

The impact of expired and empty quick-relief asthma inhalers: The Asthma and Allergy Foundation of America's Asthma Inhaler Design Survey

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ABSTRACT

Background: Despite the available treatments, asthma remains a serious illness, with a considerable socioeconomic burden associated with a high number of unscheduled visits to the emergency department (ED). Poor adherence and inadequate inhaler technique are contributing factors to poor asthma management and control.

Objective: The Asthma Inhaler Design Survey assessed the behaviors, attitudes, needs, and preferences of patients with asthma and their caregivers with regard to quick-relief inhaler usage and device design.

Methods: The Asthma and Allergy Foundation of America invited 19,157 adult patients and parents of children with asthma to take part in an online survey that focused on previous asthma diagnosis, symptom severity, and quick-relief and controller medication use. Opinions were also collected.

Results: Data from 590 respondents (366 adults; 224 children) were included in the final analysis. Relief inhalers were needed and found to be past the expiration date by 284 of 561 (50.6%) and relief inhalers were found to be empty by 270 of 560 (48.2%). Of the empty inhaler group, 28 of 270 (10.4%) had to visit the ED for treatment, 18 of 270 (6.7%) missed work or school for an unscheduled physician office visit, and 54 of 270 (20%) went without treatment. Although 78.5% indicated that they had at least two quick-relief inhalers nearby, these were not always easily accessible. Few respondents (194/578 [33.6%]) indicated that they and/or their child were very confident that they were using their inhaler properly, even though the majority had received some instruction. When asked what they would do to improve satisfaction with their quick-relief inhalers, 173 of 558 (31%) responded that they would add a dose counter.

Conclusion: Unnecessary health care utilization and avoidable loss of time at work or school were associated with the lack of full availability of properly functioning quick-relief inhalers when needed. Adding a dose counter was the most frequently cited response for improving satisfaction with quick-relief inhalers. Confidence about proper inhaler use was low, despite previous instruction.

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Asthma is a serious public health concern with a high socioeconomic burden. Approximately 39.5 million people in the United States have been diagnosed with asthma during their lifetime, and 25.7 million (7 million children and 18.7 million adults) of

those presently suffer from symptoms.^{1,2} In 2007, it was estimated that the cost of asthma totaled \$56 billion.³ This cost is largely due to unscheduled visits to physicians, emergency departments (EDs), or urgent care facilities, which are often the result of poor asthma management and control. In the United States, the frequency of ED visits for asthma among children and adults ages 5–64 years rose from 59.6 per 10,000 in 2001 to 61.8 per 10,000 in 2010.⁴ A key component of the asthma management national guidelines is a recommendation to reduce ED visits for acute asthma treatment.

An array of medication inhalers are available for patients and health care professionals (HCPs) to deliver quick-relief medication (typically short-acting β -2 agonists [SABA]; also recognized as the most effective medication for treating acute asthma symptoms and for preventing exercise-induced bronchoconstriction) and long-term control medication (such as inhaled corticosteroids).⁵ Patient adherence to therapy, although crucial for asthma management, remains poor, with reported rates of nonadherence that range from 30% to

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70%.^{6–9} Nonadherence is multifactorial, and difficulties with inhaler devices are among the important contributing factors.^{8,10,11}

Quick-relief medications are generally self-administered with metered-dose inhalers (MDIs).¹² Many of the currently available MDIs lack an integrated dose counter to track the number of doses that remain in a device. Although MDIs are designed to deliver a set number of effective medication doses, they will continue to actuate after the maximum number of doses has been reached.¹³ As such, MDIs are prone to deliver more propellants and excipients with less or no active medication, which could lead to nonadherence.¹⁴ For these reasons, the U.S. Food and Drug Administration has recommended inclusion of an integrated dose counter in MDIs.¹⁵ Manufacturers have responded to the U.S. Food and Drug Administration guidance by increasing deployment of dose counters in the United States, so that ~89% of total prescriptions for quick-relief inhalers in 2014 contained integrated dose counters.¹⁶ The proportion of quick-relief inhalers that contain integrated dose counters in the rest of the world, however, is far less (*e.g.*, ~5% in Canada and 4% in the United Kingdom).¹⁶ Furthermore, in the United States, the proportion of quick-relief inhalers that contain integrated dose counters could drop precipitously in the future if generic quick-relief inhalers that do not contain integrated dose counters become the standard.

