CHERE
CENTRE FOR HEALTH ECONOMICS
RESEARCH AND EVALUATION

UNIVERSITY OF
TECHNOLOGY SYDNEY

UTS:CHERE

The Centre for Health Economics Research and Evaluation (CHERE) was established in 1991. CHERE is a centre of excellence in health economics and health services research. It is a joint Centre of the Faculties of Business and Nursing, Midwifery and Health at the University of Technology, Sydney, in collaboration with Central Sydney Area Health Service. It was established as a UTS Centre in February, 2002. The Centre aims to contribute to the development and application of health economics and health services research through research, teaching and policy support. CHERE's research program encompasses both the theory and application of health economics. The main theoretical research theme pursues valuing benefits, including understanding what individuals value from health and health care, how such values should be measured, and exploring the social values attached to these benefits. The applied research focuses on economic and the appraisal of new programs or new ways of delivering and/or funding services. CHERE's teaching includes introducing clinicians, health services managers, public health professionals and others to health economic principles. Training programs aim to develop practical skills in health economics and health services research. Policy support is provided at all levels of the health care system by undertaking commissioned projects, through the provision of formal and informal advice as well as participation in working parties and committees.

University of Technology, Sydney
City campus, Haymarket
PO Box 123 Broadway NSW 2007
Tel: +61 2 9514 4720
Fax: + 61 2 9514 4730
Email: mail@chere.uts.edu.au
www.chere.uts.edu.au

Variation in the costs of healthcare for chronic disease in Australia: the case of asthma

Patricia Kenny[1], Jane Hall[1], Madeleine King[1]

CHERE WORKING PAPER 2008/7

1. Centre for Health Economics Research and Evaluation
Faculty of Business
University of Technology, Sydney

First Version: December 2008
Current Version: December 2008

Abstract

Objectives

Individuals with chronic conditions represent a high healthcare cost group and understanding the cost variation among individuals is important for developing appropriate policy. This study aimed to investigate the sources of variation in the cost of healthcare for a cohort of people with asthma. It examines the costs to the health system and patient out-of-pocket costs.

Methods

A longitudinal observational study of asthma-related healthcare costs in a cohort of people with asthma (n=252). Participants were followed for three years using six-monthly postal surveys and individual administrative data. The factors associated with health system and patient out-of-pocket costs were investigated using generalised linear mixed models.

Results

There was substantial variability around the average costs of healthcare for asthma which were associated with asthma-related health measures and socio-demographic variables. The health system costs were less for those living in regional areas relative to Sydney residents and both the health system and patient out-of-pocket costs were highest in the oldest age group and lowest for children. The health system and patient out-of-pocket costs were highest for the high income group while the middle income group had the lowest total cost.

Conclusions

Our findings suggest that variations should be explored in developing strategies for chronic disease management and that Australia has achieved reasonable equity in access. However, out-of-pocket costs may be a deterrent for the middle income group, which should be a general concern for policies targeting the most disadvantaged group to the exclusion of concern with universal access.

Introduction

The management of chronic disease is a crucial issue as healthcare systems face the challenge of improving health outcomes and controlling expenditure. While individuals with chronic conditions represent a high healthcare cost group, little is known about the variation of costs and utilisation of services among individuals with the same chronic condition. Understanding whether these high costs are due to uniformly high use of services, occasional acute episodes/exacerbations, or poor management and compliance is important in developing appropriate policy. For example, research has shown that higher drug co-payments, while reducing short run expenditure, are associated with poorer compliance and increased emergency department use and hospitalisation (1, 2).

Asthma is a chronic disease where good control of the condition has been shown to reduce costs and improve health outcomes.(3-5) However, many people with asthma do not use treatment appropriately or achieve optimal asthma control;(6-9) and this may be related to the cost of medication and medical visits.(10, 11) Asthma is a good case study to investigate variation and the effects of out-of-pocket payments in Australia. While there have been substantial improvements in asthma management as evidenced by declining mortality and hospitalisation, acute asthma remains a major reason for presentation to a hospital emergency department.(6) Although Australia's Pharmaceutical Benefits Scheme provides universal access to subsidised drugs, the costs can become substantial when medications must be used continuously. One study found that individuals presenting for acute asthma were likely to have reduced their use of preventive medication due to cost.(10) Another showed that individuals who face lower co-payments for prescription drugs use more inhaled corticosteroids (ICS).(7) The same study also showed that people living in remote areas use less asthma medication than people living in cities.

