
Assessing the validity of self-reported medication adherence among inner-city asthmatic adults: the Medication Adherence Report Scale for Asthma

Jessica L. Cohen, BA*; Devin M. Mann, MD, MS*; Juan P. Wisnivesky, MD, MPH*; Robert Horne, PhD†; Howard Leventhal, PhD‡§; Tamara J. Musumeci-Szabó, PhD‡; and Ethan A. Halm, MD, MPH||

Background: A validated tool to assess adherence with inhaled corticosteroids (ICS) could help physicians and researchers determine whether poor asthma control is due to poor adherence or severe intrinsic asthma.

Objective: To assess the performance of the Medication Adherence Report Scale for Asthma (MARS-A), a 10-item, self-reported measure of adherence with ICS.

Methods: We interviewed 318 asthmatic adults receiving care at 2 inner-city clinics. Self-reported adherence with ICS was measured by MARS-A at baseline and 1 and 3 months. ICS adherence was measured electronically in 53 patients. Electronic adherence was the percentage of days patients used ICS. Patients with a mean MARS-A score of 4.5 or higher or with electronic adherence of more than 70% were defined as good adherers. We assessed internal validity (Cronbach α , test-retest correlations), criterion validity (associations between self-reported adherence and electronic adherence), and construct validity (correlating self-reported adherence with ICS beliefs).

Results: The mean patient age was 47 years; 40% of patients were Hispanic, 40% were black, and 18% were white; 53% had prior asthma hospitalizations; and 70% had prior oral steroid use. Electronic substudy patients were similar to the rest of the cohort in age, sex, race, and asthma severity. MARS-A had good interitem correlation in English and Spanish (Cronbach α = 0.85 and 0.86, respectively) and good test-retest reliability (r = 0.65, P < .001). According to electronic measurements, patients used ICS 52% of days. Continuous MARS-A scores correlated with continuous electronic adherence (r = 0.42, P < .001), and dichotomized high self-reported adherence predicted high electronic adherence (odds ratio, 10.6; 95% confidence interval, 2.5–44.5; P < .001). Construct validity was good, with self-reported adherence higher in those saying daily ICS use was important and ICS were controller medications (P = .04).

Conclusions: MARS-A demonstrated good psychometric performance as a self-reported measure of adherence with ICS among English- and Spanish-speaking, low-income, minority patients with asthma.

Ann Allergy Asthma Immunol. 2009;103:325–331.

INTRODUCTION

Daily use of inhaled corticosteroids (ICS) is the foundation of evidence-based management of persistent asthma.^{1,2} Unfortunately, suboptimal adherence with ICS is well documented.^{3–7} Adherence with ICS is lower among minorities, and these

lower rates of ICS use are thought to contribute to higher asthma morbidity and mortality rates in inner-city communities.^{5–11}

From a clinical perspective, it can be difficult to determine whether poor asthma control is due to inadequate adherence with ICS or reflects severe intrinsic asthma despite adherence with therapy. Ascertaining this in an accurate way is challenging because health care professionals may not ask questions in a fashion that encourages honest reporting and patients often overestimate their medication use.^{12,13} Most self-reported measures of adherence with inhaled medications have had scant data about their validity.¹⁴ A relatively simple validated tool for assessing self-reported adherence with ICS would be valuable for several reasons. First, physicians in real-world practice rely on self-report for assessing adherence with therapy. Second, measuring adherence with the “gold standard” of electronic monitoring is impractical from a cost and logistical perspective.^{13,15,16} Although pharmacy data estimate

Affiliations: * Division of General Internal Medicine, Mount Sinai School of Medicine, New York, New York; † Department of Pharmacy, University of London, England; ‡ Institute for Health, Health Care Policy and Aging Research, Rutgers University, New Brunswick, New Jersey; § Department of Psychology, Rutgers University, New Brunswick, New Jersey; || Departments of Internal Medicine and Clinical Sciences, University of Texas Southwestern Medical Center, Dallas, Texas.

Disclosures: Authors have nothing to disclose.

Funding Sources: This study was funded by the National Institute on Aging and Center for Study of Health Beliefs and Behaviors (RO1 HS09973) and Agency for Healthcare Research and Quality (K08 HS013312). Ms Cohen was additionally supported by the Doris Duke Charitable Foundation for Clinical Research fellows.

