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Asthma control and its direct healthcare costs: findings using a derived Asthma Control Test™ score in eight Asia-Pacific areas

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ABSTRACT: The present authors explored the relationship between asthma control status, measured using a derived Asthma Control Test™ (ACT) score, and utilisation of healthcare and its cost in eight Asia-Pacific areas.

Patients were included if they were aged ⩾12 yrs and had participated in a recent survey of asthma patients. Patient-reported frequency of healthcare resource use was used to estimate the cost of asthma care. The ACT score was derived from survey questions identical or similar to the items comprising the ACT.

An ACT score was derived for 2,062 patients, of whom 59% (1,220) scored <20, suggesting that their asthma was not well controlled, and with 21% (423) scoring <15, suggesting poorly controlled asthma. The mean per-patient annual cost of asthma management for patients with a derived ACT of <15 was US$861 (95% confidence interval: US$686–1,042); US$319 (US$286–357) for patients with a derived ACT score of 15–19, and US$193 (US$173–214) for patients with a derived ACT score of ⩾20. A higher derived ACT score was associated with significantly lower annual expenditure on asthma management.

Poorer asthma control was associated with an increased frequency of all unscheduled healthcare and elevated cost. This finding was consistent across a range of Asia-Pacific areas.

KEYWORDS: Asia Pacific, asthma, asthma control test, healthcare costs

Asthma is a common chronic disease that poses a major public health problem in Asia Pacific [1–3]. Amongst teenagers in the region, >8% have reported wheeze in the past 12 months and >12% have diagnosed asthma [4]. Despite the availability of national and international guidelines, asthma management is grossly suboptimal worldwide [2, 5–9]. The Asthma Insights and Reality in Asia-Pacific (AIRIAP) survey, involving asthma subjects from eight areas (China, Hong Kong, Korea, Malaysia, the Philippines, Singapore, Taiwan and Vietnam) has demonstrated that the disease causes substantial morbidity, utilisation of healthcare resources and absence from work/school, especially in those with more severe disease.

Increased resource use and cost have been reported in patients experiencing asthma exacerbations [10], and in those with more severe disease or symptoms [11, 12]. Indeed, the AIRIAP dataset has shown that the total per-patient direct costs amount to 13% of *per capita* gross domestic product and 300% *per capita* healthcare spending, with asthma severity as one of the major determinants of high cost [3]. While it has been shown that asthma control is associated with increased utilisation of both acute and routine healthcare in the USA and Western Europe [13], similar data is lacking in the Asia-Pacific region.

Despite the recognised importance of asthma control [14–16], there is continued debate on how to assess control in a way that both supports management and is easy to use in practice [17–19]. A simple five-item patient-completed questionnaire, the Asthma Control Test™ (ACT), has been developed for asthma patients aged ⩾12 yrs and is found to compare well with asthma specialists' global assessment of asthma control [20, 21]. The questions ask patients to report, for the previous 4 weeks, on limitations to activities; shortness of breath; night-time awakening; use of rescue medication; and perception of control. Completion of the ACT results in a

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potential score of between 5 and 25; a score of ⩾20 indicates ''well controlled'' asthma and a score of <15 suggests ''poorly controlled'' asthma [21].

The five items in the ACT were similar to five of the questions in the AIRIAP survey. Thus it was possible to derive ACT scores for the participants in this survey to provide an estimate of their level of asthma control. It was also possible to examine the relationships between asthma control, as indicated by the derived ACT scores, health resource use and cost.

METHODS

Patients were included in this analysis if they took part in the AIRIAP study and were ⩾12 yrs of age. Data selected from AIRIAP included demographical variables, reported asthma symptoms, activity limitations and use of scheduled and unscheduled healthcare over the preceding 12 months. A symptom severity index similar to that used in the Global Initiative for Asthma (GINA) guidelines has been developed for use with the Asthma Insights and Reality (AIR) datasets, which divides patients into four categories of symptom severity: mild intermittent, mild persistent, moderate persistent and severe persistent [9]. Per-patient costs were derived by multiplying reported frequency of in-patient stay, hospital emergency room visits, physician contacts and asthma-related drug use by country-specific unit costs. Only direct per-patient costs were included and costs are reported in US$ for the year 2000. The methodology used to assess costs is reported in detail elsewhere [3].