The aim of this paper is to describe the variation in the cost of healthcare for a cohort of Australians with asthma, and to identify the sources of variation between and within individuals over time. It examines the costs to the health system and the patient out-of-pocket costs, as well as the extent to which this variation is associated with individual socio-economic characteristics and health status.

Methods

A longitudinal observational study of asthma-related healthcare costs and utilisation was conducted in New South Wales (NSW), Australia between 2002 and 2005. The study recruited a random community sample of 274 people with asthma by telephone, stratified by age, sex and residential area (response rate 25%). A further sample of 60 recent hospital emergency department attendees for asthma was included to ensure sufficient numbers with severe asthma (response rate 11%). Participants were followed for three years using six-monthly postal surveys and individual administrative data. The recruitment and data collection methods have been described in detail previously.(12) The current paper reports data from the 252 (community sample 211, hospital sample 41) participants who completed two or more surveys and consented to the use of their individual administrative data from Medicare Australia and the NSW Health Department Inpatient Statistics Collection (ISC).

Utilisation and cost measurement

The study measured the utilisation of health services and products for asthma and then calculated the cost to the health system and the out-of-pocket cost to each patient over each six-month survey period in which they participated. The utilisation components included: emergency department and inpatient hospital care, out-of-hospital medical visits and investigations, pharmaceuticals, and equipment used for asthma management (see Table 1 for data sources).

Hospital care

Hospital utilisation included admitted episodes and non-admitted emergency department (ED) attendances which were identified from the survey data. Individual self-reported admitted episodes were identified in the ISC database to obtain the diagnoses related group (DRG) code for the episode. Of 117 episodes reported, 62 were not identified on the database and were assigned the age appropriate 'bronchitis and asthma without complication or co-morbidity' DRG code. The cost to the health system for each inpatient episode was assigned according to the DRG and the year of the episode. The National Hospital Cost Data Collection (NHCDC) public sector cost weights(13-16) were used for all public hospital episodes. Private hospital episodes were assigned the NHCDC private sector cost weights(13, 14) for episodes before July 2003 and the Private Hospital Data Bureau (PHDB) charge weights(17, 18) for episodes during and after July 2003. The Medicare benefit paid for in-hospital medical services was included in the health system cost for inpatient hospital care for private hospital episodes. The health system cost for non-admitted ED visits was calculated using the national average cost for all five non-admitted triage categories for all diagnoses from the NHCDC Cost Report relevant to the year of the episode.(13-16) Patient out-of-pocket costs for hospital care were calculated by combining survey reported hospital costs and the Medicare data for in-hospital medical services (charge minus benefit) less the private health insurance rebates reported in the patient surveys.

Out-of-hospital medical services

The asthma-related utilisation and cost of visits to general practitioners (GP) and specialists, and diagnostic tests were estimated from the Medicare data. The health system cost was the Medicare benefit paid and the patient cost was the difference between the benefit and the charge. The proportion of all GP visits that were asthma-related was estimated from an additional survey completed by a sub-sample (n=135) which found that, on average 33% of GP visits were asthma-related. Thus, for each six-month survey period, 33% of the health

Table 1: Sources of resource utilisation and cost data and associated timeframes

Item	Time period covered by data	Source of utilisation data	Source of item cost	
			Health sector	Individuals
Medication:				
Prescription	PBS data for six-month period prior to survey date	PBS data	PBS data	PBS data
Non-prescription and prescription not covered by PBS[a]	Surveys- in past 4 weeks	Survey data (extrapolated to six months)	Survey data	Survey data
Hospital services				
Emergency Dept	Surveys – in past six months	Survey data	National hospital cost data	Nil
Inpatient	Surveys – in past six months NSW Health inpatient data for six-month period prior to survey date	Survey data and DRG for episode from NSW inpatient data	National private or public hospital DRG costs for relevant year	Surveys
Private hospital inpatient medical services[b]	Medicare data for period of episode	Medicare data (in hospital)	Medicare data (in hospital)	Medicare data (in hospital)
Medical services out of hospital	Medicare data for six-month period prior to survey date	Medicare data[c]	Medicare data	Medicare data
Diagnostic tests	Medicare data for six-month period prior to survey date	Medicare data[c]	Medicare data	Medicare data
Asthma equipment	Surveys – in past six months	Surveys	Nil	Surveys

