

REVIEW

What Do We Know about Asthma Triggers? A Review of the Literature

MARGARET K. VERNON, PH.D.,^{1,*} INGELA WIKLUND, PH.D.,¹ JILL A. BELL, PH.D.,² PETER DALE, M.SC.,³ AND KENNETH R. CHAPMAN, M.D.⁴

¹United BioSource Corporation, London, UK.

²Oxford Outcomes, Bethesda, MD, USA.

³Global Health Outcomes, GlaxoSmithKline, Stockley Park, UK.

⁴Division of Respiriology, Department of Medicine, University of Toronto, Toronto, ON, Canada.

Objective. For patients with asthma, exacerbations and poor control can result from exposure to environmental triggers, such as allergens and air particulates. This study reviewed the international literature to determine whether a global checklist of common asthma triggers might be feasible for use as a research or management tool in clinical practice. **Methods.** Literature published from 2002 to 2012 was identified through PubMed and EMBASE using the following search terms: asthma, asthma triggers, prevalence, among others. A total of 1046 abstracts were found; 85 articles were reviewed covering six continents (number of articles): Africa (1), Asia (22), Australia (1), Europe (27), North America (22), and South America (4). **Results.** The literature consistently pointed to asthma triggers as one contributor to poor asthma control. Frequently cited triggers were similar across countries/regions and included allergens (particularly pollens, molds, dust, and pet dander), tobacco smoke, exercise, air pollutants/particulates, weather patterns/changes, and respiratory infections. Definitions of asthma triggers, how triggers are taken into account in definitions of asthma control, and scientific inquiry into optimal management techniques for triggers were inconsistent and sparse. **Conclusions.** Given the apparent importance of triggers in attaining and maintaining asthma control, empirical research concerning optimal trigger management is needed. Results demonstrate that asthma triggers are similar across continents, suggesting a global checklist of triggers for use in research and clinical practice would be feasible.

Keywords control, exacerbate, exacerbations, international perspective, review

INTRODUCTION

Around the globe, it is estimated that as many as 300 million people of all ages, races, and ethnicities suffer from asthma and that asthma is becoming more common in children and adults; rising prevalence is often linked with increasing urbanization (1). It is estimated that asthma accounts for 250,000 deaths each year worldwide, most of which are preventable (2).

In the United States, asthma prevalence rates have been estimated to be 8.2% (24.6 million persons) with slightly higher prevalence rates among children compared to adults and females compared to males (3). The prevalence of asthma is increasing in the United States; the symptoms of asthma lead to 10.6 million doctor visits and 444,000 hospitalizations annually. According to the Centers for Disease Control and Prevention, 16.4 million adults (7.3%) and seven million children (9.4%) in the United States suffer from asthma, and asthma accounts for nearly 4000 deaths annually (3).

International consensus recommendations and guidelines for the treatment of asthma have identified that the primary goal of asthma management is to optimize asthma control (4). In an effort to improve asthma management, the Global Initiative for Asthma (GINA) guidelines (2) recommend evaluating control through the assessment of daytime symptoms, activity limitation,

night-time awakenings and symptoms, the need for rescue treatment, lung function, and exacerbations. Similarly, the joint American Thoracic Society/European Respiratory Society (ATS/ERS) task force report determines level of control based on existing symptoms and the extent to which the patient can carry out activities of daily living and achieve optimal quality of life, while taking into account risk of future adverse events including loss of control, exacerbations, accelerated decline in lung function, and side-effects of treatment (4). Despite slight differences in definitions within asthma control guidelines, the main goals of asthma treatment are the achievement of good asthma control and the reduction of future risk of exacerbations to the patient, with low cost and minimum adverse events (2, 4–6).

While a number of factors likely contribute to asthma control or lack of asthma control, the focus of this article is on the role of asthma triggers, which may be defined as a substance or event that leads to an acute onset or worsening of asthma symptoms lasting several hours or days (7, 8). Some triggers have been found to contribute to severe asthma exacerbations and the need for intensive care unit (ICU) admissions (9).

Typically, clinicians, authoritative bodies, and patient education programs assist patients with identifying triggers of asthma and provide suggestions for ways of reducing exposure to triggers as part of asthma control management (10, 11). In a large retrospective cohort study, results showed that triggers were discussed in 85% of patient clinic visits, and advice regarding trigger

*Corresponding author: Margaret K. Vernon, Ph.D., United BioSource Corporation, 5th Floor, 26-28 Hammersmith Grove, London W6 7HA; Tel: +44 (0) 20 8834 9577; E-mail: margaret.vernon@unitedbiosource.com

management was given in 30% of visits (12). A recent focus group study in the United States explored patients' perceptions of triggers and behaviors undertaken to manage triggers in the real world. Results demonstrated that patients with asthma identify a wide array of frequent asthma triggers in their environments, including indoor/outdoor allergens, environmental pollutants/irritants, strong odors, foods, weather, exercise, sinusitis/respiratory infections, stress, medications, and strong emotions that are perceived to contribute to the frequency and severity of asthma symptoms (13). This study also found that patients make temporary or permanent lifestyle changes to maintain control in the presence of triggers. Given the focus on trigger education and avoidance as a way of optimizing asthma control for asthma patients, and patients' perceptions of high trigger burden and lifestyle modifications made to avoid such triggers in their daily lives, the objective of this literature review was to gather empirical evidence regarding trigger management in order to inform evidence-based practice and scientific inquiry into optimal ways for managing triggers using information, educational programs, drug therapy, or a combination of the above. Based on preliminary searches of the asthma trigger literature, it was found that the adult and pediatric literature are separate, and more definitive empirical studies have been published regarding trigger management for pediatric patients. This review focuses on evidence concerning trigger avoidance for adult asthma patients.