The Asthma Inhaler Design (ID) Survey was conducted by the Asthma and Allergy Foundation of America (AAFA), partly to assess if patients with asthma and their caregivers are confident in the training that they received and if this training instilled confidence in using their inhalers. The Asthma ID Survey also inquired into their attitudes, needs, and preferences in regard to quick-relief inhaler usage and the impact of dissatisfaction and nonadherence.

METHODS

Invitations to complete the Asthma ID Survey were sent to the opt-in e-mail contacts from AAFA's database of patients and caregivers. The survey (from December 7, 2012, to January 13, 2013),¹⁷ included 29 multiple-choice and open-ended questions. The individuals who took part in the survey remained anonymous. The participants were not compensated for completing the survey. The questionnaire was designed to ensure that the fully screened survey population consisted of adult patients or of caregivers of pediatric patients with asthma who were currently using a quick-relief inhaler that contained albuterol or levalbuterol (questions 1–3) (Table 1). If the eligible respondent indicated that both the respondent and his or her child (age 4–17 years) had been diagnosed with asthma, exercise-induced asthma, or exercise-induced broncho-

constriction by a HCP, they were asked to respond about their child for the remainder of the survey and to only consider the one child who had the most recent birthday if more than one child met the eligibility criteria.

Per Office for Human Research Protections approved assurance, created under 45 Code of Federal Regulations 46.103,¹⁸ the protocol for the Asthma ID Survey was exempt from informed written consent because:

1. The research presented no more than minimal risk of harm to the subjects
2. The exemption did not adversely affect the rights and welfare of the subjects
3. The research could not practicably be carried out without the exemption
4. Whenever appropriate, the subjects were provided with additional pertinent information after participation.¹⁸

The data were collected in an anonymized manner; therefore, any disclosure of the subject's response outside the research could not place the subject at risk for criminal, civil, financial, employment, or reputational liability.

Factors assessed in the survey included questions about diagnosis, severity, quick-relief and controller medication use, opinions about spacers, cost, dose counters, problems with inhalers, and overall inhaler design. Not all of the fully screened respondents chose to answer every question.

RESULTS

Demographics and Asthma Control

Of the 19,157 invitations sent, 878 surveys were initiated, and a total 590 eligible respondents were identified (survey response rate, 3.1%) (Table 1). Of these respondents, 366 (62.0%) were adult self-respondents and 224 (37.9%) were parent or guardian respondents. Respondents' demographics are shown in Table 2. Eighty-six percent were female, 45.7% indicated that they had a household income >\$50,000, 75.8% had been diagnosed with asthma more than 5 years ago, 74.7% were currently taking inhaled asthma controller medication, and 33.4% indicated that they used their quick-relief inhaler at least three times a week. The majority of respondents considered their asthma to be well controlled.

Overall, 45.9% considered their own or their child's asthma to be "moderate" (Fig. 1). Twenty-six percent of adults were more likely to label their own asthma as "severe," whereas 37.9% of parents or guardians were more likely to label their child's asthma as "mild." The majority of respondents also considered their asthma to be well controlled: 74.7% of the respondents were currently taking inhaled asthma controller medication, and