a The PBS data were not expected to capture the major portion of usage where: 1) the drug cost less than the PBS general patient co-payment, 2) the drug could be purchased with or without a prescription, 3) the drug was not listed on the PBS for the full period of the study, 4) the drug was listed for restricted use only.
b Public hospital DRG costs included medical services but private hospital DRG costs did not.
c Proportion of GP visits, selected specialists and selected diagnostic tests as described in text.

system and patient costs of each participant's GP visits were included. The specialist visits which were asthma-related were identified by the type of specialists who commonly have a role in managing asthma. These included: specialists in general, paediatric and thoracic medicine as well as immunologists and ear, nose and throat specialists. It was deemed likely that a person with asthma would visit these specialists for asthma-related conditions and only visits to these specialists were included. Similarly, specific diagnostic tests which were expected to be asthma-related were counted as such. These included: allergy tests and respiratory tests (respiratory function, chest x-ray and sputum microscopy & culture).

Pharmaceuticals and equipment

The utilisation and cost of asthma drugs were identified from survey data and individual Pharmaceutical Benefits Scheme (PBS) data from Medicare Australia. The PBS benefit was used to calculate the cost to the health system for prescription medicines, while the patient out-of-pocket cost was calculated as the gross price of the prescription less the PBS benefit. The survey data were used to calculate patient out-of-pocket costs where there was reason to believe that the PBS data would not capture the major portion of usage. These included: short-acting beta agonists (SABA), leukotreine receptor antagonists and oral cortico-steroids (OCS). Most SABA & OCS items cost less than the PBS general patient co-payment and would only attract a PBS benefit (and therefore appear in the data) for concession cardholders or for general patients when they become eligible for the safety-net (which applies for the remainder of the calendar year after the qualifying level of personal health expenditure is reached). SABA would also not appear in the PBS data when purchased without a prescription. The leukotreine receptor antagonist, montelukast, was added to the PBS during the study and had restrictions on its use. Consequently, the PBS data would not capture usage by those who used it prior to the PBS listing or by those who do not satisfy the PBS restrictions. Survey data were used to estimate the out-of-pocket costs for all non-prescription medicines used for asthma and for equipment such as spacers and nebulisers.

Asthma-related health measures

All asthma-related health measures were collected in the six-monthly surveys. These included questions about activity limitations due to asthma in the past 6 months (3 items), sleep disturbance due to asthma in the past 4 weeks (1 item), SABA use in the past 4 weeks (2 items) and urgent medical visits for an asthma attack in the past 4 weeks (1 item). The three activity limitations items were combined to produce a score between 0 (no limitation) and 4 (extremely limited) which has been described elsewhere.(19) The two SABA use items (the number of days used in the past 4 weeks and the number of times on those days) were used to calculate the average number of times per day in the past 4 weeks.(19) The survey also included questions about the use and frequency of preventive medications to treat asthma in the past 4 weeks. Participants were classified as using asthma treatment if they reported using these medicines on most or all days. Asthma treatment was classified as either inhaled corticosteroids (ICS) alone or combined ICS and long-acting beta agonists (LABA), regardless of whether ICS and LABA were used as one or two drugs.

Statistical analysis

Data from the hospital and community samples were combined for all analyses. The costs to the health system and patient out-of-pocket costs were analysed separately. The factors

associated with each cost type were investigated using generalised linear mixed models.(20) Two-part models (21, 22) were used because the distribution of each cost variable was highly skewed with substantial numbers of zero observations (10-20%) and a long right tail (Table 2). The first part modelled the probability of a positive cost using a binomial distribution function with a logit link, while the second part modelled the expected cost conditional on a positive cost using a gamma distribution function with a log link. Because of the repeated measures nature of the data, the models included a random person-specific intercept for each part of the two-part model and the covariance of the two random parameters.

