Title
Sources of variation in the costs of health care for asthma patients in Australia

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Abstract

Objectives

Individuals with chronic conditions, such as asthma, on average incur high health care costs though good control can reduce costs and improve health outcomes. However, there may be substantial variation between patients in their use of services and therefore costs. Our objective was to investigate the sources of such variation in health system and out-of-pocket costs for people with asthma.

Methods

A longitudinal observational study of 252 people with asthma followed for three years, using six-monthly postal surveys and individual administrative data. Factors associated with costs were investigated using generalised linear mixed models.

Results

There was substantial variability in costs between individuals but relatively little within-person change over time for the majority. Costs to the health system and out-of-pocket costs were higher with increasing asthma-related health problems and increasing age. Health system costs were less for patients living outside the capital city and for those in the middle income group relative to high and low income groups.

Conclusions

Those with poorly controlled asthma and the elderly require more carefully targeted strategies to improve their health and ensure appropriate use of resources. Access to appropriate services for those living outside of capital cities should be improved. Co-payments for the middle-income groups and those living in regional areas should be reduced to improve equity in the use of services.

Introduction

The management of chronic disease is a crucial issue as health systems face the challenge of improving health outcomes and controlling expenditure. While individuals with chronic conditions generate high costs, little is known about the variation of costs and utilisation of services between patients. Understanding whether high costs are due to uniformly high use of services, occasional acute episodes or exacerbations, or poor management and compliance is important in developing appropriate policy. Higher drug co-payments, while reducing short run expenditure, are associated with poorer compliance and increased emergency department use and hospitalisation.[1, 2] While estimates of disease costs are limited in their relevance to policy, understanding variations between individual patients can identify problems of access to care and the need to target programs.

Asthma is a chronic disease where good control 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] which may be related to the cost of medication and medical visits.[10, 11] While there have been substantial improvements in asthma management, as evidenced by declining mortality and hospitalisation rates, acute asthma remains a major reason for emergency presentation to a hospital.[6] Although Australia's Pharmaceutical Benefits Scheme provides universal access to subsidised drugs, out-of-pocket 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.[7] The same study also showed that people living in remote areas use less asthma medication than people living in cities.

Our objective was to investigate the variation in costs to the health system and out-of-pocket costs for Australians with asthma. It identifies sources of variation between and within individuals over time, as well as the extent to which this variation is associated with socio-economic characteristics and health status. A secondary objective was to investigate whether routine administrative data can be augmented by survey data to shed light on costs associated with chronic conditions over time.

Methods

A longitudinal observational study of asthma-related health care costs and utilisation was conducted in New South Wales (NSW), Australia between 2002 and 2005. A mixed recruitment method was used; a random community sample of 274 people with asthma was recruited by telephone, stratified by age, sex and residential area and a sample of 60 recent hospital emergency department (ED) attendees for asthma (included to ensure sufficient numbers with severe asthma). Participants were followed for three years using six-monthly postal surveys to collect self reported health measures, use of services and costs. Administrative data were obtained for medical services, pharmaceutical benefits and hospital admissions.[12] Of the 334 patients, 252 (community 211, hospital 41) completed two or more questionnaires 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

Utilisation of health services and products and the associated cost to the health system and to each participant were calculated over each six-month survey period in which they participated.

Hospital care

Hospital utilisation included admitted episodes and non-admitted ED attendances. Individual self-reported admissions were identified in the ISC database and costs assigned based on the diagnoses related group (DRG) code. In-hospital medical services for private hospital episodes (not included in the private hospital DRG cost weight) were costed at the Medicare benefit paid. The cost for non-admitted ED visits was the national average cost for all five non-admitted triage categories for all diagnoses. Patient out-of-pocket costs for hospital care were calculated by combining survey reported hospital costs and Medicare data for in-hospital medical services (charge minus benefit) less the private health insurance rebates reported in the patient surveys. Detailed data sources and estimation methods are reported elsewhere.[13]

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. Specific diagnostic tests which were expected to be asthma-related were included.

Pharmaceuticals and equipment

The utilisation and cost of asthma drugs were identified from survey data and individual data from Medicare Australia. The Pharmaceutical Benefits Scheme 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 prescription price less the benefit. Survey data were used to calculate patient out-of-pocket costs for prescription medicines mainly purchased outside the benefits scheme, for all non-prescription medicines and for equipment used for asthma.

Asthma-related health measures

Asthma-related health measures, collected in the six-monthly surveys, were activity limitations due to asthma in the past 6 months (scored from 0=no limitation to 4=extremely limited), sleep disturbance due to asthma in the past 4 weeks (average nights/week), short-acting beta agonist use in the past 4 weeks (average times/day) and urgent medical visits for an asthma attack in the past 4 weeks. These measures have been described previously.[14] Health related quality of life is not included in this analysis as it was only available for the adults, excluding 30% of the sample.