The specific objectives of literature review were to (1) review guidelines and educational materials in order to present current thinking on definitions of triggers and best practices on current methods for clinical management of triggers; (2) gather information on international types of asthma triggers and raise awareness of common triggers patients are encountering in their lives; and (3) gather empirical evidence for guidelines on recommended trigger management practices from the medical and scientific literature. These study objectives were undertaken for the purpose of gaining a better understanding of the role of triggers in asthma control in order to improve trigger management in clinical practice and to identify areas for further research.

METHODS

In order to achieve the objectives of this literature review, two search strategies were employed. The first search strategy was undertaken to identify asthma trigger definitions, management guidelines, empirical evidence for such guidelines, and how triggers are taken into account in asthma control definitions and standardized measures. This first search strategy involved three search methods. First, medical literature databases (PubMed and EMBASE) were searched for published guidelines on asthma. The search was limited to articles published in the past 10 years (2002–2012), articles published in English, and articles involving adult asthma patients. Search terms included "asthma" and "practice guideline"

or "guideline." Two-hundred and thirty-one abstracts were yielded from the asthma guideline search. Upon review of the abstracts, it was determined that many of the articles were not truly published guidelines for asthma management or practice but rather articles that referenced asthma guidelines somewhere in their title or abstract. Thus, abstracts were reviewed, and only seminal guideline articles were retrieved and retained for full review. In addition to searches conducted in the literature databases, professional organization and society websites (e.g., American Thoracic Society, European Respiratory Society, American Colleges of Asthma Allergy and Immunology [ACAAI], American Academy of Asthma Allergy and Immunology [AAAAI]), and Centers for Disease Control (CDC) were also searched for relevant guidelines on asthma control and trigger definitions and management guidelines. Further, targeted Google Scholar searches were conducted using terms such as "asthma trigger definition," "asthma trigger management," and "asthma trigger education" to fill in any gaps in information regarding trigger definitions or guidelines for management.

Seminal guidelines identified and included in the review consisted of eight articles and reports: GINA Guidelines (2); ATS/ERS Guidelines (4, 6); National Heart Lung and Blood Institute: Expert Panel Report 3 (EPR-3): Guidelines for Diagnosis and Management of Asthma (14); Canadian Adult Asthma Consensus Guideline Update 2003 (15); a review article of asthma control assessment tools (16); the CDC Community Guide—Asthma Control (17); and materials provided to asthma educators, including the Certified Asthma Educators Handbook (18).

The second search strategy was conducted to identify international types of triggers and involved medical literature database searches (PubMed and EMBASE) for published studies including information on asthma triggers, international incidence or prevalence of such triggers, and/or ways in which patients manage or cope with triggers they encounter in their environments.¹ A sequential search methodology was employed where the first search included key terms designed to identify international types, incidence, and prevalence of asthma triggers, yielding 1046 abstracts; the second search included key terms designed to identify trigger management strategies, yielding 111 abstracts;² and the third search included a combined search of the first two searches to remove any duplicates yielded from searches 1 and 2, yielding 906 abstracts for review. The search was limited to articles published in the past 10 years (2002–2012), articles published in English, and articles involving adult asthma patients. Abstracts were screened to identify papers based on the predetermined inclusion criteria (e.g., English, 2002–2012, adult asthma patients). Letters or comments were excluded. Case studies or extremely small populations were excluded. When multiple abstracts by the same researchers and about similar triggers and regions were identified, one or two representative papers were chosen for full review. Based on these selection criteria, a total of 85 articles were selected for full text review.

RESULTS

Definitions of Asthma Triggers

In order to provide a framework for this manuscript, both the asthma guidelines identified and articles included in this review were reviewed for standard definitions of "asthma triggers."