Part One:

$$p_{ij} \sim \text{Bernoulli}(\theta_{ij})$$

$$\text{logit}(\theta_{ij}) = (\alpha_1 + \delta_{i1}) + \sum_{k=1}^{K} \alpha_k x_{ki}$$

Part Two:

$$(\text{Y}_{ij} \,|\, \text{Y}_{ij} > 0) \sim \text{Gamma}(a_{ij}, b_{ij})$$

$$a_{ij} = \mu_{ij} b_{ij} \text{ and } b_{ij} = \frac{\mu_{ij}}{\sigma_{ij}^2}$$

$$\log(\mu_{ij}) = (\beta_1 + \delta_{i2}) + \sum_{k=1}^{K} \beta_k x_{ki}$$

where

$$\begin{bmatrix} \delta_{i1} \\ \delta_{i2} \end{bmatrix} \sim Normal\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_1^2 & \sigma_1\sigma_2 \\ \sigma_1\sigma_2 & \sigma_2^2 \end{pmatrix} \right]$$

for j=1 to 5 observations (surveys 2 to 6), i=1 to *N* individuals and k=1 to *K* covariates. The α's and β's are the regression parameters for part 1 and part 2 respectively. δ_{i1} is the random intercept term for part 1 (the random person effect for the occurrence of cost) and σ_1^2 is the associated variance. δ_{i2} is the random intercept term for part 2 (the random person effect for the magnitude of cost conditional on a positive cost) and σ_2^2 is the associated variance. $\sigma_1\sigma_2$ is the covariance of the two random intercepts. Estimation was by residual pseudo-likelihood using SAS Proc Glimmix (23) and t-tests were used to test the significance of fixed effects.

Table 2: Study response* and distribution of six-monthly costs† over time

	Data collection wave					
	1	2	3	4	5	6
n	252	252	225	204	187	168
% response	100	100	89	81	74	67
Cost to the health system						
Mean	457	461	402	388	596	379
Standard deviation	1,429	1,664	1,176	1,055	1,993	1,190
Minimum	0	0	0	0	0	0
Maximum	14,008	16,185	12,220	11,591	15,675	13,126
Median	71	84	75	89	106	100
% = zero	11	10	12	11	10	12
Cost to patients						

Mean	78	84	82	77	113	117
Standard deviation	145	148	174	139	500	406
Minimum	0	0	0	0	0	0
Maximum	1,426	1,824	2,186	1,428	6,775	5,045
Median	39	48	40	40	41	31
% = zero	12	12	12	14	11	20

* Subjects with all data sources available at each 6-monthly survey period
† 2002 Australian dollars

The models aimed to identify the socio-demographic characteristics and self-reported asthma-related health measures associated with asthma-related costs to the health system and to patients. Costs from survey periods 2 to 6 were modelled as a function of hospital admissions at period 1, time varying health measures (asthma-related activity limitations and sleep disturbance in periods 2 to 6) and the baseline socio-demographic variables, sex, age group, residential area (capital city or regional), private health insurance (PHI) and gross household income group. The same covariates were included in both models (costs to the health system and patient out-of-pocket costs) and in both parts of each model (logistic or gamma).

The predicted mean cost for the whole sample was calculated as the conditional expected cost from the gamma part of the model times the probability of a positive cost from the logistic part, given by the equation:

$$\hat{\mathrm{Y}}_{ij} = \left[\exp\left(\left(\hat{\beta}_1 + \hat{\delta}_{i2}\right) + \sum_{k=1}^{K} \hat{\beta}_k x_{ki} \right) \right] \times \left[\frac{\exp\left(\left(\hat{\alpha}_1 + \hat{\delta}_{i1}\right) + \sum_{k=1}^{K} \hat{\alpha}_k x_{ki} \right)}{1 + \exp\left(\left(\hat{\alpha}_1 + \hat{\delta}_{i1}\right) + \sum_{k=1}^{K} \hat{\alpha}_k x_{ki} \right)} \right]$$

This was calculated using simulation which took 1000 random draws from the estimated distributions of the logistic part and gamma part random intercepts, with the expected cost estimated for each draw. The reported expected cost is the mean of the 1000 replications.

To identify if the same individuals consistently had high or low costs (within-person variation), we calculated the maximum within-person difference for each individual as the difference between the most expensive and least expensive time-points for health system and out-of-pocket costs.