Table 1 Screening process for survey respondents

	No. Respondents
Invitations sent <i>via</i> AAFA asthma opt-in e-mails	19,157
Initial respondents to invitation	878
Screener 1, Q1: "Have you or your child ever been diagnosed, by a HCP, with asthma, exercise-induced asthma, or exercise-induced bronchospasm?"	
Self (I have been diagnosed)	466
Parents	285
My child has been diagnosed	165
Both my child/children and I have been diagnosed	120
Screener 2, Q6: "Do you currently use a quick-relief inhaler to treat your asthma symptoms?" (<i>values are for those who answered "yes"</i>)	
Adults	411
Children	237
Screener 3, Q7: "Which of the following quick-relief asthma inhaler brands, if any, do you/your child currently use?"	
Adults#	366
Children#	224
Brands reported used	
ProAir (Teva Respiratory, LLC, Frazer, PA)	214
Proventil (Merck Sharp & Dohme Corp, San Diego, CA)	95
Ventolin (GlaxoSmithKline, Brentford, UK)	190
Xopenex (Sunovion Pharmaceuticals, Marlborough, MA)	84
Other	58
Don't know	7
Fully screened respondents	590

AAFA = Asthma and Allergy Foundation of America; Q = question; HCP = health care professional.

*Feedback from patients who responded "no" was terminated.

#No. respondents who answered and parents who confirmed use of and/or familiarity with ProAir, Proventil, Ventolin, Xopenex, or responded "don't know" (those who declined to answer the question or who named a medication other than ProAir, Proventil, Ventolin, or Xopenex were not included in the fully screened respondents group).

33.4% indicated that they used their quick-relief inhaler at least three times a week (Table 2).

Inhaler Usage

Of the 580 fully screened respondents, 50.7% were given a spacer when first prescribed a quick-relief inhaler, of which 54.4% used them "most of the time" to "always." Although the majority of respondents (82.8%) indicated that they received instructions on the proper use of their own quick-relief inhaler, only 33.6% indicated they were "very confident" in their own or their child's inhaler technique without a spacer (Table 2).

The majority of respondents (78%) indicated that they were in possession of at least two inhalers, and 38.8% had three or more inhalers. The distinguishing factors among the quick inhalers consisted of color (76.1%); shape (51.1%); oversize or too big (34.8%); and location (27.0%), which included purses or handbags (66.8%), the medicine cabinet (36.2%), pockets (22.6%), backpacks (22.1%), cars (16.8%), and gym bags (13.4%) (multiple selections were allowed). Inhalers were less

frequently (<5%) stored in a briefcase, bedside nightstand, the kitchen, or school or office or home desk. Of the 561 respondents who answered the question "Have you ever gone to use your quick-relief inhaler and found that it was past its expiration date?", 50.6% answered "yes," 44.9% answered "no," and 4.5% answered "I don't know/do not recall" (Fig. 2 A).

Adherence and Inhaler Satisfaction

Nearly half of the respondents (48.2% [$n = 560$]) indicated that they had found their quick-relief inhalers to be empty when needed (Fig. 2 B), of whom, 20.0% had to go without treatment, 10.4% had to visit the ED to receive treatment, and 6.7% missed school or work to make an unscheduled visit to their physician (Fig. 2 C). Of note, 83.0% of those finding their inhaler empty had been diagnosed with asthma >5 years ago, 86.4% had received instruction on using their quick-relief inhaler, and 43.7% indicated they used their quick-relief inhaler more than three times per week. The most common response to the open-ended ques-