The medical literature database searches including "asthma trigger" as a search term yielded hundreds of abstracts (see Methods section), authoritative bodies (e.g., AAAAI and ACAAI) provide guidance on how to best manage asthma triggers (10, 19), and educational materials for Certified Asthma Educators (18) include training on common triggers that provoke asthma and how to educate asthma patients about maintenance of control in the presence of triggers. However, in review of all of these materials, no standardized medical definitions of an asthma trigger were found in the literature, guidelines, or educational materials. The most concrete, albeit simplistic, definition of asthma trigger found was from the Concise Dictionary of Modern Medicine, which defined asthma trigger as, "a factor that may exacerbate asthma; a stimulus that causes an increase in asthma symptoms and/or airflow limitation" (20). GINA Guidelines suggest that triggers are typically environmental factors which put an individual at risk for transient (acute) worsening of asthma symptoms (2). Based on these definitions, and the ways in which the term trigger was used, as well as examples of asthma triggers provided in the literature, guidelines, and educational materials reviewed, "asthma trigger" appears to be a term that refers to a stimulus that may exacerbate symptoms of asthma. However, trigger appears not to be a term used to refer to something that may cause or contribute to the development of asthma. Indeed, the ACAAI (19) discusses asthma triggers as stimuli that do not bother most individuals but may make asthma symptoms worse among people already diagnosed with asthma.

Alternatively, guidelines and articles reviewed in the literature often focused on "risk factors," generally referring to factors that contribute to the risk of developing asthma rather than something that might exacerbate symptoms of asthma (2). Unlike triggers which exacerbate symptoms, risk factors are thought to increase the chances of developing asthma, and risk involves a complex interplay between both genetic and environmental factors. In general, risk factors for developing asthma identified in this review included allergies, obesity, socioeconomic status, urbanization, exposure to first- or second-hand smoke, genetics, gender, and age (21–25). Despite differing clinical definitions of triggers and risk factors, some overlap was identified in factors considered to be a risk factor versus a trigger. For example, smoking may put individuals at higher risk for developing asthma (21, 24, 25), and first- or second-hand smoke may also trigger acute worsening of asthma symptoms (24, 26–31). For purposes of this review, we focused on triggers of asthma symptoms, which we operationalized as factors that contribute to worsening of asthma symptoms among patients with a known diagnosis of asthma.

International Asthma Trigger Review

A main objective of this literature review was to review types of triggers as described internationally and to identify any regional similarities or differences in the types of triggers that may exacerbate asthma symptoms around the world. Articles reviewed covered six continents (number of articles): Africa (1), Asia (22), Australia (1), Europe (27), North America (22), and South America (4). Further, three articles reviewed were multi-regional, publishing information about triggers in more than one region listed above.

In review of these articles, triggers described by adult asthma patients were typically allergic or non-allergic; common allergic triggers include pollens, molds, pet dander, dust, or food allergens. Non-allergic triggers include air pollution or irritants, respiratory infections, exercise, strong odors, certain medications, exposure to cold air, or emotional factors (10). Table 1 summarizes the types of triggers identified by region and country. Common asthma triggers across regions included allergic rhinitis (e.g., viral and bacterial infections), allergens (particularly pollens,

TABLE 1.—Triggers identified by region and country.

Region	Countries	Triggers discussed
Africa	South Africa (52)	Emotional factors (52)
Asia	Turkey (41, 53–55) India (27–29, 56) Indonesia (57) Japan (58) United Arab Emirates (59) China (60–62)	Allergic rhinitis (54) Respiratory infection (57, 58, 60) Occupational irritants (53, 61) Air pollutants and particulates (60) Weather/climate (27, 42, 56) Allergens (27, 42, 59, 60, 62) Food (55) Exercise (60) Emotional factors (42, 60) Tobacco smoke (27–29) Medication (42)
Australia	Australia (63)	Allergens (63) Emotional factors (63)
Europe	United Kingdom (41) Italy (64, 65) Greece (66) France (67) Spain (68, 69) Sweden (30, 38)	Allergens (30, 38, 41) Allergic rhinitis (64, 67) Weather/climate (30, 38, 65) Occupational irritants (66) Air pollutants and particulates (38, 68, 69) Tobacco smoke (30)
North America	United States (23, 26, 36, 70–73) Greenland (74) Canada (24, 32, 75)	Allergens (23, 26, 70, 73, 74) Air pollutants and particulates (72) Tobacco smoke (24, 26) Respiratory symptoms (74) Occupational irritants (32, 36, 71) Anxiety/panic disorder (75)
South America	Brazil (8, 76) Costa Rica (31)	Rhinitis/sinusitis (8) Air pollutants and particulates (8) Occupational irritants (8, 76) Tobacco smoke (31)

molds, dust/dust mites, foods, and pet dander), air pollutants/particulates, exercise, irritants (e.g., tobacco smoke), strong odors, weather-related factors (e.g., cold or dry air), medication, and psychological factors (e.g., emotional anxiety or stress). Surprisingly, there were more similarities than differences among commonly recognized asthma triggers across regions. Although types of asthma triggers recognized were similar across regions (e.g., environmental allergens), specific pollens or other environmental allergens present might differ between regions. No studies were found that surveyed lifestyle adjustments or avoidance behaviors used by patients to cope with triggers in the real world. Notably, no studies discussed the potential impacts of such lifestyle adjustments on patients' health-related quality of life.