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. Factors associated with each cost type were investigated using generalised linear mixed models.[15] Two-part models [16, 17] 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 1). 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 (Appendix). To account for within person correlation due to the repeated measures, the models included a random person-specific intercept for each part of the two-part model and the covariance of the two random parameters. Estimation was by residual pseudo-likelihood using SAS Proc Glimmix [18] and fixed effects tested with the t-test.

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 (as an indicator of asthma-related health at baseline), 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/region), private health insurance and gross household income. Hospital admission in period 1 was included as a lagged covariate because it was expected to be correlated with costs and health measures within each time period, while sleep disturbance and activity limitation were included as time varying covariates as both have been shown to explain different components of variation in asthma-specific quality of life; activity limitation explained substantial between-person variation and sleep disturbance explained substantial within-person change over time.[14] The variables used for sample stratification (age, sex and residential area) were included in all models. 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 (Appendix). This was calculated using simulation taking 1000 random draws from the estimated distributions of the logistic and gamma 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

Sample

The hospital sample included more women and young adults than the community sample and had more asthma-related health problems (Table 2). Compared to the Australian asthma population, a higher proportion of both samples used asthma medication (Table 2). The survey response rate declined over time: 168 (67%) responded to all six surveys (hospital sample 59%; and community sample 68%). 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%; p=0.01). The costs to the health system at time-point 1 were higher for those with complete follow-up (median=$78) compared to those with incomplete follow-up (median=$56; p=0.07). Patient out-of-pocket cost did not differ by follow-up completion.

Costs to the health system for asthma

The average cost to the health system was $457 in the first six months (Table 1) with 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 3).

The model coefficients are reported in Table 4; statistically significant effects in part 1 of the model indicate an association with the probability of a positive cost while statistically significant effects in part 2 indicate an association with the size of the cost conditional on a positive cost. Two effects (activity limitations and age) were significant in both the binomial and gamma parts of the model, household income was significant in the binomial part only and three effects (admission at time-point 1, residential area and private health insurance) were significant in the gamma part only. The direction of the effect is relative to the reference group; for example the negative coefficients for age indicate lower costs for all groups relative to the reference group (60-75 years) while the positive coefficient for activity limitation indicates that as activity limitation increases, costs also increase.

Age and two asthma-related health measures (activity limitation and admission at time-point 1) had the greatest impact on expected costs. Figure 1 illustrates the expected costs for selected sub-groups. The average six-monthly health system cost was highest for the oldest age-group, substantially less for the next age-group and lowest for the three youngest age groups. Health system costs for the middle income group were lower relative to both the high and low income groups and lower for those with private health insurance relative to those without. An asthma-related admission at time-point 1 had a much greater impact on expected health system costs than the socio-demographic variables.

Patient out-of-pocket costs for asthma

The average out-of-pocket cost to patients was $78 in the first six months (Table 1) and 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 3).

Three effects (activity limitations, age and income) were significant in both the binomial and gamma parts of the patient costs model, two effects (residential area and private health insurance) were significant in the binomial part only and another two effects (admission at time-point 1 and sleep disturbance) were significant in the gamma part only (Table 4). Only the effects for the two youngest age-groups were significant, indicating that children had lower patient costs relative to the reference group (60-75 years) but that the adult groups did not differ significantly.

Two asthma-related health indicators (activity limitation and admission at time-point 1) had the greatest impact on expected costs to patients. The average six-monthly patient out-of-pocket cost showed a gradient with household income where the high income group had the highest costs and the low income group had the lowest (Figure 1). Patient costs for those with private health insurance were slightly higher relative to those without. An asthma-related admission at time-point 1 had a much greater impact on expected patient out-of-pocket costs than the socio-demographic variables.

Discussion

By modelling routine administrative data augmented with survey data, we found that health care costs for asthma varied between individuals. Increasing activity limitations, age and

household income were associated with a higher probability of incurring costs, both health system and out-of-pocket. Activity limitations, age, and previous admission were associated with higher health system and out-of-pocket costs. The higher cost for those with evidence of poor asthma control is not surprising, and the higher cost for older people is consistent with other Australian research.[6] Costs to the health system were less for those living outside the capital city and for those with private health insurance, while the probability of an out-of-pocket cost was higher. The higher health system costs for capital city residents may relate to supply or demand factors. Those living outside the city may be unable to access the same level of services or there may be differences in asthma-related problems not captured by our measures. It is unlikely that holding private health insurance leads to lower service use for this condition in the Australian system, and this finding probably reflects the better health of the insured. Further research directly investigating access would enhance interpretation for informing policy.