Received for publication January 6, 2009; Received in revised form April 27, 2009; Accepted for publication May 6, 2009.

adherence in patients within closed health care systems, such as health maintenance organizations and Veterans Affairs facilities,^{16–18} this information is known only months after the fact, and dispensing data methods have their own methodological limitations.^{19,20}

The purpose of this study was to establish the internal, criterion, and construct validity of the Medication Adherence Report Scale for Asthma (MARS-A)^{21–23} for measuring adherence with ICS among patients with persistent asthma. A generic version of MARS has been used to measure adherence with oral medication use, and data are limited on its psychometric properties for measuring use of inhaled medicines and adherence among minority asthmatic patients in the United States.^{21,24,25} We also sought to develop a Spanish version of MARS-A and evaluate its preliminary validity.

METHODS

Study Design

MARS-A was administered in a multicenter, prospective cohort study of adults with persistent asthma recruited from general medicine clinics in 2 urban communities.^{26,27} Patients with a smoking history of 10 pack-years or more or chronic obstructive lung disease were excluded. Surveys were administered in English or Spanish at baseline enrollment, 1 month, and 3 months. Information collected included sociodemographics, clinical history, medication beliefs, and adherence with ICS. Asthma morbidity measures included hospitalizations and emergency department visits, intubations, and oral steroid use. The protocol was approved by the institutional review board and written informed consent obtained from all study participants.

Self-reported Medication Adherence

MARS-A is 10-item questionnaire with several desirable characteristics for assessing ICS use. It includes both generic (“I use it regularly every day”) and asthma-specific questions about medication use (“I only use it when I feel breathless”; Fig 1).²⁸ It also assesses both intentional (“I

avoid using it if I can”) and nonintentional nonadherence (“I forget to use it”).^{23,29} Questions are framed as negative statements to minimize social desirability bias and set a tone of nonadherence being normal, and medication use is rated on a 5-point Likert scale (1 indicating always to 5 indicating never).

MARS-A was translated into Spanish by a native speaker, and the Spanish and English translations were reviewed and compared by independent bilingual research staff. Self-reported adherence is reported as the average of the 10 questions (range of 0 to 5, higher numbers indicate greater adherence). High self-reported adherence was defined as a MARS score of 4.5 or higher.

Electronic Medication Adherence

For the electronic adherence substudy, patients had to be prescribed an ICS by metered-dose inhaler (MDI) so an electronic monitor could be attached. Patients prescribed an ICS diskus were excluded from the electronic adherence study because no diskus electronic monitor was available at the time. The first 53 patients enrolled in the cohort who met these criteria were enrolled in the electronic adherence substudy, and all were prescribed twice-daily ICS. The expense of the monitors limited the scope of this substudy.

An MDI-log monitor (Medtrac Technologies, Lakewood, Colorado) monitored ICS use for the first month of the study. Patients were told their ICS use was being monitored. When the MDI-logs were collected, patients reported device problems or whether they used any other ICS inhaler during the 30-day period. According to methods used previously, we truncated electronic adherence to avoid overestimations due to intentional “dumping” or unintentional actuation.^{15,30,31}

The primary measure of electronic adherence was the percentage of days used in 30 days that a patient used 1 puff or more during that 24-hour period. The evaluation started on the day after the monitor was attached. A secondary measure of electronic adherence was the percentage of doses used in the 30 days divided by the number of doses prescribed during which each dosing period needed to be separated by 3.5 hours or more to prevent overcounting multiple actuations from 1 period (a convention used in prior studies).^{15,30,31} Checking analyses examined the percentage of days used in the first 15 days vs the second 15 days to evaluate if the new monitoring device significantly influenced initial adherence. High electronic adherence was defined as use of ICS on more than 70% of days prescribed—a convention used in previously published studies.^{32,33}

Statistical Analysis

The χ^2 test, *t* test, and rank sum tests compared characteristics of patients in the electronic adherence substudy with those in the larger sample. Internal reliability of MARS-A in English and Spanish at all 3 time points was evaluated with Cronbach α (a measure of interitem correlation) and

How often do you do the following?