Approximately 15% of articles reviewed ($n = 13$) reported on occupational asthma. Occupation was particularly important in adult asthma cases in a number of different regions (e.g., Asia, Europe, and South America). Some articles described workplace exposure as a risk factor for developing asthma (32, 33), some reported higher rates of asthma among certain occupations (34, 35), and some reported occupational exposure as a contributor to difficult-to-control asthma (8) or exacerbations (36, 37). In a statement by the American Thoracic Society, work exacerbated asthma occurs in a relatively large proportion (>20%) of adult asthma patients, conditions at work such as chemicals, dust, common allergens, second-hand smoke, and physical exertion are common triggers found in the workplace (37).

Strategies for Managing Asthma Triggers

In our review of asthma control, treatment, and management guidelines and educational materials provided to asthma educators regarding how patients are advised to manage triggers they encounter in their environments, results demonstrated that authoritative and educational bodies by and large recommended that patients work to identify triggers they encounter in their environments that seem to exacerbate symptoms of asthma and then strive to avoid or reduce exposure to these triggers. For example, the ACAAI suggests that the most promising strategy for asthma management is for the patient to be aware of what situations induce an attack, such as exposure to a particular allergen, change in weather, and respiratory infections, and to avoid the situations that cause symptoms whenever possible (19). The AAAAI recommends individualized therapy for the treatment and management of asthma (10). Such personalized plans include environmental control measures to avoid asthma triggers, medication, an asthma action plan, and a close partnership with family and healthcare providers. Similarly, Canadian Guidelines for Management of Asthma (15) suggest that determination of the possible triggers of asthma (which may be done through completion of a questionnaire or allergy testing) is an important component of overall management of asthma. Once triggers are identified for individuals, the Canadian Guidelines suggest a personalized action plan which includes pharmacological treatment as well as regular

assessment of triggers as part of ongoing asthma management. One guideline was found that reported empirical results supporting trigger management strategies to be too inconclusive to provide recommendations for adults (17).

Findings from this literature review are mixed in terms of whether allergen and trigger education and avoidance improve asthma control. Five interventional studies were found that tested the effects of trigger education and avoidance on aspects of improved asthma control. Four studies demonstrated improvements in some aspect of control or lung function in interventional groups, or superior levels of control compared to control groups at end of study (38–41). One study did not demonstrate improved control (reductions in exacerbations) with lifestyle modifications such as avoidance of smoking (42). Further, results within these studies were mixed; for example, in one recent study by Bobb and colleagues (41), patients who were given individually tailored allergen and trigger avoidance advice as part of their primary care had significantly better lung function at 3 and 6 months compared to the usual care group. However, no significant differences were found in self-reported perceived symptoms and asthma control. These mixed results are consistent with findings from the National Heart Lung and Blood Institute (NHLBI) Expert Panel Report (14); in their review of literature, results of randomized interventions which included trigger education following an emergency room (ER) visit for asthma exacerbations in one study reduced incidence of emergency department visits over the 6 months following the intervention (11) and in another study did not reduce emergency department visits, particularly among patients with persistent asthma (43). None of the interventional studies reviewed took into account potential negative consequences of trigger avoidance on patients' day-to-day functioning, well-being, or health-related quality of life.

Asthma Control Definitions: How Are Triggers Taken into Account?

Guidelines for the treatment of asthma have identified that the primary goal of asthma management is to optimize asthma control; the literature reviewed here consistently pointed to asthma triggers as one contributor to poor asthma control (7). Control is typically defined by the absence of symptoms, normal lung function, and no activity limitations due to asthma (2). Recently, the American Thoracic Society task force (4) defined asthma control as the "extent to which the various manifestations of asthma have been reduced or removed by treatment." When evaluating level of control, the ATS guidelines recommend incorporating both current clinical control (e.g., symptoms, reliever use, and lung capacity) and future risk (e.g., exacerbations and lung function decline). Control definitions reviewed did not explicitly take into account lifestyle adjustments made in order to maintain symptom control in the face of known triggers; trigger avoidance may fall under the "activity impairment" part of the asthma control definition.

Two articles were found that reviewed endpoints and assessment tools designed to measure level of asthma

control (4, 16). The ATS/ERS task force (4) discusses the four cardinal components of the definition of asthma (including symptoms, airway obstruction, airway hyperresponsiveness, and airway inflammation), and suggests that there is no gold standard measure which can be recommended as a single endpoint that comprehensively evaluates all aspects of asthma. Further, they recommend multiple methods for evaluating asthma control, including patient reports of symptom-free days and clinical or biological markers such as ambulatory lung function tests. None of these take into account the frequency or magnitude of symptoms in the presence of triggers specifically, nor do they take into account lack of symptoms due to activity adjustments made to maintain symptom control.

In a review of patient-reported asthma questionnaires for assessing asthma control, Halbert and colleagues (16) found that there are five widely used and validated instruments: the Asthma Control Questionnaire (ACQ) (44); the Asthma Control Scoring System (ACSS) (45); the Asthma Control Test (ACT) (46); the Asthma Therapy Assessment Questionnaire (ATAQ) (47); and the Lara Asthma Symptom Scale (LASS) (48). While all measures reviewed take aspects of the definition of asthma control presented by GINA into account (daytime/night-time symptoms, activity limitations, need for rescue treatment, lung function, exacerbations), none specifically take trigger avoidance into account when evaluating level of symptoms and activity limitation.