Results

The characteristics of the sample at recruitment to the study are reported in Table 3. More than half of the sample reported the regular use of ICS (either alone or in combination with LABA). While on average respondents reported using SABA more than once daily in the past month, 22% reported no use. Less than half (44%) reported asthma-related sleep disturbance in the past month, while few reported urgent medical visits or hospitalisation. The majority (75%) reported activity limitation due to asthma in the past 6 months, but on average the activity limitation score indicated only a little limitation.

Table 3: Characteristics of the sample at recruitment to the study (n=252)

	%	Mean (sd)
Hospital recruitment	16	
Sex male	44	
Age (years):		
5-10	19	
11-17	16	
18-39	19	
40-59	22	
60-75	23	
Residence:		
Regional New South Wales	47	
Sydney metropolitan	53	
Private health insurance for hospital	49	
Gross household income per week:		
Missing data	13	
$1-699	42	
$700-1499	28	
>=$1500	17	
Activity limitation due to asthma (past 6 months, 0-4)*		0.9 (0.9)
Sleep disturbance due to asthma (past month, nights/week)		0.8 (1.5)
Short-acting beta agonist use (past month, times/day)		1.3 (1.5)
Urgent medical visit due to asthma (past month)	14	
Hospital admission due to asthma (past 6 months)	6	
Current asthma treatment:		
Inhaled corticosteroid & long-acting beta agonist	34	
Inhaled corticosteroid alone	25	

*0=no limitation, 4=Extremely limited

The survey response rate declined over the follow-up period; of the 252 respondents with administrative data and at least two surveys, 168 (67%) responded to all six surveys (Table 1). Age was the only characteristic where respondents with complete follow-up and those with partial follow-up differed significantly (χ^2=13.30, df=4, p=0.010); the 11-17 years age group had the lowest rate of complete data (44%) and the 60-75 years age

group had the highest (76%). Over the follow-up period (time-points 2 to 6), the 252 respondents provided a total of 1,036 observations (each covering six months of resource use).

Costs to the health system for asthma

The average cost to the health system was $457 (standard deviation 1,429; range 0 to 14,008) in the first six months and $445 per six months (standard deviation 1,462; range 0 to 16,185) over the remainder of the study (time-points 2 to 6). The majority of individuals showing relatively small within-person changes over time; for 75% of the sample, the maximum within-person difference was $361 or less (Table 4). The model explained 29% of the variance between individuals in the probability of having a cost and 45% of the variance in the amount of the cost when there was a cost.

Table 4: Maximum within-person difference* in health system and out-of-pocket costs for individuals over 6 data collection waves

	Maximum Difference in Health System Costs† n=252	Maximum Difference in Patient out-of-pocket costs† n=252
Mean (standard deviation)	658 (1768)	144 (434)
Maximum	13,924	6,444
90th percentile	1704	270
75th percentile	361	132
Median	155	68
25th percentile	62	30
10th percentile	22	10
Minimum	0	0

*Cost at the most expensive time-point minus the cost at the least expensive time-point.
† 2002 Australian dollars.

Two of the three asthma-related health measures were significantly associated with costs to the health system. As the level of asthma-related activity limitation increased so did both the probability of a cost and the amount of the cost, while those with an asthma-related hospital admission within the first six months (time-point 1) had higher costs in the subsequent periods than those with no admission at time-point 1 (Table 5). Age was associated with both the probability of a cost and the amount of the cost; while residential area was associated with the amount of the cost, but not the probability of a cost (Table 5). The average six-monthly cost to the health system was highest for the oldest age group (60-75 years); it was $348 less for the next age group (40-59 years) and $460 to $500 less for the three youngest age groups (5-10, 11-17 and 18-39 years, Table 6). Average costs to the health system were lower for Regional NSW residents than for Sydney residents.

Gross household income was significantly associated with the probability of a cost to the health system but not the amount of the cost; the middle income group ($700-1499 per week) had a significantly lower probability of a cost than either the high ($1500 or more per week) or low ($699 or less per week) groups (Table 5). The average six-monthly cost to the health system was $51 to $187 more for the high income group than for the middle group (Table 6). PHI was associated with the amount of the cost but not the probability of

a cost; the average six-monthly cost to the health system for those with PHI was $37 to $200 less than for those without PHI.