Answers:(1)Always(2)Often(3)Sometimes(4)Rarely(5)Never

1. I only use my [NAME OF MEDICINE] when I need it
2. I only use it when I feel breathless
3. I decide to miss out a dose
4. I try to avoid using it
5. I forget to take it
6. I alter the dose
7. I stop taking it for a while
8. I use it as a reserve, if my other treatment doesn't work
9. I use it before doing something which might make me breathless
10. I take it less than instructed

Figure 1. Using the Medication Adherence Report Scale for Asthma (MARS-A). Copyright of MARS-A and all variants is owned by the originator Robert Horne, PhD, and permission to use it should be obtained by requests to Rob.horne@pharmacy.ac.uk.

principal components analysis.³⁴ Stability of MARS-A was evaluated with Spearman correlations among the scores at all 3 intervals.

Criterion validity was evaluated using Spearman correlations between self-reported adherence (MARS-A) and electronic adherence. We also correlated high self-reported adherence (mean MARS score, ≥ 4.5) with the dichotomous outcome of high electronic adherence ($\geq 70\%$ of days used). Alternate definitions of high electronic adherence (use on $\geq 80\%$ of days prescribed) and a MARS-A score of 4.0 or higher showed similar patterns to those presented. We conducted sensitivity analyses excluding the 10 patients who reported using another ICS canister during the month to determine if electronic adherence was underestimated. To determine construct validity, we used Wilcoxon and χ^2 tests to determine associations between high self-reported adherence and the response to 2 medication questions that should be correlated with good adherence: "How often do you take your [ICS name] on days when you are NOT having symptoms?" and "Is your [ICS name] a controller medication?" All statistical tests were performed with Stata statistical software,

version 9.0 (StataCorp, College Station, Texas), and used 2-tailed tests.

RESULTS

Response Rates and Patient Characteristics

The overall cohort included 318 patients with persistent asthma who completed the baseline survey. Of these, 278 (87%) completed the 1-month follow-up, and 245 (77%) completed the 3-month follow-up. All 53 patients enrolled in the electronic adherence substudy completed it. Interviews were conducted in the patient's language of choice, with 18% choosing Spanish.

Consistent with the epidemiology of inner-city asthma, this was largely a group of low-income, Hispanic, and African American women with high rates of prior asthma hospitalization and oral steroid use (Table 1). Approximately three-quarters had used oral steroids, 70% used oral steroids in the past year, 53% were hospitalized, and 13% were intubated for their asthma. Patients in the electronic adherence substudy were similar to those who did not have their ICS use moni-

Table 1. Demographic and Clinical Characteristics of the 318 Study Participants

Characteristics	All patients (n = 318)	Electronic adherence substudy patients (n = 53)	Patients not in the electronic monitoring substudy (n = 265)	P value ^a
Age, mean (SD), y	48 (13)	47 (12)	48 (14)	.38
Female, No. (%)	264 (83)	45 (85)	219 (83)	.73
Ethnicity, No. (%)				
Hispanic	185 (58)	34 (63)	151 (57)	.43
Black	93 (29)	17 (31)	76 (28)	
White, non-Hispanic	40 (12)	3 (6)	37 (14)	
Insurance status, No. (%)				
Medicaid/Medicare	254 (80)	49 (92)	205 (78)	.10
Private insurance, Blue Cross, HMO	60 (19)	4 (8)	56 (21)	
Uninsured	4 (1)	0	4 (1)	
Native language, No. (%)				
English	219 (69)	38 (72)	181 (68)	.85
Spanish	99 (31)	15 (29)	84 (31)	
Income <\$15,000, No. (%)	197 (62)	39 (74)	159 (60)	.07
Education level <high school, %	105 (33)	23 (43)	82 (31)	.19
Asthma history, No. (%)				
Age of onset ≤ 20 y	162 (51)	30 (56)	135 (51)	.49
Ever intubated	32 (10)	7 (13)	26 (10)	.48
Ever taken oral steroids	229 (72)	38 (72)	185 (70)	.70
Ever hospitalized for asthma	171 (54)	28 (53)	143 (54)	.86
Comorbid conditions, No. (%)				
Allergic rhinitis	207 (65)	36 (68)	172 (65)	.65
Diabetes mellitus	80 (25)	14 (26)	66 (25)	.81
GERD	118 (37)	17 (32)	101 (38)	.45
Congestive heart failure	13 (4)	3 (6)	10 (4)	.62
Depression	149 (47)	29 (55)	119 (45)	.20
Hypertension	149 (46)	24 (45)	125 (47)	.86
Social habits, No. (%)				
Current smoker (last 3 mo)	114 (36)	21 (39)	93 (35)	.70

Abbreviations: GERD, gastroesophageal reflux disease; HMO, health maintenance organization.