Table 2 Demographics of the AAFA Asthma ID Survey

Characteristic	Response, % (no.)*
Sex (n = 558)#	
Female	86.0 (480)
Male	12.5 (70)
Age (n = 558)*	
18–24 y	3.0 (17)
25–34 y	16.5 (92)
35–44 y	30.5 (170)
45–54 y	27.2 (152)
≥55 y	19.7 (110)
Household income (n = 557)	
<\$25,000	14.5 (81)
\$25,000–49,999	18.7 (104)
\$50,000–74,999	15.1 (84)
\$75,000–99,999	12.6 (70)
≥\$100,000	18.0 (100)
Frequency of quick-relief inhaler use (n = 587)	
<1/wk	43.3 (254)
1–2/wk	23.3 (137)
3–5/wk	17.7 (104)
>5/wk	15.7 (92)
Time since diagnosis (n = 590)	
<1 y	3.9 (23)
<5 y	20.3 (120)
>5 y	75.8 (447)
Received instruction on how to use quick-relief inhaler (n = 584)	
Yes, prescriber	57.4 (335)
Yes, someone in prescriber's office	18.7 (109)
Yes, pharmacist	6.8 (40)
No instruction	17.1 (100)

AAFA = Asthma and Allergy Foundation of America.

*When percentages do not add to 100%, respondents selected “prefer not to answer” but did not skip the question.

#Age and sex of adult respondent or of parent or guardian.

tion “What changes would you make to your inhaler?” was “include a dose counter” (Table 3).

DISCUSSION

The results of the Asthma ID Survey showed that properly functioning quick-relief inhalers were available only approximately half the time when needed, which resulted in lost time at work or school and in an increase in health care utilization. Approximately one-third of respondents in the Asthma ID Survey indicated that satis-

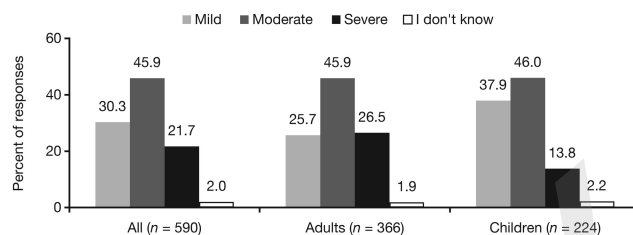


Figure 1. Responses to the question “In your own opinion, do you consider your/your child’s asthma to be mild, moderate, or severe? Please check one.” (Percentages do not add to 100% due to rounding).

faction with their quick-relief inhalers would be improved by the addition of a dose counter. Even though the majority of respondents indicated that they or their child had “moderate” or “severe” asthma and had received some instruction (from their prescriber, an office staff member, or a pharmacist), a minority expressed confidence in their inhaler technique.

In the United States, during the time of the study, only ~36% of SABA prescriptions were written for a device with an integrated dose counter.¹⁶ When assuming that our respondents represent the general cohort of patients with asthma in the United States at the time this survey was conducted, the survey likely addresses a cohort in which a minority used a SABA with an integrated dose counter. Therefore, the results of the Asthma ID Survey indicate that proper counting of SABA are desired by patients and might prevent avoidable loss of time at work or school and unnecessary health care utilization. These findings are also supported by the findings of other studies that indicate that the lack of a dose counter can have psychological consequences.¹⁹ In an open-label study at 37 outpatient centers (n = 268), 62% of the patients reported anxiety about not knowing the quantity of medication that remained in their inhaler.²⁰

The benefits of adding a dose counter have been assessed in the clinical setting in a prospective, open-label study of albuterol sulfate hydrofluoroalkane MDI with a new integrated dose counter (n = 235, per protocol population). Results from this study indicated that >95% of patients reported that it was “easy” to “somewhat easy” to ascertain how many doses remained in the albuterol sulfate hydrofluoroalkane MDI with a dose counter.¹⁹ In contrast, >50% patients indicated that they were “not very certain” or “not certain at all” of the amount of medication left in their current inhaler.¹⁹ Results from this study are in agreement with the finding of the AAFA Asthma ID Survey, which highlights the advantages of adding an integrated dose counter to an MDI.