Both the ACT and AIRIAP responses are based on a recall period of 4 weeks and a number of the questions elicit similar information. A mapping algorithm was developed to estimate ACT responses from the AIRIAP items, using questions that were similar or identical in the two questionnaires (Appendix 1). The score for each ACT item was estimated for each eligible patient for whom sufficient data was recorded for the mapping algorithm to generate a response.

Patients were divided into three groups: those with a derived ACT of ⩾20, an ACT of 15–19 and an ACT of <15 [21]. The number and percentage of patients in each ACT group reporting hospital contact (in-patient stay or emergency room visit) or other unscheduled physician care over the past 12 months was calculated, as was the average per-patient cost of scheduled and unscheduled care over the previous 12 months.

In order to further explore the determinants of the cost of care, multiple regression of per-patient cost against country, symptom severity, demographics and ACT score was undertaken. A regression analysis was conducted.

This analysis closely follows the methodology used to explore cost and control in the Western European AIR study [22].

RESULTS

Of the 3,207 patients included in the AIRIAP survey, 2,478 were aged ⩾12 yrs and so were eligible for inclusion in this analysis. An ACT score was evaluable for 2,062 (83%) of these patients. The most common reason for exclusion was that the data recorded were not sufficient to determine the frequency with which relief inhalers were required (ACT question 4).

The mean age of eligible respondents was 38 yrs, ranging from 32 yrs in Malaysia to 45 yrs in China. Of the respondents, 54% were female, with Hong Kong having the lowest percentage (39%) and Korea the highest percentage (69%). Twenty per cent were smokers, ranging from 13% in Vietnam to 27% in the Philippines. Slightly more than half (52%) of the patients included reported mild intermittent asthma symptoms, although more than half of the patients reported persistent symptoms in China, Korea and Vietnam. The characteristics of the eligible patients are summarised in table 1.

A high percentage of patients reported frequent asthma symptoms: 50% of patients (1,242) reported activity limitation all, most or some of the time (responses 1–3 on ACT question 1); 28% (695) reported shortness of breath three times or more a week (responses 1–3 on ACT question 2); 33% (815) reported that asthma symptoms woke them up at night or earlier than usual in the morning once a week or more (responses 1–3 on ACT question 3) and 44% of patients (1,101) reported use of a rescue inhaler ''a few times a week'' or more often (responses 1–3 on ACT question 4). Despite the high percentage of patients reporting symptoms and rescue medication use, 64% (1,589) of patients reported that they would rate their asthma as well controlled or completely controlled (responses 4–5 on ACT question 5) (fig. 1).

TABLE 1 Characteristics of eligible patients

	China	Hong Kong	Korea	Malaysia	The Philippines	Singapore	Taiwan	Vietnam	Total
Number eligible n	381	349	252	342	230	271	295	358	2478
Age yrs	45.7±21.5	35.6±18.9	43.9±16.5	32.6±15.1	35.9±17.3	33.9±18.3	41.1±22.2	40.3±16.8	38.8±19.1
Females[#]	51	39	69	55	58	55	53	60	54
Smokers	19	21	20	19	27	21	25	13	20
Symptom severity index									
Mild intermittent	46	59	48	57	60	65	55	30	52
Mild persistent	23	14	19	23	14	19	19	23	20
Moderate persistent	14	17	18	11	11	12	15	28	16
Severe persistent	17	10	14	8	15	4	11	18	12

Data are presented as mean±SD or %, unless otherwise indicated. [#]: Sex not recorded for six patients.