^a P value comparing characteristics of patients who were and were not in the electronic adherence substudy.

tored electronically with regard to age, sex, race, asthma history, and severity.

Medication Adherence

Self-reported medication adherence according to MARS-A scores is indicated in Table 2. The mean (SD) MARS-A score (range, 1–5) was 4.3 (0.8) at baseline, 4.1 (0.8) at 1 month, and 4.3 (0.8) at 3 months, equivalent to skipping ICS rarely or never. Monitoring patients for 1 month did not change their self-reported adherence (MARS-A scores were 4.0 at baseline before monitoring, 4.1 at 1 month when the monitor was returned, and 4.1 at 3 months [2 months after monitoring ceased]). MARS-A scores were similarly stable within the nonmonitored patients.

Electronic Adherence

According to the electronic adherence measure, on average, patients used their ICS 52% of days and took 35% of prescribed doses (Table 3). Ten patients reported using an ICS inhaler without the MDI-log device attached at some time during the electronic monitoring period. Eliminating these 10 patients from the analyses yielded a mean ICS use on 55% of days prescribed and 38% of doses prescribed. Checking analyses showed that all electronic measures of adherence were highly correlated (30 days, first 15 days, and second 15 days, $r = 0.78$ to 0.97 ; $P < .001$).

Internal Validity of MARS-A

The Cronbach α for MARS-A was 0.85 at baseline and 1 month (and 0.84 at 3 months). MARS performed equally well in English and Spanish at all 3 periods (baseline: English, 0.85; Spanish, 0.84; 1 month: English, 0.85; Spanish, 0.86; and 3 months: English, 0.85; Spanish, 0.83). MARS-A scores appeared relatively stable over time, with correlations between MARS-A scores at baseline and 1 month ($r = 0.65$), 1 month and 3 months ($r = 0.70$), and baseline and 3 months ($r = .64$) ($P < .001$). Principal component analysis found that 1 factor accounted for 88.7% of the variance, suggesting that MARS-A measured only adherence.

Table 2. Self-reported Medication Adherence by Medication Adherence Rating Scale for Asthma (MARS-A) Scores Over Time Among Those Receiving and Not Receiving The Electronic Monitors^a

Period	All patients	Electronic adherence substudy patients (n = 53)	Nonmonitored patients (n = 265)
Baseline	4.2	4.0	4.3
1 month	4.3	4.1	4.3
3 months	4.3	4.1	4.3

^a There was no statistically significant difference in the MARS-A scores whether patients were electronically monitored or not.

Criterion Validity of MARS-A

Table 4 gives the matrix of Spearman correlations between the self-reported MARS-A scores at 2 periods and the various electronic adherence definitions. Overall, higher self-reported ICS adherence (MARS-A scores) was significantly correlated with better electronic adherence. As indicated in Table 4, this correlation between MARS-A scores and electronic adherence persisted with MARS-A scores at 1 and 3 months. The association held whether electronic adherence was based on percentage of days used or percentage of doses used. We also found significant associations between MARS-A and electronic adherence further divided into the first vs last 15 days of monitoring. The strength of the association increased further when 10 participants who used an ICS inhaler without the MDI-log device sometime during the monitoring period were removed from the analysis ($r = 0.50$, $P < .001$). Alternate analyses that compared the dichotomous self-reported and electronic adherence scores, classifying patients with a MARS-A score of 4.5 or higher and electronic adherence of 70% or higher as high adherers, showed that patients who reported high adherence according to MARS-A had 10-fold higher odds of being high adherers by electronic report (odds ratio [OR], 10.6; 95% confidence interval [CI], 2.5–44.5; $P < .001$).