Average patient out-of-pocket costs were not large. A minority had high expenditure, predominantly for medication. These costs will impose a greater burden on low and middle income groups. However, income related variation also was evident in health system costs, after adjusting for age and health status. This may be due to our health status measures not being sufficiently sensitive to real differences or it could indicate the impact of co-payments on the mid-income group, consistent with other Australian research.[7, 10, 19]

These results should be interpreted with caution as the causal direction of associations can be difficult to determine in an observational study. The health status measures were limited as data collection did not include clinical measures and the models excluded measures directly affecting costs, such as urgent medical visits and the use of short-acting beta agonists. The

recruitment strategy intentionally over-sampled people with severe asthma in order to have sufficient numbers of such patients. Thus our results cannot be extrapolated to all asthma patients in Australia.

There were substantial variations in the costs and utilisation and many high users remain high users over time, thus generating high costs. To the extent that the high use group have more severe asthma and/or poorer control there is a need for better targeted asthma management strategies such as policies to improve compliance and a greater understanding of patient preferences about asthma medication.[20, 21] However, the differences in use of health care was only partially explained by the asthma severity and control measures. Residents outside the capital city are lower service users, suggesting poorer access to services. Further, although there is pro-poor bias in service use (the low income group did not incur significantly lower service use than the high income group), the middle income group used fewer services. Out-of-pocket costs may be a deterrent as this group are expected to meet higher co-payments.

There are three issues warranting policy attention. Those with poorly controlled asthma and the elderly require more carefully targeted strategies to improve their health and ensure the appropriate use of resources. Access to appropriate services for those living outside of capital cities should be improved. Co-payments for the middle-income groups and those living in regional areas should be reduced to improve equity in the use of services.

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Appendix

Model

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:

$$(Y_{ij} \mid Y_{ij} > 0) \sim \text{Gamma}(a_{ij}, b_{ij})$$

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

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

where

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

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.

The predicted mean cost is given by the equation:

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

This was calculated using simulation, where 1000 random draws were taken from the estimated distributions of the two random effects and the equation estimated for each draw. The predicted mean cost is taken as the mean of the 1000 replications.

Table 1: 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
Maximum	14,008	16,185	12,220	11,591	15,675	13,126
Quartile 3	274	241	257	281	326	315
Median	71	84	75	89	106	100
Quartile 1	16	31	17	22	26	27
Minimum	0	0	0	0	0	0
% = 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
Maximum	1,426	1,824	2,186	1,428	6,775	5,045
Quartile 3	83	95	97	82	100	120
Median	39	48	40	40	41	31
Quartile 1	14	16	12	12	13	8
Minimum	0	0	0	0	0	0
% = zero	12	12	12	14	11	20

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

Table 2: Characteristics of the sample at recruitment and comparable characteristics estimated for the Australian asthma population[*]

	Hospital Sample n=41 %	Community Sample n=211 %	Total Sample n=252 %	Australian asthma population 2001[†§] %
Socio-demographic				
Sex male	32	46	44	45
Age (years) - recruitment strata				
5-10	17	19	19	
11-17	7	18	16	
18-39	39	16	19	
40-59	27	21	22	
60-75	10	26	23	
Age (years) - population comparison				
5-14	25	29	28	20
15-34	29	18	19	37
35-64	46	37	39	33
65+	0	16	14	10
Residence:				
Regional New South Wales	37	49	47	
Sydney metropolitan	63	51	53	
Private health insurance (hospital)	46	50	49	50
Gross weekly household income:				
Missing data	7	14	13	
$1-699	56	39	42	
$700-1499	10	32	28	
$1500+	27	15	17	
Gross weekly household income:				
Less than $1000[¶]	66	64	64	62
Current smoker (%of 162 adults)	23	11	13	25
Use of asthma medication (past 2 weeks)				
Short-acting beta agonists				
5-14	50	56	55	44
15-34	58	76	71	56
35-64	74	66	67	51
65+	-	79	79	55
Inhaled corticosteroids				
5-14	60	48	49	27
15-34	83	54	61	26
35-64	89	61	66	38
65+	-	88	88	55
Asthma-related health				
Urgent medical visit for asthma (past month)	37	9	14	
Hospital admission for asthma (past 6 months)	32	1	6	
	Mean (sd)	Mean (sd)	Mean (sd)	
Activity limitation due to asthma (past 6 months, 0-4[**])	1.6 (1.2)	0.8 (0.7)	0.9 (0.9)	
Sleep disturbance due to asthma (past month, average nights/week)	1.5 (2.3)	0.7 (1.2)	0.8 (1.5)	
Short-acting beta agonist use (past month, average times/day)	2.0 (1.8)	1.1 (1.4)	1.3 (1.5)	

* Estimated from the Australian National Health Survey 2001.