DISCUSSION

Results from the review demonstrated that asthma triggers are widely referred to in the empirical and scientific literature and are discussed in asthma management guidelines and educational materials. While patients commonly receive advice to reduce exposure to or avoid triggers, and studies have demonstrated that in real-world settings patients do go to great lengths to avoid triggers (13), few empirical studies were found that demonstrated efficacy of such avoidance techniques on improved asthma control in adults. In this literature review, those studies that did present findings from trigger interventions (e.g., education about triggers or reductions in exposure to triggers) reported somewhat mixed results, with some studies demonstrating improved symptoms or reductions in exacerbations (11), and other studies not consistently demonstrating improved asthma control with intervention (41, 42). These findings are consistent with published guidelines from the CDC, which report that empirical support for asthma trigger management in the home is inconclusive for adults (17). Further, no studies were found that discussed possible negative consequences for patients of lifestyle or behavioral changes undertaken to reduce exposure to triggers; for example, the short- and long-term health consequences of not engaging in fitness activities to avoid exercise as a possible asthma trigger.

Some trigger management techniques likely do not have profound negative impacts on patients' health-related

quality of life and may even have positive health implications (e.g., avoiding cigarette smoke or using natural cleaning products). However, other management techniques, such as avoiding exercise, staying indoors, or giving up pets may have profound impact. Additional research is needed to provide a sound scientific basis for trigger reduction and avoidance strategies; the potentially negative impact of avoidance strategies on health-related quality of life should be quantified in such research.

There is more consistent and conclusive empirical literature on the effectiveness of trigger management techniques for children and adolescents with asthma, although the impact of avoidance measures on quality of life has not been explored (17, 49). Our current review included only studies with adults; conclusions and implications of a similar review for children and adolescents would likely be different. In our review of asthma control definitions and assessment tools, triggers and their role in leading to poor asthma control were not directly taken into account, despite the fact that activity limitation may be one indicator of poor control (2). Thus, current asthma control definitions and tools that simply evaluate symptoms without regard to patients' lifestyle adjustments in the presence of triggers may overestimate asthma control if patients are engaging in trigger reduction or avoidance techniques to reduce symptoms. The potential importance of this factor is suggested by the recent finding that activity limitation is the single strongest predictor of future exacerbations when patients with asthma are evaluated using control questionnaires (50). Future research should explore ways to take into account patients' lifestyle and behavioral adjustments in the face of triggers when evaluating level of asthma control. These findings also have implications for clinical practice; when discussing symptom experiences with patients to determine level of asthma control, health-care providers should be mindful of whether patients are able to carry out their day's activities without interruption by asthma symptoms or trigger avoidance. Finally, emphasizing the role of triggers and how they are associated with the lack of symptom control seems to be an important point to factor into asthma management guidelines.

A final goal of this literature review was to survey the international literature regarding known asthma triggers in order to determine whether types of asthma triggers patients encounter are common across regions and countries so that a universal checklist for categorization and identification of triggers for use in research and clinical practice would be feasible. Ritz and colleagues (51) have published a trigger check list including 32 possible triggers. While comprehensive, this list does not take into account activity limitations resulting from triggers and may be burdensome to implement in research studies and clinical practice, given the length of the inventory. Results here suggest that asthma triggers identified as common across regions fell within three specific categories including allergic triggers (e.g., pet dander and dust mites), physical triggers (e.g., allergic rhinitis and exercise), and environmental triggers (e.g., air pollutants/particulates, tobacco smoke, and weather-related factors) (see

TABLE 2.—Asthma trigger categories.

Category	Example
Allergic triggers	Pet dander Dust mites Pollens Molds
Physical triggers	Allergic rhinitis Exercise
Environmental triggers	Air pollutants Tobacco smoke Humidity Cold air

Table 2). These categories of common asthma triggers could be used by researchers and clinicians to develop evidence-based practice guidelines for maintaining control in the presence of triggers across countries and regions. Specifically, having a somewhat universal or common set of known triggers could assist with development of empirically based interventions and evaluation of such interventions for coping with specific types of asthma triggers patients may encounter in their environments. Further, clinicians could use such a common trigger checklist as a discussion point with new patients when evaluating their symptom patterns and level of control to determine most appropriate and effective treatment course given trigger exposure patterns. Finally, having a somewhat small yet known set of common trigger types and avoidance behaviors undertaken to manage triggers that could be incorporated into assessment of levels of asthma control could provide a more precise evaluation of treatment efficacy in both clinical studies and clinical practice.

One limitation of this research was that we only reviewed studies in English; country/language-specific studies published in local medical journals might have identified additional or different triggers than those identified and discussed in the English medical literature. In spite of this limitation, there was vast diversity in the types of international trigger studies reviewed; studies reviewed here included diverse methods, populations studied, and research objectives. Results from the studies reviewed suggest that some of the most common asthma triggers may be relatively universal across different countries and regions (see Table 2).