Overall, 47.2% of patients were higher adherers according to a MARS-A score of 4.5 or higher, and 32.1% were high adherers defined as electronic adherence of 70% or higher. High self-reported adherence according to MARS-A (score of ≥ 4.5) had a sensitivity of 82.4% and specificity of 69.4% for electronically confirmed adherence, with a positive likelihood ratio of 2.7 and the negative likelihood ratio of 0.25 (area under the receiver operating characteristic curve, 0.75).

On the basis of receiver operating curve characteristic analyses, the optimal cut point for MARS-A was 4.5, which correctly classified 73.6% of participants. Among patients identified by MARS-A as good adherers, 82.3% were good adherers according to the electronic monitor. Conversely, 69.4% of those identified by MARS-A as poor adherers were poor by the electronic measure. However, people were more likely to overreport adherence than underreport it. A total of 30.6% of those who MARS-A identified as good adherers turned out to be poor adherers in the monitoring substudy, whereas just 17.6% of true good adherers reported poor adherence (underreporting).

Construct Validity of MARS-A

We examined associations between MARS-A and 2 additional items to evaluate construct validity. As predicted, patients who said they use their ICS even when they were not having symptoms were much more likely to be classified as good adherers by MARS-A (OR, 61.9; 95% CI, 18.5–207.0.0; $P < .001$). Similarly, patients who correctly said their ICS was a controller medication (vs a rescue medicine) were more likely to be good adherers according to MARS-A (OR, 1.8; 95% CI, 1.01–3.2; $P = .04$), although the

Table 3. Electronic Measures of Adherence With Inhaled Corticosteroids (ICS)^a

Electronic measures of adherence with ICS	All patients given electronic monitor (n = 53)	Excluding patients who did not exclusively use electronically monitored ICS inhaler (n = 43)
Percentage of days used		
All 30 days	0.52 (0.29) [0–0.97]	0.55 (0.29) [0–0.97]
Initial 15 days	0.57 (0.31) [0–1]	0.59 (0.30) [0–1]
Final 15 days	0.47 (0.30) [0–1]	0.50 (0.30) [0–1]
Percentage of doses used	0.35 (0.24) [0–0.95]	0.38 (0.25) [0–0.95]

^a Data are presented as mean (SD) [range or adherence]. Ten patients indicated that they used an ICS inhaler for some part of the 30-day period during which the metered-dose inhaler log device was attached to the ICS canister that they started the month with.

Table 4. Associations Between Self-reported Adherence Scores and Electronic Adherence^a

Self-reported adherence	Electronic adherence			
	Percentage of days ICS used			Percentage of doses used for all 30 days
	All 30 days	First 15 days	Last 15 days	
MARS-A scores				
1 month				
All monitored patients	0.40 ^c	0.47 ^c	0.35 ^c	0.39 ^c
Subset of monitored patients ^b	0.48 ^d	0.35 ^c	0.50 ^d	0.46 ^c
3 months				
All monitored patients	0.39 ^c	0.45 ^c	0.26 ^e	0.36 ^c
Subset of monitored patients ^b	0.50 ^c	0.50 ^d	0.44 ^c	0.49 ^c

Abbreviations: ICS, inhaled corticosteroids; MARS-A, Medication Adherence Rating Scale for Asthma.

^a The *P* values show level of statistical significance for the associations between the self-reported MARS-A scores and the different definitions of electronic adherence (shown in the columns). All except for 1 comparison showed a significant correlation between the MARS-A and electronic adherence.

^b Data also show that the associations were even stronger in subgroup analyses that excluded 10 patients who reported using an ICS canister without the electronic monitor at some point during the 30-day monitoring period (n = 43).

^c *P* ≤ .01.

^d *P* ≤ .001.

^e *P* = .07.

magnitude of the association was more modest than prior “use when no symptoms” item.