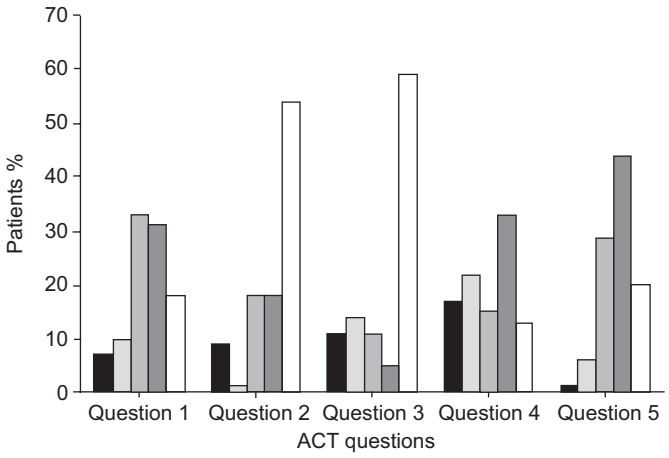

FIGURE 1. Derived responses to each of the Asthma Control Test™ (ACT) questions. Question 1: activity limitation; question 2: shortness of breath; question 3: night-time awakening; question 4: use of rescue medication; question 5: patient perception of control. ■: response 1; ■: response 2; ■: response 3; ■: response 4; □: response 5.

Of the patients with an evaluable ACT score, 59% (1,220) reported a derived ACT score of <20, and 21% (423) a derived ACT score of <15. The derived ACT was at the best possible value of 25 for only 1% of patients [22] in the survey. There appeared to be an association between a lower derived ACT score and a more severe symptom severity. However, a small number of patients reporting severe persistent symptoms had a derived an ACT score of ⩾20 (n=21; 7%). One-third (n=337; 34%) of patients who reported intermittent symptoms had a derived ACT score of <20 (table 2). Of patients with persistent asthma symptoms of any severity, 83% (883) reported a derived ACT score of <20 and 37% (395) a derived ACT score of <15 (table 2).

Of patients with a derived ACT score of <20, 34% (415) reported hospital contact (in-patient care or emergency room visit). Unscheduled healthcare related to asthma, including in-patient care, an emergency room visit or an unscheduled primary care visit was reported at least once in the previous year by 52% (637) of patients with a derived ACT score of <20. For patients with a derived ACT score of <15, the respective figures were 52% (221) and 68% (286). Of patients with a derived ACT score of ⩾20, 13% (108) had hospital contact and 34% (285) reported unscheduled healthcare use (table 3).

Mean per-patient total annual cost of asthma management was US$193 (95% confidence interval (CI): US$173–214) in patients with a derived ACT score of 20 or above; US$319 (US$286–357) in patients with a derived ACT score of 15–19 and US$861 (US$686–1,042) in patients with a derived ACT score of <15. Mean per-patient costs varied markedly between areas. In all areas, cost was highest for patients with a derived ACT score of <15 and was lowest for those with a derived ACT score of ⩾20, except for the Philippines (fig. 2).

TABLE 2 Derived Asthma Control Test™ (ACT) scores and asthma symptom severity

Patient group#	Derived ACT score			Derived ACT score	Total n
	5–14	15–19	Total <20	20–25	
All patients	423 (21)	797 (39)	1220 (59)	842 (41)	2062
Mild intermittent symptoms	28 (3)	309 (31)	337 (34)	658 (66)	995
Mild persistent symptoms	35 (9)	233 (57)	268 (66)	140 (34)	408
Moderate persistent symptoms	157 (42)	193 (52)	350 (94)	23 (6)	373
Severe persistent symptoms	203 (71)	62 (22)	265 (93)	21 (7)	286

Data are presented as n (%), unless otherwise indicated. All percentages refer to the number in the ACT group as percentage of row total. #: ACT was not evaluable for 416 out of 2,478 eligible patients. See text for more details.