CONCLUSION

In summary, this literature review confirmed that while asthma triggers are widely discussed, few empirical studies exist to support recommendations made to patients on how to manage triggers they encounter in their environments. Further, asthma triggers are not taken into account in assessments of asthma control, despite activity limitation forming part of the definition of asthma control and widespread discussion of triggers as factors that lead to asthma symptoms and loss of control. This literature review demonstrated that there may be a set of common asthma

trigger types across regions and countries including allergic, physical, and environmental triggers. This framework of common trigger categories could be used to further develop empirically based intervention and evaluation for optimal methods for coping with triggers encountered, in more precise evaluation of asthma control, and to optimize asthma control for individual patients in clinical practice.

ACKNOWLEDGMENT

The authors acknowledge Dr. Nancy Kline Leidy for her review and input into the content of this manuscript.

DECLARATION OF INTEREST

This article was supported by GlaxoSmithKline.

Professor Chapman received support from the GSK-CIHR Research Chair in Respiratory Health Care Delivery at the University Health Network, Toronto, Canada.

NOTES

¹Search terms included asthma + terms related to triggers (trigger, allergen, risk factor, etc.) + incidence or prevalence.

²Search terms included asthma + trigger terms + terms related to coping strategy (avoidance, behavior modification, etc.)

REFERENCES

- Masoli M, Fabian D, Holt S, Beasley R. The global burden of asthma: executive summary of the GINA Dissemination Committee report. *Allergy* 2004; 59:469–478.
- GINA. Global strategy for asthma management and prevention. Available at: www.ginasthma.com. Accessed September 1, 2009.
- CDC. Vital signs: asthma prevalence, disease characteristics, and self-management education—United States, 2001–2009. Available at: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6017a4.htm?s_cid=mm6017a4_w. Accessed January 3, 2011.
- Reddel HK, Taylor DR, Bateman ED, Boulet LP, Boushey HA, Busse WW, Casale TB, Chaney P, Enright PL, Gibson PG, de Jongste JC, Kerstjens HA, Lazarus SC, Levy ML, O'Byrne PM, Partridge MR, Pavord ID, Sears MR, Sterk PJ, Stolf SW, Sullivan SD, Szeffler SJ, Thomas MD, Wenzel SE. An official American Thoracic Society/European Respiratory Society statement: asthma control and exacerbations: standardizing endpoints for clinical asthma trials and clinical practice. *Am J Respir Crit Care Med* 2009; 180:59–99.
- Sarafino EP, Goldfeder J. Genetic factors in the presence, severity, and triggers of asthma. *Arch Dis Child* 1995; 73:112–116.
- Taylor DR, Bateman ED, Boulet LP, Boushey HA, Busse WW, Casale TB, Chaney P, Enright PL, Gibson PG, de Jongste JC, Kerstjens HA, Lazarus SC, Levy ML, O'Byrne PM, Partridge MR, Pavord ID, Sears MR, Sterk PJ, Stolf SW, Szeffler SJ, Sullivan SD, Thomas MD, Wenzel SE, Reddel HK. A new perspective on concepts of asthma severity and control. *Eur Respir J* 2008; 32:545–554.
- de Vries MP, van den Beemt L, Lince S, Muris JW, Thoonen BP, van Schayck CP. Factors associated with asthma control. *J Asthma* 2005; 42:659–665.
- Araujo AC, Ferraz E, Borges Mde C, Filho JT, Vianna EO. Investigation of factors associated with difficult-to-control asthma. *J Bras Pneumol* 2007; 33:495–501.