DISCUSSION

This study sought to evaluate the validity of MARS-A as a tool for measuring self-reported adherence to ICS use in English and Spanish among adults with persistent asthma. Our data show that MARS-A demonstrated 3 desirable features as a survey instrument.³⁴ It had (1) good internal validity in both English and Spanish, (2) good criterion validity when compared with the gold standard of electronically measured adherence with ICS use, and (3) strong construct validity. The original publication by Horne and colleagues that proposed MARS-A for measuring inhaled medication use among asthmatic patients in England demonstrated good internal and construct validity.²⁸ This study confirms and extends the original finding by replicating the good internal and construct validity and by adding a rigorous evaluation of criterion validity (comparing self-reported to electronically confirmed adherence), the strongest indicator of validity.³⁵ This is also the first study to our knowledge that translated MARS-A into

Spanish and demonstrated good psychometric performance in both English and Spanish for patients in the United States.

Several aspects of MARS-A performed well for several reasons. First, both the phrasing of the questions and ordering of the answers seek to minimize the social desirability bias of falsely reporting good adherence. Second, there are items that ascertain 2 distinct but common drivers of suboptimal medication use: (1) intentional nonadherence (“I try to avoid using it”) and (2) unintentional nonadherence (“I forget to take it”).^{23,28,36} Third, it also contains questions that ask about symptom-driven use of ICS, which is common (“I only use it when I feel breathless”). We have previously reported that half of inner-city patients with moderate and severe asthma have the “no symptoms, no asthma” belief.³⁷ Such patients think about and manage their asthma as an acute, episodic illness that only requires medication use when they are having respiratory symptoms.

Among this inner-city population with a high burden of asthma morbidity, frequent contacts with the health care system, and access to low-cost medicine, patients still only used their ICS on slightly more than half of all days (mean,

52%–55%) and took little more than one-third of the doses prescribed (35%–38%). These rates of adherence are clearly suboptimal, although such modest rates of ICS use are similar to those reported in the overall literature on medication use, as well as previous studies of compliance with ICS among patients with persistent asthma.^{3–7} Many reasons for poor adherence with ICS use have been reported, but our previous work in US and UK populations found that suboptimal disease beliefs about the chronicity of asthma and medication beliefs about the importance of using ICS (even when asymptomatic) and worries about side effects were important factors.^{22,37,38}

The strengths of MARS-A should be viewed in the context of its limitations. Although MARS-A had good overall psychometric properties, it seemed best at characterizing relative levels of adherence. Because self-reported adherence overestimates the absolute frequency of use and/or number of doses taken, caution is warranted if strict number of days or doses used is needed (eg, drug trials). Those wanting more concrete information on the frequency of ICS use may want to supplement MARS-A with a question such as “In the past 7 days, how many days did you miss or skip your ICS for any reason?” as has been suggested by other investigators.³⁹ How well such a frequency of daily use question performs compared with the more relative frequency of use items that comprise MARS-A merits further investigation.

Although the internal validity and construct validity analyses were based on 278 participants, the criterion validity tests relied on the smaller sample of 53 patients in the electronic adherence substudy. The modest size of the electronic monitoring dataset is typical of other studies that use these devices.^{13,32,40} We also did not find any significant differences between the groups that were and were not monitored. We deliberately studied medication adherence among inner-city populations with the highest burden of asthma morbidity and mortality. The generalizability of our findings to different settings is unknown. Because the number of Spanish-speaking patients was modest, further validation work in Spanish-speaking populations is merited. There were not enough Spanish-speaking patients in the electronic adherence substudy to permit a valid evaluation of criterion validity of the translated version. Hispanic patients in this study were predominantly Puerto Rican or Dominican, so replications of language and findings in other Latino subgroups would be beneficial. Despite these limitations, the findings are consistent with previous studies supporting the utility of MARS-A as a tool for assessing self-reported adherence to ICS in asthma.^{22,23,28}

From a clinical perspective, MARS-A may be most useful in patients with severe asthma that remains poorly controlled despite an apparently robust anti-inflammatory drug regimen. In this situation, the most important (but often the most challenging) evaluation to make is whether a patient is doing poorly *despite* good adherence or *because of* unrecognized poor adherence. Use of a standard, nonjudgmental short adherence questionnaire might be more likely to uncover non-

adherence than the usual question, “Are you taking your [ICS drug name]?” question. A possible shortcut in selected situations might be asking 1 question about intentional and unintentional ICS nonadherence and 1 question about symptom-driven use (using ICS only when they feel breathless). However, future research will be needed to formally evaluate whether a shorter version of MARS-A can be developed and validated. In any event, physicians should be mindful that overreporting of adherence with ICS use is still fairly common even with a carefully designed self-report instrument. For patients who are doing poorly, using pharmacy dispensing information or family or caregiver reports may be useful adjuncts to corroborating true patterns of ICS use.