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¶ Excluding those with missing data.

** 0=no limitation, 4=Extremely limited.

Table 3: 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.

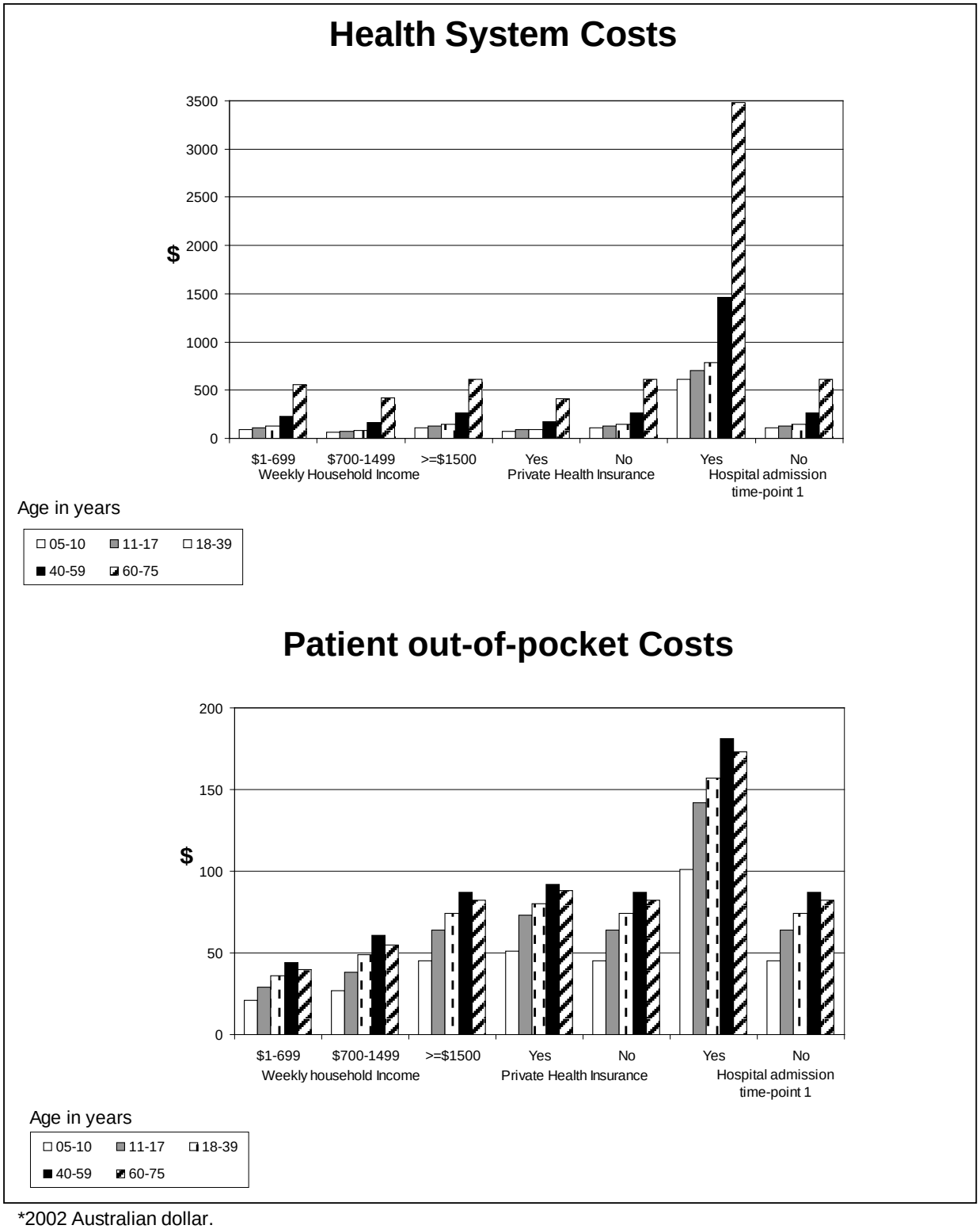
Table 4: Asthma costs per 6 month survey period (surveys 2 to 6): model coefficients and standard errors from a two-part binomial logit and gamma log model (n=252).

	Health system		Patient out-of-pocket	
	Estimate	Standard error	Estimate	Standard error
Part 1 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	
Part 2 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.

Figure 1: Expected costs* for asthma as predicted by models for selected sub-groups†



*2002 Australian dollar.

†All estimates for female Sydney residents reporting no activity limitation or sleep disturbance.