9. Sala KA, Dressler AM, Aglio T, Spinella PC, Schramm CM, Carroll CL. Allergic triggers associated with more severe asthma exacerbations. *Chest* 2010; 138:310A.
10. American Academy of Allergy Asthma & Immunology (AAAAI). Tips to remember: asthma triggers and management. Updated 2010. Available at: <http://www.aaaai.org/patients/publicedmat/tips/asthmatriggersandmgmt.stm>. Accessed November 23, 2010.
11. Teach SJ, Crain EF, Quint DM, Hylan ML, Joseph JG. Improved asthma outcomes in a high-morbidity pediatric population: results of an emergency department-based randomized clinical trial. *Arch Pediatr Adolesc Med* 2006; 160:535–541.
12. Rank MA, Wollan P, Li JT, Yawn BP. Trigger recognition and management in poorly controlled asthmatics. *Allergy Asthma Proc* 2010; 31:99–105.
13. Vernon MK, Wiklund I, Bell J, Leidy NK, Dale P, Chapman KR. Asthma control and asthma triggers: the patient perspective. In: American Thoracic Society International Conference, May 13–18, 2011, Denver, CO.
14. National Heart Lung and Blood Institute (NHLBI). National Asthma Education and Prevention Program. Expert Panel Report 3: guidelines for the diagnosis and management of asthma. Full Report; 2007.
15. Lemiere C, Bai T, Balter M, Bayliff C, Becker A, Boulet LP, Bowie D, Cartier A, Cave A, Chapman K, Cowie R, Coyle S, Cockcroft D, Ducharme FM, Ernst P, Finlayson S, FitzGerald JM, Hargreave FE, Hogg D, Kaplan A, Kim H, Kelm C, O'Byrne P, Sears M, Markham AW. Adult asthma consensus guidelines update 2003. *Can Respir J* 2004; 11(Suppl. A):9A–18A.
16. Halbert RJ, Tinkelman DG, Globe DR, Lin SL. Measuring asthma control is the first step to patient management: a literature review. *J Asthma* 2009; 46:659–664.
17. CDC. The community guide – asthma control. Available at: <http://www.thecommunityguide.org/asthma/index.html>. Accessed July 16, 2012.
18. National Asthma Educator Certification Board (NAECB). Certified Asthma Educator (AE-C): candidate handbook. 2009.
19. American College of Allergy Asthma & Immunology (ACAAI). Common asthma triggers. Updated 2010. Available at: <http://www.aaaai.org/allergist/asthma/asthma-triggers/Pages/default.aspx>. Accessed December, 2010.
20. McGraw-Hill Concise Dictionary of Modern Medicine. Columbus, OH: McGraw-Hill Companies, Inc., 2002. Available at: <http://medical-dictionary.thefreedictionary.com/trigger>. Accessed January 3, 2011.
21. Thomsen SF, Duffy DL, Kyvik KO, Backer V. Genetic influence on the age at onset of asthma: a twin study. *J Allergy Clin Immunol* 2010; 126:626–630.
22. Aggarwal AN, Chaudhry K, Chhabra SK, D'Souza GA, Gupta D, Jindal SK, Katiyar SK, Kumar R, Shah B, Vijayan VK. Prevalence and risk factors for bronchial asthma in Indian adults: a multicentre study. *Indian J Chest Dis Allied Sci* 2006; 48:13–22.
23. Dumanovsky T, Matte TD. Variation in adult asthma prevalence in Hispanic subpopulations in New York City. *J Asthma* 2007; 44:297–303.
24. Ghosh S, Pahwa P, Rennie DC, Janzen B. Gender-related interactive effect of smoking and rural/urban living on asthma prevalence: a longitudinal Canadian NPHS study. *J Asthma* 2009; 46:988–994.
25. Gwynn RC. Risk factors for asthma in US adults: results from the 2000 Behavioral Risk Factor Surveillance System. *J Asthma* 2004; 41:91–98.
26. Hastert TA, Babey SH, Brown ER, Meng YY. Pets and smoking in the home associated with asthma symptoms and asthma-like breathing problems. *Policy Brief UCLA Cent Health Policy Res* 2007 (PB2007-2); 1–7.
27. Behera D, Kaur S, Gupta D, Verma SK. Avoidance of allergens by the patients with bronchial asthma. *J Assoc Physicians India* 2008; 56:325–328.
28. Gupta D, Aggarwal AN, Chaudhry K, Chhabra SK, D'Souza GA, Jindal SK, Katiyar SK, Kumar R, Shah B, Vijayan VK. Household environmental tobacco smoke exposure, respiratory symptoms and asthma in non-smoker adults: a multicentric population study from India. *Indian J Chest Dis Allied Sci* 2006; 48:31–36.
29. Mishra V. Effect of indoor air pollution from biomass combustion on prevalence of asthma in the elderly. *Environ Health Perspect* 2003; 111:71–78.
30. Ringsberg KC, Bjarneman P, Lowhagen O, Oden A, Toren K. Differences in trigger factors and symptoms between patients with asthma-like symptoms and patients with asthma: development of a basis for a questionnaire. *Respir Med* 2002; 96:305–311.
31. Avila L, Soto-Martinez ME, Soto-Quiros ME, Celedon JC. Asthma, current wheezing, and tobacco use among adolescents and young adults in Costa Rica. *J Asthma* 2005; 42:543–547.
32. Gautrin D, Newman-Taylor AJ, Nordman H, Malo JL. Controversies in epidemiology of occupational asthma. *Eur Respir J* 2003; 22:551–559.
33. Kogevinas M, Zock JP, Jarvis D, Kromhout H, Lillienberg L, Plana E, Radon K, Toren K, Alliksoo A, Benke G, Blanc PD, Dahlman-Hoglund A, D'Errico A, Hery M, Kennedy S, Kunzli N, Leynaert B, Mirabelli MC, Muniozguren N, Norback D, Olivieri M, Payo F, Villani S, van Sprundel M, Urrutia I, Wieslander G, Sunyer J, Anto JM. Exposure to substances in the workplace and new-onset asthma: an international prospective population-based study (ECRHS-II). *Lancet* 2007; 370:336–341.
34. Arif AA, Whitehead LW, Delclos GL, Tortolero SR, Lee ES. Prevalence and risk factors of work related asthma by industry among United States workers: data from the third national health and nutrition examination survey (1988–94). *Occup Environ Med* 2002; 59:505–511.
35. Karjalainen A, Kurppa K, Martikainen R, Karjalainen J, Klaukka T. Exploration of asthma risk by occupation—extended analysis of an incidence study of the Finnish population. *Scand J Work Environ Health* 2002; 28:49–57.
36. Henneberger PK, Mirabelli MC, Kogevinas M, Anto JM, Plana E, Dahlman-Hoglund A, Jarvis DL, Kromhout H, Lillienberg L, Norback D, Olivieri M, Radon K, Toren K, Urrutia I, Villani S, Zock JP. The occupational contribution to severe exacerbation of asthma. *Eur Respir J* 2010; 36:743–750.
37. Henneberger PK, Redlich CA, Callahan DB, Harber P, Lemiere C, Martin J, Tarlo SM, Vandenplas O, Toren K, ATS Ad Hoc Committee on Work-Exacerbated Asthma. An official American Thoracic Society statement: work-exacerbated asthma. *Am J Respir Crit Care Med* 2011; 184:368–378.
38. Frisk M, Blomqvist A, Stridh G, Sjoden PO, Kiviloog J. Occupational therapy adaptation of the home environment in Sweden for people with asthma. *Occup Ther Int* 2002; 9:294–311.
39. van den Bemt L, van Knapen L, de Vries MP, Jansen M, Cloosterman S, van Schayck CP. Clinical effectiveness of a mite allergen-impermeable bed-covering system in asthmatic mite-sensitive patients. *J Allergy Clin Immunol* 2004; 114:858–862.
40. Bobb C, Ritz T. Do asthma patients in general practice profit from a structured allergy evaluation and skin testing? A pilot study. *Respir Med* 2003; 97:1180–1187.
41. Bobb C, Ritz T, Rowlands G, Griffiths C. Effects of allergen and trigger factor avoidance advice in primary care on asthma control: a randomized-controlled trial. *Clin Exp Allergy* 2010; 40:143–152.
42. Goksel O, Celik GE, Erkekli FO, Gullu E, Mungan D, Misirligil Z. Triggers in adult asthma: are patients aware of triggers and doing right? *Allergol Immunopathol (Madr)* 2009; 37:122–128.
43. Sockrider MM, Abramson S, Brooks E, Caviness AC, Pilney S, Koerner C, Macias CG. Delivering tailored asthma family education in a pediatric emergency department setting: a pilot study. *Pediatrics* 2006; 117: S135–S144.
44. Juniper EF, O'Byrne PM, Guyatt GH, Ferrie PJ, King DR. Development and validation of a questionnaire to measure asthma control. *Eur Respir J* 1999; 14:902–907.
45. Boulet LP, Boulet V, Milot J. How should we quantify asthma control? A proposal. *Chest* 2002; 122:2217–2223.
46. Nathan RA, Sorkness CA, Kosinski M, Schatz M, Li JT, Marcus P, Murray JJ, Pendergraft TB. Development of the asthma control test: a survey for assessing asthma control. *J Allergy Clin Immunol* 2004; 113:59–65.
47. Vollmer WM, Markson LE, O'Connor E, Sanocki LL, Fitterman L, Berger M, Buist AS. Association of asthma control with health care utilization and quality of life. *Am J Respir Crit Care Med* 1999; 160:1647–1652.
48. Lara M, Sherbourne C, Duan N, Morales L, Gergen P, Brook RH. An English and Spanish Pediatric Asthma Symptom Scale. *Med Care* 2000; 38:342–350.