ACKNOWLEDGMENTS

We thank Jessica Lorenzo, Julian Baez, Jessica Segni, Nicky O'Connor, and Amy Carney, whose help was invaluable to this study.

REFERENCES

1. Adams N, Bestall J, Jones PW. Budesonide at different doses for chronic asthma. *Cochrane Database Syst Rev*. 2001;(4):CD003271.
2. National Asthma Education and Prevention Program. Expert panel report 3 (EPR-3): guidelines for the diagnosis and management of asthma—summary report 2007. *J Allergy Clin Immunol*. 2007;120:S94–138.
3. Rand CS, Wise RA. Measuring adherence to asthma medication regimens. *Am J Respir Crit Care Med*. 1994;149:S69–76.
4. Bender B, Milgrom H, Rand C. Nonadherence in asthmatic patients: is there a solution to the problem? *Ann Allergy Asthma Immunol*. 1997;79:177–185.
5. Diette GB, Wu AW, Skinner EA, et al. Treatment patterns among adult patients with asthma: factors associated with overuse of inhaled beta-agonists and underuse of inhaled corticosteroids. *Arch Intern Med*. 1999;159:2697–2704.
6. Legorreta AP, Christian-Herman J, O'Connor RD, et al. Compliance with national asthma management guidelines and specialty care: a health maintenance organization experience. *Arch Intern Med*. 1998;158:457–464.
7. Apter AJ, Boston RC, George M, et al. Modifiable barriers to adherence to inhaled steroids among adults with asthma: it's not just black and white. *J Allergy Clin Immunol*. 2003;111:1219–1226.
8. Grant EN, Alp H, Weiss KB. The challenge of inner-city asthma. *Curr Opin Pulm Med*. 1999;5:27–34.
9. Krishnan JA, Diette GB, Skinner EA, et al. Race and sex differences in consistency of care with national asthma guidelines in managed care organizations. *Arch Intern Med*. 2001;161:1660–1668.
10. Rand CS, Apter AJ. Mind the widening gap: have improvements in asthma care increased asthma disparities? *J Allergy Clin Immunol*. 2008;122:319–321.
11. Strunk RC, Ford JG, Taggart V. Reducing disparities in asthma care: priorities for research: National Heart, Lung, and Blood Institute workshop report. *J Allergy Clin Immunol*. 2002;109:229–237.
12. Rand CS, Wise RA, Nides M, et al. Metered-dose inhaler adherence in a clinical trial. *Am Rev Respir Dis*. 1992;146:1559–1564.
13. Berg J, Dunbar-Jacob J, Rohay JM. Compliance with inhaled medications: the relationship between diary and electronic monitor. *Ann Behav Med*. 1998;20:36–38.
14. Paterson C, Britten N. A narrative review shows the unvalidated use of self-report questionnaires for individual medication as outcome measures. *J Clin Epidemiol*. 2005;58:967–973.
15. Julius SM, Sherman JM, Hendeles L. Accuracy of three electronic monitors for metered-dose inhalers. *Chest*. 2002;121:871–876.