Table 5: Asthma costs per 6 month survey period (surveys 2 to 6): model coefficients and standard errors from a two-part binomial logit and gamma log model (n=252).

	Health system		Patient out-of-pocket	
	Estimate	Standard error	Estimate	Standard error
Binomial model				
Intercept	6.51***	1.14	2.04***	0.56
Asthma-related health measures				
Activity limitations†	0.94***	0.26	0.50*	0.20
Sleep disturbance†	0.08	0.17	0.10	0.12
Admission survey 1	-0.50	0.58	0.61	0.65
Socio-demographic covariates				
Male	-0.48	0.27	0.01	0.27
Age				
05-10	-4.08***	1.04	-0.89*	0.39
11-17	-4.21***	1.05	-0.88*	0.42
18-39	-3.37**	1.06	-0.12	0.45
40-59	-2.98**	1.05	0.34	0.44
60-75	Reference		Reference	
Residential area				
Regional NSW	-0.33	0.26	0.65*	0.27
Sydney metropolitan	Reference		Reference	
Private health insurance	-0.05	0.27	0.64*	0.28
Income (gross household)				
Missing	-1.23*	0.53	-0.50	0.53
$1-699 pw	-0.80	0.47	-0.61	0.44
$700-1499 pw	-1.42**	0.45	-0.94*	0.43
$1500 or more pw	Reference		Reference	
Gamma model				
Intercept	5.91***	0.28	4.19***	0.25
Asthma-related health measures				
Activity limitations†	0.38***	0.05	0.29***	0.04
Sleep disturbance†	0.03	0.02	0.06**	0.02
Admission survey 1	1.75***	0.29	0.68**	0.25
Socio-demographic covariates				
Male	-0.12	0.14	-0.12	0.13
Age				
05-10	-1.57***	0.22	-0.43*	0.19
11-17	-1.41***	0.23	-0.09	0.21
18-39	-1.39***	0.22	-0.09	0.20
40-59	-0.81***	0.20	0.02	0.18
60-75	Reference		Reference	
Residential area				
Regional NSW	-0.40**	0.14	-0.14	0.13
Sydney metropolitan	Reference		Reference	
Private health insurance	-0.40**	0.15	0.00	0.13
Income (gross household)				
Missing	-0.27	0.26	-0.42	0.23
$1-699 pw	-0.08	0.22	-0.61**	0.19
$700-1499 pw	-0.36	0.22	-0.22	0.19
$1500 or more pw	Reference		Reference	
Random effects				
Binomial model intercept variance	0.64	0.20	1.10	0.23
Gamma model intercept variance	1.00	0.12	0.76	0.08

Covariance	0.73	0.15	0.53	0.13
Residual	0.45	0.02	0.34	0.02

*p<0.05; **p<0.01; ***p<0.001.
† Time varying variable.

Table 6: Expected six-monthly costs* for asthma (selected sub-groups**)

	Gross weekly household income*			Admission survey 1		Private health insurance	
Age	$1-699	$700-1499	>=$1500	Yes	No	Yes	No
Health system costs							
05-10	94	62	113	612	113	76	113
11-17	107	70	131	701	131	87	131
18-39	124	86	143	790	143	95	143
40-59	230	163	261	1458	261	175	261
60-75	561	422	609	3483	609	409	609
Patient out-of-pocket costs							
05-10	21	27	45	101	45	51	45
11-17	29	38	64	142	64	73	64
18-39	36	49	74	157	74	80	74
40-59	44	61	87	181	87	92	87
60-75	40	55	82	173	82	88	82

*2002 Australian dollar.
**All estimates for female Sydney residents reporting no activity limitation or sleep disturbance.

Patient out-of-pocket costs for asthma

The average out-of-pocket cost to patients was $78 (standard deviation 145; range 0 to 1426) in the first six months and $93 per six months (standard deviation 296; range 0 to 6775) over the remainder of the study (time-points 2 to 6). The majority of individuals showed relatively small changes over time; for 75% of the sample, the maximum within-person difference was $132 or less (Table 4). The models explained 15% of the variance between individuals in the probability of having a cost and 20% of the variance in the amount of the cost when there was a cost.