Demographics of the respondents were a reflection of AAFA’s constituent database, which consists of donors, subscribers, and volunteers. We expected respondents to be more likely than the average patient to have seen an allergist or to be more knowledgeable about asthma (a potential source of bias). Parents and guardians who

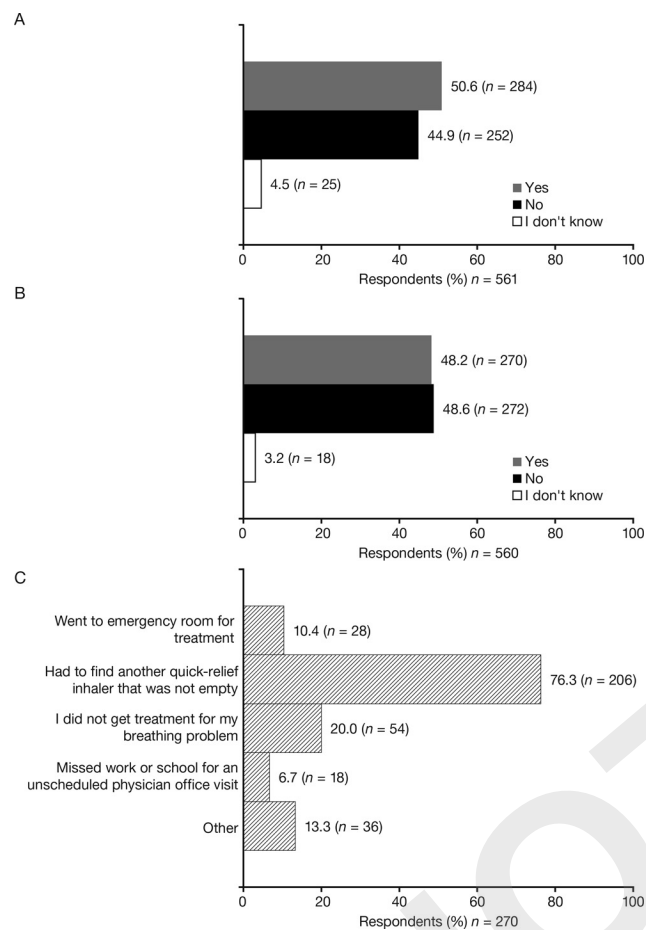


Figure 2. Response to the following questions. (A) "Have you ever gone to use your quick-relief inhaler and found that it was past its expiration date?" (B) "Have you ever gone to use your quick-relief inhaler and found that it was empty?" (C) "If yes (in answer to question in part B"), which of the following occurred as a result of finding your quick-relief inhaler empty?" Please check all that apply".

responded to the survey provided their own age and sex rather than that of their child. This may explain the preponderance of female respondents. In addition, data in this report were not weighted to the general U.S. population. Despite these limitations, this study provided valuable insights that may be applied to the average patient, such as opportunities for the family HCP to improve asthma management and control by extending education for the patient with asthma beyond the basics.

The National Heart, Lung, and Blood Institute, National Asthma Education and Prevention Program Expert Panels recommend that, for patients with intermittent or persistent asthma, quick-relief medication must be available and should be taken as needed to relieve symptoms.⁵ Although respondents of this survey indicated that they have at least one quick-relief inhaler on hand, almost half of the respondents indicated that their inhalers contained expired medication or were empty when needed. These findings are similar to those reported in the telephone

Table 3. Responses to the open-ended question "What changes would you make to your inhaler to improve its functionality?"

Verbatim Responses (n = 558)	Responses, %
Dose counter or meter	31
Built-in spacer	10
More secure mouthpiece	3
Stronger propellant or plume	3
Anticlogging	2
Cover or case or lock to prevent accidental discharge	2
Voice notice or alarm alerting approaching expiration or final doses	1
Improve taste	1
Larger labeling (including expiration date)	1
Bigger canister/smaller canister	1
Larger mouthpiece/smaller mouthpiece	1

survey in which 25% of patients with asthma reported that they had found their MDI empty during an asthma exacerbation.²¹ As such, few patients keep any record of their quick-relief inhaler use and are unaware of the maximum number of actuations recommended for their particular inhaler.²¹ It is estimated that up to 40% of patients believe they are taking their asthma medication when they are actually activating an empty or nearly empty MDI.¹⁴