TABLE 3 Derived Asthma Control Test™ (ACT) scores and use of healthcare resources

	Derived ACT score			Derived ACT score	Total
	5–14	15–19	Total <20	20–25	
Subjects n	423	797	1220	842	2062
Hospital contact#	221 (52)	194 (24)	415 (34)	108 (13)	523 (25)
Any unscheduled care¶	286 (68)	351 (44)	637 (52)	285 (34)	922 (45)

Data are presented as the number of patients (% of ACT group) reporting in previous 12 months, unless otherwise indicated. #: Defined as in-patient stay or emergency room visit; ¶: defined as hospital contact or emergency primary care physician visit.

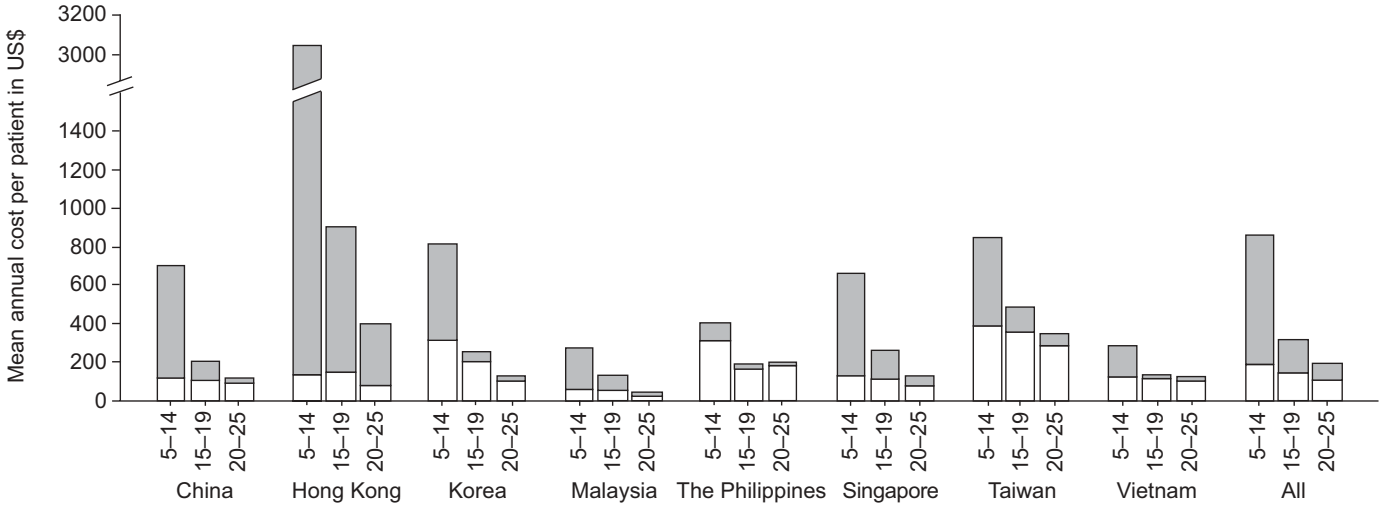

FIGURE 2. Cost of scheduled (□) and unscheduled (■) healthcare by country and derived Asthma Control Test™ scores.

For patients with a derived ACT score of <15, unscheduled healthcare resource use accounted for 78% of direct healthcare cost (US$673 per patient; 95% CI US$519–887). For patients with a derived ACT score of 15–19, unscheduled care accounted for 54% of cost (US$173 per patient; US$140–210) and for patients with a derived ACT score of ⩾20, 43% of cost (US$84 per patient; US$69–101). This pattern of increasing spending on unscheduled healthcare as a proportion of direct healthcare cost in association with worsening asthma control was found across most areas. Unscheduled healthcare constituted the majority of health spending in Hong Kong, but only accounted for a minority of spending in the Philippines.

The regression analysis found that, after correcting for country and symptom severity, a higher derived ACT score was associated with significantly lower expenditure on asthma management ($p<0.01$).

