logistic regressions were performed on all predictors to determine any relationship between individual predictors and the risk of re-admission. Each predictor with $p < 0.2$ was entered into the multivariate analysis (4). For all these eligible predictors the interaction between them was determined and any significant interaction ($p < 0.05$) was also entered into the multivariate regression analysis. In the final multiple regression analysis all associations with a $p < 0.05$ were considered as statistically significant relationships.

Results

Data were collected for 440 patients and the re-admission rate was 25.5% (112 patients re-admitted).

Preliminary logistic regression analysis

The preliminary analysis (Table 1) indicated that the higher the Townsend index (OR=1.71, 95% CI: 1.01-2.90), the higher the Jarman score (OR=1.76, 95% CI: 1.02-3.02), having a history

Table 1. Results of the preliminary logistic regression analysis of predictors for the asthmatic patients hospitalised between 1994-1998.

Predictor	Subgroup	Study cases (%) [readmitted (%), non-readmitted (%)]	OR[a] (CI)[b]	P value
Age (year)	N/A	440 (100%) [112 (25.5%), 328 (74.5%)]	1.00 (0.99-1.01)	0.41
Sex	Male	178 (40.5%) [31 (17.4%), 147 (82.6%)]	2.12 (1.33-3.39)	0.002*
	Female	262 (59.5%) [81 (30.9%), 181 (69.1%)]		
Ethnicity	South Asian	67 (15.2%) [20 (29.9%), 47 (70.1%)]	1.30 (0.73-2.31)	0.37
	Non South Asian	373 (84.8%) [92 (24.7%), 281 (75.3%)]		
Smoking habit	Smoker	71 (15.9%) [24 (33.8%), 47 (66.2)]	0.66 (0.32-1.36)	0.26
	Ex-smoker	49 (11.1%) [16 (32.7%), 33 (67.3%)]	1.08 (0.50-2.33)	
	Non-smoker	128 (29.1%) [31 (24.2%), 97 (75.8%)]		
	Under 16 years + unknown	137 + 55 (43.9%) [41 (21.4%), 151 (78.6%)]		
History of allergy	Yes	182 (41.4%) [58 (31.9%), 124 (68.1%)]	1.77 (1.15-2.72)	0.01*
	No	258 (58.6%) [54 (20.9%), 204 (79.1%)]		
History of eczema/hay fever	Yes	108 (24.5%) [35 (32.4%), 73 (67.6%)]	1.59 (0.99-2.56)	0.06
	No	332 (75.5%) [77 (23.2%), 255 (76.8%)]		
Asthma onset age	Childhood onset (≤15 years)	99 (22.5%) [29 (29.3%), 70 (70.7%)]	1.02 (0.58-1.83)	0.93
	Adult onset (>15 years)	132 (30.0%) [38 (28.8%), 94 (71.2%)]		
	Under 16 years + unknown	139 + 70 (47.5%) [47 (22.5%)%), 162 (77.5%)]		
Medication regimen on discharge	Including salmet.[c] and/or flutic.[d]	96 (21.8%) [24 (25.0%), 72 (75%)]	0.99 (0.58-1.68)	0.96
	Including traditional medicines	283 (64.3%) [70 (24.7%), 213 (75.3%)]		
	Unknown	61 (13.9%) [18 (29.5%), 43 (70.5%)]		
Townsend index** [Range]	Deprived [2 to 5.27]	170 (38.6%) [50 (29.4%), 120 (70.6%)]	1.71 (1.01-2.90)	0.05*
	Affluent [-3.7 to -0.35]	143 (32.5%) [28 (19.6%), 115 (80.4%)]		
	Unknown	127 (28.9%) [34 (26.8%), 93 (73.2%)]		
Jarman score*** [Range]	High workload [20.2 to 47.4]	165 (37.5%) [50 (30.3%), 115 (69.7%)]	1.76 (1.02-3.02)	0.04*
	Low workload [-9.7 to 19.2]	131 (29.8%) [26 (19.8%), 105 (80.2%)]		
	Unknown	144 (32.7%) [36 (25.0%), 108 (75.0%)]		

a: Odds Ratio; b: Confidence interval; c: Salmeterol; d: Fluticasone; * Significant P value; **Divided based on the median [deprived: TI≥1.99; affluent: TI<1.99]; *** Divided based on the median [high workload: JS≥ 20.23; low workload: JS<20.23]

Table 2. Results of the multivariate logistic regression analysis for a model containing eligible predictors and their significant interactions

Predictor/ Interaction	p value
Gender	0.002[a]
Jarman score	0.02[a]
History of allergy	0.03[a]
Townsend index	0.33
History of eczema/hay fever	0.17
Townsend index*Jarman score	0.17
Jarman score*History of allergy	0.95
Townsend index*History of allergy	0.73
History of allergy*History of eczema/hay fever	0.60

a: significant predictors remained in the final model

of allergy (OR=1.77, 95% CI: 1.15-2.72) and being female (OR=2.12, 95% CI: 1.33-3.39) could be risk factors for asthma re-admission. In addition, there was a non-significant (p=0.057) but positive relationship between the history of eczema/hay fever and the re-admission risk (OR=1.59, 95% CI: 0.99-2.56). This p value (i.e. $p < 0.2$) made this predictor eligible for entry into the multivariate logistic regression analysis. For other variables, preliminary logistic regression analysis revealed that they are highly unlikely to act as a significant risk factor ($p > 0.2$) for asthma re-admission.