The inability to access quick-relief medication for any reason can have serious medical and socioeconomic repercussions.^{21–24} It has long been acknowledged that up to three-fourths of the total costs associated with asthma may be mainly due to unplanned visits to the ED.²² The Centers for Disease Control and Prevention's National Asthma Control Program Grantees reported that 22.2% of children and 13.8% of adults with asthma had visited the ED at least once a year in response to an exacerbation (nearly 2 million total visits per year).^{23,24} They also reported that 39.8% of children and 24.1% of adults with asthma had visited urgent care facilities at least once a year. A recent analysis of multicenter data from ED interviews conducted with 1095 patients with acute asthma revealed that 30% admitted to running out of their medication within 1 week of their ED visit.²⁵ The family HCP may potentially lessen the consequences of severe asthma exacerbations, and ultimately reduce the number of ED and urgent care visits, by discussing the immediate availability and access to quick-relief medication with patients with asthma or with their parents. This discussion includes

awareness of medication expiration dates and medication status (*i.e.*, empty inhalers), and the use of an MDI with an integrated dose counter, whilst also providing clear instructions on inhaler technique. Inhaler technique that is quickly and confidently adopted by the patient may contribute to improved adherence.

The data presented in this report support the findings of other surveys and studies that indicate the importance of an integrated dose counter in an MDI.^{19–21} In addition to improved patient satisfaction, an inhaler with an integrated mechanical dose counter may also improve adherence and clinical outcomes and, ultimately, reduce costs.²⁶ Going forward, this study may also have applicability to quick-relief inhaler manufacturing and utilization worldwide. Although the benefits of quick-relief inhalers that contain integrated dose counters have largely been recognized recently in the United States, where ~89% of the total prescriptions for quick-relief inhalers in 2014 contained integrated dose counters, other countries lag in the deployment of integrated dose counters.¹⁶ The proportion of quick-relief inhalers that contain integrated dose counters in the rest of the world remains low (*e.g.*, ~5% in Canada and 4% in the United Kingdom).¹⁶ In the U.S. marketplace of the near future, the proportion of quick-relief inhalers that contain integrated dose counters could drop precipitously (perhaps to as low as the rest of the world) if generic quick-relief inhalers do not contain integrated dose counters, which promise to be less expensive, are approved and widely used.

Reducing the number of visits to the ED and urgent care facilities and time lost from school or work will ultimately contribute to decreasing the socioeconomic burden of asthma in the United States. The AAFA Asthma ID Survey highlighted the importance of these issues for the family HCP, as identified by patients and caregivers themselves.