DISCUSSION

This analysis derived ACT scores in a large cohort of asthma patients in the Asia-Pacific area and provides new evidence quantifying the link between asthma control and unscheduled healthcare resource use and cost. Poorer asthma control, as measured by derived ACT, was associated with a higher requirement for hospitalisation and unscheduled healthcare over the previous year and elevated cost.

There are limitations to this study. First, the ACT scores were derived retrospectively from questions in the AIRIAP survey that did not perfectly match the ACT questions. Secondly, the questions were administered in the context of a much larger questionnaire and framing effects may distort the scores achieved. Third, healthcare resource use was based on patient recall over a period of 1 yr, which could potentially introduce further inaccuracy [23], although recall of emergency events in particular has been found to be acceptable over such a period [24]. Other limitations include pooling of heterogeneous country data, and costing based on patient recollection of events. This analysis includes areas with substantially different levels of economic development and with correspondingly varied health systems: the high per-patient cost in Hong Kong and to a lesser degree Taiwan, Korea and Singapore is likely to be due to higher unit costs reflecting higher wages combined with easier access to healthcare in these areas, compared with economically less developed areas such as Vietnam and Malaysia. However, the association between lower derived ACT scores and higher healthcare resource use and cost appears to be robust across the areas considered.

Within these limitations, this analysis provides valuable new information on the economic burden of uncontrolled asthma in Asia-Pacific areas. Extensive efforts were made to generate a representative patient sample in the AIRIAP survey and these data provide the most comprehensive assessment of asthma management and control in the region to date. The AIRIAP survey findings represent a valuable research resource.

Additional analysis of the AIRIAP dataset [3] found that only 2.5% of the population met with all the modified GINA criteria for asthma control: minimal chronic symptoms, including nocturnal symptoms, minimal exacerbations, no emergency visits for asthma, minimal need for short-acting β-agonists and no limitation of physical activity [5]. That this current analysis found a comparable though slightly lower percentage of patients (1%) achieving the best possible derived ACT score of 25 further suggests that the ACT may be a valid tool in assessing asthma control, even in epidemiological studies. However, some discrepancy did exist between the derived ACT scores and symptom severity, as assessed by the GINA criteria, in particular with one in three patients reporting only intermittent symptoms also achieving a score on ACT of <20.

The AIRIAP dataset found that >40% of asthma patients in the region had utilised urgent care at least once in the 12 months preceding the survey, and that asthma severity, as defined by frequency of symptoms, correlated significantly with hospitalisation and emergency visits [2]. BOONSAWAT *et al.* [6] also noted in their study that increasing symptom severity was significantly associated with increased emergency healthcare use. This current analysis is the first in the Asia-Pacific region to estimate the association between healthcare use and asthma

control status. The analysis showed that compared with patients achieving an ACT score of $\geqslant$20, more than twice as many patients with an ACT score $<$20 reported some form of hospital contact. Furthermore the total cost of healthcare, especially the cost of unscheduled healthcare, was notably higher in patients with poorer asthma control as measured by the derived ACT score.

The questions used to derive the ACT score ask the patients to recall events over the 4 weeks preceding the survey interview, and questions relating to healthcare resource use ask them to recall the previous year. This analysis has therefore demonstrated an association between recent asthma control and a history of high healthcare cost. A different study design would be required to evaluate whether the ACT score also forecasts future healthcare resource use and cost, and whether ACT can be used to guide management and improve the economic efficiency of treatment. Such studies would best assess ACT, resource use and cost in a prospective manner.

In conclusion, poorer asthma control, as defined by the Asthma Control Test™ score, was associated with an increased requirement for all unscheduled healthcare and elevated cost. This finding was consistent across a range of Asia-Pacific areas.