Interaction Evaluation

Evaluation for the interaction between eligible predictors, using the chi-square test, revealed that there were significant direct associations between TI with JS (P=0.0001) and allergy with eczema (P=0.0001) and indirect associations between TI with allergy (P=0.003) and JS with allergy (P=0.008). So combinations of these variables, as four new terms, were included in the multivariate logistic regression analysis. In addition, there was a non-significant borderline interaction between gender and allergy (P=0.06), so that the proportion of allergic asthmatics among female patients tended to be more than male.

Table 3. Risk of re-admission for asthmatic patients with different gender, allergy and Jarman score characteristics

Gender (M or F)	Workload (High or Low)	Allergy (Yes or No)	[P/1-P]*	Relative Re-admission Risk
Male	Low	No	0.29	1.00
Male	Low	Yes	0.55	1.90
Male	High	No	0.59	2.03
Male	High	Yes	1.11	3.83
Female	Low	No	0.77	2.65
Female	Low	Yes	1.44	5.00
Female	High	No	1.56	5.38
Female	High	Yes	2.93	10.10

* Probability of re-admission/Probability of no re-admission

Multivariate logistic regression model

The number of the subjects with complete data for the predictors in the multivariate analysis were 280 (71 re-admitted and 209 not re-admitted). Table 2 shows the final results for the eligible predictors and their significant interactions entered into the multivariate logistic regression analysis, using the forward stepwise method. This table indicates that sex (OR=2.65, 95% CI: 1.42, 4.92), JS (OR=2.03, 95% CI: 1.13-3.65) and allergy (OR=1.88, 95% CI: 1.06-3.32) could remain in the model as significant risk factors (p value s less than 0.05). This meant that female patients, patients registered within the practices with a higher workload and those who had a history of allergy were at a higher risk of re-admission. The final model obtained was as follows:

$$\textit{Prob. (re-admission) / Prob. (no re-admission)} = e^{-1.25} \times e^{0.97X_2} \times e^{0.71X_2} \times e^{0.63X_3}$$

(Equation 1)

where X_1 is sex (male=0, female=1), X_2 is JS (low workload=0, high workload=1) and X_3 is the history of allergy (negative=0, positive=1). Thus, female patients could be $e^{0.97} = 2.65$ times more likely to be re-admitted than male patients, irrespective of the JS and allergy status. In addition, patients registered with a practice with a high GP workload could be $e^{0.71} = 2.03$ times more at risk of being re-admitted compared to those registered with low GP workload, irrespective of the sex and allergy status. Likewise, allergic asthmatic could have $e^{0.63} = 1.88$ times a higher risk of re-admission than non-allergic patients, irrespective of the sex and practice workload. Overall, therefore, a female asthmatic patient with a history of allergy who is registered with a practice from the high workload group has the highest risk of re-admission to hospital. This risk is 2.65 x 2.03 x 1.88 = 10.11 times more than a male, non-allergic patient who is registered with a practice from the low workload group (with the lowest re-admission risk). Similarly, using equation 1, table 3 represents the risk of re-admission for asthmatics with different combinations of gender, allergy and Jarman scores. In this table, non-allergic male asthmatics registered with a low workload practice were considered as the reference group and relative risk of re-

admission for patients with other characteristics have been presented compared to this reference.

Discussion

The analysis revealed that asthmatic females, those with a history of allergy and asthmatics registered in a practice with a high workload (high Jarman score) are more likely to be readmitted. Previous studies have reported higher hospital admission rates (5) and more use of health care services (6) by female asthmatics. Trawick et al. (7) observed that high-risk female asthmatics are twice as likely to be admitted as high-risk male asthmatics. Singh et al. (8) have also reported that female asthmatics had double the number of emergency department visits because of acute asthma compared to those of males.

Gender related differences have been found to be due to socio-economic status inequalities (9). This was not confirmed by the observations from the current study because there was no significant relationship between the Townsend deprivation index and gender. Biological differences between men and women have also been reported as confounding factors for a higher asthma morbidity rate in female asthmatics (10). It is documented that female hormones could affect the tone of smooth muscles in the airways, airway responsiveness and the immune response (11). Singh et al. (8) have cited other investigations confirming an increased likelihood of indoor environmental exposures and a higher atopy prevalence in female asthmatics. The latter observation has been confirmed by allergy data in the current study (a tendency for female asthmatics to have a history of allergy was observed, p=0.06). Other gender related reasons causing a higher morbidity risk in female asthmatics could be differences in the severity, poorer knowledge of asthma management, incorrect inhaler technique and under-treatment (8, 12).

Using the preventer to bronchodilator ratio as an indicator of asthma prescribing quality, a low ratio (low prescribing quality) was reported for practices with a higher JS (higher workload) (13). Law and Morris (14) have also observed higher morbidity and mortality rates for health authorities located in districts with higher Jarman scores. If a higher workload or pressure on the practice is considered as a reason for non-availability of the GP (at least from the patient's point of view), then this could be a reason for poor asthma control and a higher rate of hospital casualty attendance (15). On the other hand, if the Jarman score is assumed as a proxy of deprivation (16), then this could also act as a confounding factor to highlight the association between this score with the risk of a re-admission. This was confirmed by a significantly strong relationship between the Jarman score and the Townsend material deprivation index (χ^2 = 135.9, df=1, p=0.0001) in the current study. A higher risk of hospitalisation for patients with a low socio-economic status has already been reported (17, 18).

Allergy was found as another significant predictor in the model derived from the analysis. This confirms the previous reports in which a positive history of allergy and being in continuous contact with allergens have been known as risk factors of morbidity, asthma severity and hospitalisation for asthma (19, 20).

This study confirms that more attention should be paid to the asthmatic patients with a higher risk of hospitalisation in particular female and allergic patients and those registered within the practices with a higher workload

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