REFERENCES

- Moorman JE, Akinbami LJ, Bailey CM, et al. National Surveillance of Asthma: United States, 2001–2010. National Center for Health Statistics. Vital Health Stat 3 Nov:1–67, 2012.
- Centers for Disease Control and Prevention. National Health Interview Survey (NHIS) data: 2011 lifetime and current asthma. Atlanta, GA: US Department of Health and Human Services, CDC: 2012. Available online at www.cdc.gov/asthma/nhis/2011/data.htm; accessed March 28, 2014.
- Barnett SB, and Nurmagambetov TA. Costs of asthma in the United States: 2002–2007. J Allergy Clin Immunol 127:145–152, 2011.
- U.S. Department of Health and Human Services. Office of Disease Prevention and Health Promotion. Healthy People 2020. Washington, DC. Available online at www.healthypeople.gov/2020/topicsobjectives2020/objectiveslist.aspx?topicId=36; accessed April 9, 2014.
- National Asthma Education and Prevention Program. Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma. National Heart, Lung and Blood Institute, National Institutes of Health: U.S. Department of Health and Human Services, 2007 Aug 28. NIH Publication No. 07-4051. Available online at <http://www.nhlbi.nih.gov/files/docs/guidelines/asthgdln.pdf>; accessed April 9, 2014.
- Martinez FD, and Vercelli D. Asthma. Lancet 382:1360–1372, 2013.
- Global Strategy for Asthma Management and Prevention, Global Initiative for Asthma (GINA) 2012. Available online at www.ginasthma.org/; accessed March 25, 2014.
- Bender BG, and Bender SE. Patient-identified barriers to asthma treatment adherence: Responses to interviews, focus groups, and questionnaires. Immunol Allergy Clin North Am 25:107–130, 2005.
- Rand CS, and Wise RA. Measuring adherence to asthma medication regimens. Am J Respir Crit Care Med 149:S69–S76; discussion S77–S78, 1994.
- Giraud V, and Roche N. Misuse of corticosteroid metered-dose inhaler is associated with decreased asthma stability. Eur Respir J 19:246–251, 2002.
- Blaiss MS. Part II: Inhaler technique and adherence to therapy. Curr Med Res Opin 23(suppl. 3):S13–S20, 2007.
- Kim H, and Mazza J. Asthma. Allergy Asthma Clin Immunol 7(suppl. 1):S2, 2011.
- Rubin BK, and Durotoye L. How do patients determine that their metered-dose inhaler is empty? Chest 126:1134–1137, 2004.
- Conner JB, and Buck PO. Improving asthma management: The case for mandatory inclusion of dose counters on all rescue bronchodilators. J Asthma 50:658–663, 2013.
- U.S. Department of Health and Human Services. Guidance for Industry. Integration of Dose-Counting Mechanisms into MDI Drug Products. Available online at www.fda.gov/downloads/Drugs/GuidanceComplianceRegulatoryInformation/Guidances/ucm071731.pdf; accessed March 29, 2014.
- IMS Health. National Prescription Audit™ 2014. Data for all diagnoses. Share of short-acting beta2 agonist (SABA) market. Available online at <http://www.imshealth.com>; accessed April 1, 2014.
- SurveyMonkey. Available at <https://www.surveymonkey.com/>; accessed January 20, 2014.
- U.S. Department of Health and Human Services. Code of Federal Regulations. Protection of Human Subjects. Available online at <http://www.hhs.gov/ohrp/humansubjects/guidance/45cfr46.html>; accessed February 24, 2015.
- Given J, Taveras H, Iverson H, and Lepore M. Prospective, open-label assessment of albuterol sulfate hydrofluoroalkane metered-dose inhaler with new integrated dose counter. Allergy Asthma Proc 34:42–51, 2013.
- Sander N, Fusco-Walkert SJ, Harder JM, and Chipps BE. Dose counting and the use of pressurized metered-dose inhalers: Running on empty. Ann Allergy Asthma Immunol 97:34–38, 2006.
- Ogren RA, Baldwin JL, and Simon RA. How patients determine when to replace their metered-dose inhalers. Ann Allergy Asthma Immunol 75:485–489, 1995.
- Barnes PJ, Jonsson B, and Klim JB. The costs of asthma. Eur Respir J 9:636–642, 1996.
- Centers for Disease Control and Prevention. Asthma Facts—CDC's National Asthma Control Program Grantees. Atlanta, GA: U.S. Department of Health and Human Services, 2013.
- National Hospital Ambulatory Medical Care Survey: 2010 Emergency Department Summary Tables. Available online at http://www.cdc.gov/nchs/data/ahcd/nhamcs_emergency/2010_ed_web_tables.pdf; accessed April 1, 2014.
- Hasegawa K1, Brenner BE, Clark S, Camargo, CA. Emergency department visits for acute asthma by adults who ran out of their inhaled medications. Allergy Asthma Proc 35:42–50, 2014.
- Makela MJ, Backer V, Hedegaard M, and Larsson K. Adherence to inhaled therapies, health outcomes and costs in patients with asthma and COPD. Respir Med 107:1481–1490, 2013. □

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