All three asthma-related health measures were significantly associated with costs to patients. As the level of asthma-related activity limitation increased so did both the probability of a cost and the amount of the cost, while an increase in asthma-related sleep disturbance was associated with an increase in the amount of the cost but not the probability of a cost. Those with an asthma-related hospital admission at time-point 1 had higher costs in the subsequent periods than those with no admission at time-point 1 (Table 5). Age was associated with both the probability of a cost and the amount of the cost; while residential area was associated with the probability of a cost, but not the amount of the cost (Table 5). Expected six-monthly costs to patient were $11 to $42 lower for children than for the two oldest age groups (40-59 and 60-75 years, Table 6). Regional NSW residents had a higher probability of an out-of-pocket cost than Sydney residents.

Gross household income was significantly associated with both the probability of a patient cost and the amount of the cost; the middle income group had a significantly lower probability of a cost than the high group and, when there was a cost, it was significantly lower for the low income group compared to the other groups (Table 5). For

the high income group, the average six-monthly patient cost was $24 to $43 more than for the low income group and $18 to $27 more than for the middle group (Table 6). PHI was associated with the probability of a patient cost but not the amount of the cost; the average six-monthly cost to patients was $5 to $9 more for those with PHI relative to those without PHI.

Discussion

The healthcare costs to patients and the health system costs for asthma varied between individuals but showed little within-person variation over time. Thus those with more severe asthma-related problems remained relatively high cost users. Not surprisingly healthcare costs were higher for those with evidence of poor asthma control. Both health system and patient out-of-pocket costs were associated with asthma-related activity limitation and patient out-of-pocket costs were associated with asthma-related sleep disturbance. An asthma-related admission at baseline was associated with higher health system and patient out-of-pocket costs at subsequent time-points and had the largest effect on costs.

Some of the variation in cost was explained by socio-economic and demographic characteristics. Older people used more resources and incurred higher out-of-pocket costs, consistent with other Australian research.(6) Other variables associated with costs were area of residence, PHI and household income. Costs to the health system were less for those living in Regional NSW compared to Sydney residents and for those with PHI compared to those without, but out-of-pocket costs were similar. The high income group cost the health system more than the middle or low income groups and incurred higher out-of-pocket costs.

Average patient out-of-pocket costs were not large and were similar across all income groups. While these were highest for the high income group, they may impose a greater burden for the low and middle income groups. The model explained only a small portion of the variance, indicating that this was largely driven by unmeasured factors. Overall, these costs were highly skewed with the majority having a relatively low cost and a minority having high expenditure which was predominantly for medication.

Perhaps more surprising is the finding that income related variation in health sector borne costs persists after adjusting for age and health. Costs were higher for both the low and high income groups relative to the middle group. Most of the low income group are entitled to lower co-payments for medication and may be more likely to receive general practitioner services without additional user charges. This lower utilisation by the middle income group may be related to co-payments, which would be consistent with other research.(7, 10)

These results should be interpreted with caution as the causal direction of associations can be difficult to determine in an observational study. Also, the data collection did not include physical measures of asthma status and many measures such as urgent medical visits, are linked to resource use so were not suitable for this study. Response rates were low, particularly in the most mobile group of young adults, and while the sample may not be representative of all NSW people with asthma, non-responders were similar to responders on most measured characteristics.(12) Nonetheless, this study does comprise people with a wide range of asthma severity and sufficient numbers in sub-groups to detect differences, which was the aim of the study.

Our findings show that there is substantial variation in the costs and health care utilisation within this group of people with a chronic condition; and that many high users remain a high cost to the health system. While the experience of asthma may not be generalisable

to all other chronic conditions, it does suggest that variations should be explored in developing strategies for chronic disease management. The findings suggest a reasonable achievement of equity in access and that high out-of-pocket costs are not widespread. There is pro-poor bias in that the low income group did not incur significantly lower service use than the high income group. However, the middle income group did use fewer services and this may suggest that out-of-pocket costs are a deterrent in this group, who are also expected to meet higher co-payments. This should be a general concern for all policies targeting the most disadvantaged group to the exclusion of concern with universal access.