-
16. Osterberg L, Blaschke T. Adherence to medication. *N Engl J Med*. 2005;353:487–497.
17. Milgrom H, Bender B, Ackerson L, et al. Noncompliance and treatment failure in children with asthma. *J Allergy Clin Immunol*. 1996;98:1051–1057.
18. Nestor A, Calhoun AC, Dickson M, et al. Cross-sectional analysis of the relationship between national guideline recommended asthma drug therapy and emergency/hospital use within a managed care population. *Ann Allergy Asthma Immunol*. 1998;81:327–330.
19. Bender B, Wamboldt FS, O'Connor SL, et al. Measurement of children's asthma medication adherence by self report, mother report, canister weight, and Doser CT. *Ann Allergy Asthma Immunol*. 2000;85:416–421.
20. Rau JL. Determinants of patient adherence to an aerosol regimen. *Respir Care*. 2005;50:1346–1356.
21. Horne R, Weinman J. Patients' beliefs about prescribed medicines and their role in adherence to treatment in chronic physical illness. *J Psychosom Res*. 1999;47:555–567.
22. Horne R, Weinman J. Self-regulation and self-management in asthma: exploring the role of illness perceptions and treatment beliefs in explaining nonadherence to preventer medication. *Psychol Health*. 2002;17:17–32.
23. Menckeborg TT, Bouvy ML, Bracke M, et al. Beliefs about medicines predict refill adherence to inhaled corticosteroids. *J Psychosom Res*. 2008;64:47–54.
24. Horne R, Clatworthy J, Polmear A, et al. Do hypertensive patients' beliefs about their illness and treatment influence medication adherence and quality of life?. *J Hum Hypertens*. 2001;15 Suppl 1:S65–68.
25. Thompson K, Kulkarni J, Sergejew AA. Reliability and validity of a new Medication Adherence Rating Scale (MARS) for the psychoses. *Schizophr Res*. 2000;42:241–247.
26. Wisnivesky JP, Sampson H, Berns S, et al. Lack of association between indoor allergen sensitization and asthma morbidity in inner-city adults. *J Allergy Clin Immunol*. 2007;120:113–120.
27. Wisnivesky JP, Lorenzo J, Lyn-Cook R, et al. Barriers to adherence to asthma management guidelines among inner-city primary care providers. *Ann Allergy Asthma Immunol*. 2008;101:264–270.
28. Horne R, Hankins M. *The Medication Adherence Report Scale*. Brighton, England: Center for Health Care Research; 2002.
29. Cochrane GM, Horne R, Chaney P. Compliance in asthma. *Respir Med*. 1999;93:763–769.
30. Smith A, Krishnan JA, Bilderback A, et al. Depressive symptoms and adherence to asthma therapy after hospital discharge. *Chest*. 2006;130:1034–1038.
31. Nides MA, Tashkin DP, Simmons MS, et al. Improving inhaler adherence in a clinical trial through the use of the nebulizer chronolog. *Chest*. 1993;104:501–507.
32. Apter AJ, Reisine ST, Affleck G, et al. Adherence with twice-daily dosing of inhaled steroids. Socioeconomic and health-belief differences. *Am J Respir Crit Care Med*. 1998;157:1810–1817.
33. Williams LK, Joseph CL, Peterson EL, et al. Patients with asthma who do not fill their inhaled corticosteroids: a study of primary nonadherence. *J Allergy Clin Immunol*. 2007;120:1153–1159.
34. Streiner DL, Norman GR. *Health Measurement Scales: A Practical Guide to Their Development and Use*. Oxford, England: Oxford University Press; 1995.
35. Apter AJ, Tor M, Feldman HI. Testing the reliability of old and new features of a new electronic monitor for metered dose inhalers. *Ann Allergy Asthma Immunol*. 2001;86:421–424.
36. Clifford S, Barber N, Horne R. Understanding different beliefs held by adherers, unintentional nonadherers, and intentional nonadherers: application of the Necessity-Concerns Framework. *J Psychosom Res*. 2008;64:41–46.
37. Halm EA, Mora P, Leventhal H. No symptoms, no asthma: the acute episodic disease belief is associated with poor self-management among inner-city adults with persistent asthma. *Chest*. 2006;129:573–580.
38. Ponieman D, Wisnivesky JP, Leventhal H, et al. Impact of positive and negative medication beliefs on adherence with inhaled steroids in inner-city asthmatics. *Ann Allergy Asthma Immunol*. In press.
39. Haynes RB, McDonald HP, Garg AX. Helping patients follow prescribed treatment: clinical applications. *JAMA*. 2002;288:2880–2883.
40. Hamid S, Kumaradevan J, Cochrane GM. Single centre open study to compare patient recording of PRN salbutamol use on a daily diary card with actual use as recorded by the MDI compliance monitor. *Respir Med*. 1998;92:1188–1190.
- Requests for reprints should be addressed to:
Ethan A. Halm, MD, MPH
Division of General Internal Medicine
University of Texas Southwestern Medical Center
5323 Harry Hines Blvd
Dallas, TX 75390-8889
E-mail: Ethan.Halm@UTsouthwestern.edu
-