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REFERENCES

1 Lai CKW, Douglass C, Ho SS, *et al.* Asthma epidemiology in the Far East. *Clin Exp Allergy* 1996; 26: 5–12.
2 Lai CKW, De Guia TS, Kim YY, *et al.* Asthma control in the Asia-Pacific region: the Asthma Insights and Reality in Asia-Pacific Study. *J Allergy Clin Immunol* 2003; 111: 263–268.
3 Lai CKW, Kim Y-Y, Kuo S-H, Spencer M, Williams AE, on behalf of the Asthma Insights and Reality and Asia Pacific Steering Committee. Cost of asthma in the Asia-Pacific region. *Eur Respir Rev* 2006; 98: 10–16.
4 Lai CKW, the ISAAC Asia Pacific Group. Time trends of asthma prevalence in Asia Pacific schoolchildren. *Eur Respir J* 2004; 24: Suppl. 48, 665s.
5 Rabe KF, Vermeire PA, Soriano JB, Maier WC. Clinical management of asthma in 1999: the Asthma Insights and Reality in Europe (AIRE) study. *Eur Respir J* 2000; 16: 802–807.
6 Boonsawat W, Charoenphan P, Kiatboonsri S, *et al.* Survey of asthma control in Thailand. *Respirology* 2004; 9: 373–378.
7 Neffen H, Fritscher C, Schacht FC, *et al.* Asthma control in Latin America: the Asthma Insights and Reality in Latin America (AIRLA) survey. *Pan Am J Public Health* 2005; 17: 191–197.
8 Adams RJ, Fuhlbrigge A, Guilbert T, Lozano P, Mertinez F. Inadequate use of asthma medications in the United States: results of the Asthma in America national population survey. *J Allergy Clin Immunol* 2002; 110: 58–64.
9 Rabe KF, Adachi M, Lai CKW, *et al.* Worldwide severity and control of asthma in children and adults: the global asthma insights and reality surveys. *J Allergy Clin Immunol* 2004; 114: 40–47.
10 Molina J, Lane SJ, Plusa T, Keech ML. The cost of managing asthma exacerbations in primary care in nine countries. *Am J Respir Crit Care Med* 2004; 169: A330.
11 Antonicelli L, Bucca C, Neri M, *et al.* Asthma severity and medical resource utilisation. *Eur Respir J* 2004; 23: 723–729.
12 Miller MK, Johnson C, Miller DP, Deniz Y, Bleecker ER, Wenzel SE. Severity assessment in asthma: an evolving concept. *J Allergy Clin Immunol* 2005; 116: 990–995.
13 Vollmer WM, Markson LE, O'Connor E, Frazier EA, Berger M, Buist AS. Association of asthma control with health care utilization: a prospective evaluation. *Am J Respir Crit Care Med* 2002; 165: 195–199.
14 Global Initiative for Asthma (GINA). Global strategy for asthma management and prevention: 2004 update. http://www.ginasthma.org. 2004. Date last accessed: April 19, 2006.
15 National Institute of Health (NIH) NHLaBIN. Expert Panel Report 2: Guidelines for the diagnosis and management of asthma. Bethesda, MD, NIH publication 97–4051; 1997.
16 Li JT, Oppenheimer J, Bernstein IL, Nicklas RA. Attaining optimal asthma control: a practice parameter. *J Allergy Clin Immunol* 2005; 116: S3–S11.
17 Bateman ED. Measuring asthma control. *Curr Opin Allergy Clin Immunol* 2001; 1: 211–216.
18 Bateman ED, Boushey HA, Bousquet J, *et al.* Can guideline-defined asthma control be achieved? The Gaining Optimal Asthma controL study. *Am J Respir Crit Care Med* 2004; 170: 836–844.
19 Magnan A. Tools to assess (and achieve?) long-term asthma control. *Respir Med* 2004; 98: Suppl. 2, S16–S21.
20 Nathan RA, Sorkness CA, Kosinski M, *et al.* Development of the asthma control test: a survey for assessing asthma control. *J Allergy Clin Immunol* 2004; 113: 59–65.
21 Schatz M, Li JT, Sorkness CA, *et al.* Responsiveness of the Asthma Control Test (ACT) to changes in specialist ratings of asthma control and FEV1. *Am J Respir Crit Care Med* 2004; 169: A319.
22 Vervloet D, Williams AE, Lloyd A, Clark TJH. Cost of managing asthma as defined by a derived Asthma Control Test™ in seven European Union countries. *Eur Respir Rev* 2006; 98: 17–23.
23 Petrou S, Murray L, Cooper P, Davidson LL. The accuracy of self-reported healthcare resource utilization in health economic studies. *Int J Technol Assess Health Care* 2002; 18: 705–710.
24 Evans C, Crawford B. Patient self-reports in pharmacoeconomic studies. Their use and impact on study validity. *Pharmacoeconomics* 1999; 15: 241–256.