References

1. Hsu J, Price M, Huang J, Brand R, Fung V, Hui R, et al. Unintended consequences of caps on Medicare drug benefits.[see comment]. New England Journal of Medicine 2006;354(22):2349-59.
2. Tamblyn R, Laprise R, Hanley JA, Abrahamowicz M, Scott S, Mayo N, et al. Adverse events associated with prescription drug cost-sharing among poor and elderly persons.[see comment]. JAMA 2001;285(4):421-9.
3. Barnes PJ, Jonsson B, Klim JB. The costs of asthma. European Respiratory Journal 1996;9(4):636-42.
4. Lane S, Molina J, Plusa T. An international observational prospective study to determine the Cost Of Asthma eXacerbations (COAX). Respiratory Medicine 2006;100:434-450.
5. Williams AE, Lloyd, A. C., Watson, L., Rabe, K. F. Cost of scheduled and unscheduled asthma management in seven European Union countries. European Respiratory Review 2006;15(98): 4-9.
6. Australian Centre for Asthma Monitoring. Asthma in Australia 2005. Canberra: Australian Institute for Health and Welfare; 2005. Report No.: ACM 6.
7. Australian Centre for Asthma Monitoring. Patterns of asthma medication use in Australia. Canberra: Australian Institute of Health and welfare; 2007. Report No.: ACM 11.
8. Partridge MR, van der Molen T, Myrseth S-E, Busse WW. Attitudes and actions of asthma patients on regular maintenance therapy: the INSPIRE study. BMC Pulmonary Medicine 2006;6:13.
9. Rabe KF, Vermeire PA, Soriano JB, Maier WC. Clinical management of asthma in 1999: the Asthma Insights and Reality in Europe (AIRE) study.[see comment]. European Respiratory Journal 2000;16(5):802-7.
10. Goeman DP, Aroni RA, Stewart K, Sawyer SM, Thien FC, Abramson MJ, et al. Patients' views of the burden of asthma: a qualitative study. Medical Journal of Australia 2002;177(6):295-9.
11. Horne R, Price D, Cleland J, Costa R, Covey D, Gruffydd-Jones K, et al. Can asthma control be improved by understanding the patient's perspective? BMC Pulmonary Medicine 2007;7:8.
12. Kenny P, Lancsar E, Hall J, King M, Chaplin M. The individual and health sector costs of asthma: the first year of a longitudinal study in New South Wales. Australian & New Zealand Journal of Public Health 2005;29(5):429-35.

13. Commonwealth Department of Health and Ageing. National Hospital Cost Data Collection Cost Report Round 6, (2001-2002). Canberra: Commonwealth Department of Health and Ageing; 2003 November 2003.
14. Commonwealth Department of Health and Ageing. National Hospital Cost Data Collection Cost Report Round 7 (2002-2003). Canberra: Commonwealth Department of Health and Ageing; 2004 December 2004.
15. Commonwealth Department of Health and Ageing. National Hospital Cost Data Collection Cost Report Round 8 (2003-2004) AR-DRGv5.0. Canberra: Commonwealth Department of Health and Ageing; 2005 December 2005.
16. Commonwealth Department of Health and Ageing. National Hospital Cost Data Collection Cost Report Round 9 (2004-2005) AR-DRGv5.0. Canberra: Commonwealth Department of Health and Ageing; 2006 September 2006.
17. Australian Government Department of Health and Aging. Private Hospital Data Bureau Annual Report 2003-2004. Canberra: Australian Government Department of Health and Aging; 2005.
18. Australian Government Department of Health and Aging. Private Hospital Data Bureau Annual Report 2004-2005. Canberra: Australian Government Department of Health and Aging; 2006.
19. King M, Kenny P, Marks G. Asthma control and health-related quality of life: related constructs with implications for measurement. Quality of Life Research. in press 2009.
20. McCulloch CE, Searle SR. Generalized, Linear, and Mixed Models. New York: John Wiley & Sons; 2001.
21. Buntin MB, Zaslavsky AM. Too much ado about two-part models and transformation?: Comparing methods of modeling Medicare expenditures. Journal of Health Economics 2004;23(3):525-542.
22. Cooper NJ, Lambert PC, Abrams KR, Sutton AJ. Predicting costs over time using Bayesian Markov chain Monte Carlo methods: an application to early inflammatory polyarthritis. Health Economics 2007;16(1):37-56.
23. SAS Institute Inc. The Glimmix Procedure, June 2006. In: SAS Institute Inc.; 2006.