APPENDIX 1. ASTHMA INSIGHTS AND REALITY IN THE ASIA-PACIFIC (AIRIAP) TO ASTHMA CONTROL TEST™ (ACT) MAPPING ALGORITHM

ACT items and corresponding AIRIAP survey question(s)	ACT responses and corresponding responses from the AIRIAP survey questions				
ACT question 1					
In the past 4 weeks how much of the time did your asthma keep you from getting as much done at work, school or home?	All of the time	Most of the time	Some of the time	A little of the time	None of the time
AIRIAP#					
How much do you feel that your asthma limits what you¶ can do in … social activities/playing [and] … housekeeping chores?	Both responses ''A lot''	Worst response ''A lot''	Worst response ''Some''	Worst response ''Little''	Both responses ''Not at all''
ACT question 2					
During the past 4 weeks, how often have you had shortness of breath?	More than once a day	Once a day	Three to six times a week	Once or twice a week	Not at all
AIRIAP					
What asthma symptoms have you had... [If ''Shortness of Breath'' reported]: How many times in a typical week do you experience asthma symptoms?	Eight times per week or more frequently	Seven times per week	3, 4, 5 or 6 times per week	One or two times per week	Shortness of breath not experienced
ACT question 3					
During the past 4 weeks how often did your asthma symptoms (wheezing, coughing, shortness of breath, chest tightness or pain) wake you up at night or earlier than usual in the morning?	Four or more times a week	2–3 times a week	Once a week	Once or twice	Not at all
AIRIAP					
Have you been awakened by a cough, or wheezing, or shortness of breath, or chest tightness during the night? How often do you have these symptoms at night?	''Every night'' OR ''Most nights''	''At least three nights a week'' OR ''Twice a week''	''Once a week (five times a month)'' OR ''Three or four times a month''	''Twice a month'' OR ''Once a month''	None of the symptoms in the past 4 weeks
ACT question 4					
During the past 4 weeks how often have you used your rescue inhaler or nebulizer medication (such as salbutamol)?	Three or more times per day	1 or 2 times per day	2 or 3 times per week	Once a week or less	Not at all
AIRIAP+					
Which of [these asthma medications] do you take for ''quick relief'' of asthma symptoms? How often do you take them?	''Daily'' AND three times per day or more often	''Daily'' AND 1 per day or 2 per day	''2–3 times per week''	''Once a week'' or less often	Not taken
ACT question 5					
How would you rate your asthma control during the past 4 weeks?	Not controlled at all	Poorly controlled	Somewhat controlled	Well controlled	Completely controlled
AIRIAP					
Overall, how well would you say that your asthma has been controlled in the past four weeks?	''Not controlled at all''	''Poorly controlled''	''Somewhat controlled''	''Well controlled''	''Completely controlled''

#: All questions begin ''In the past 4 weeks''. ¶: All references to ''Your asthma'' also include ''your child's asthma'' when appropriate. +: Up to four ''quick relief'' drugs reported. ACT response estimated from the quick relief drug used most frequently.

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ERRATUM

"Introduction". M. Spiteri. *Eur Respir Rev* 2005; 14: 97, 125.

R. Lutter should have been included as the co-author of the Introduction.

R. Lutter was also Guest Editor of issue 14: 97, Current perspectives in epithelial cell injury and repair, alongside M. Spiteri.