49. Morgan WJ, Crain EF, Gruchalla RS, O'Connor GT, Kattan M, Evans R III, Stout J, Malindzak G, Smartt E, Plaut M, Walter M, Vaughn B, Mitchell H. Results of a home-based environmental intervention among urban children with asthma. *N Engl J Med* 2004; 351:1068–1080.
50. Schatz M, Zeiger RS, Yang SJ, Chen W, Crawford W, Sajjan S, Allen-Ramey F. The relationship of asthma impairment determined by psychometric tools to future asthma exacerbations. *Chest* 2012; 141:66–72.
51. Ritz T, Steptoe A, Bobb C, Harris AH, Edwards M. The asthma trigger inventory: validation of a questionnaire for perceived triggers of asthma. *Psychosomat Med* 2006; 68:956–965.
52. Kolbe J, Fergusson W, Vamos M, Garrett J. Case-control study of severe life threatening asthma (SLTA) in adults: psychological factors. *Thorax* 2002; 57:317–322.
53. Akpinar-Elci M, Elci OC, Odabasi A. Work-related asthma-like symptoms among florists. *Chest* 2004; 125:2336–2339.
54. Akpinar-Elci M, Cimrin AH, Elci OC. Prevalence and risk factors of occupational asthma among hairdressers in Turkey. *J Occup Environ Med* 2002; 44:585–590.
55. Ozol D, Mete E. Asthma and food allergy. *Curr Opin Pulm Med* 2008; 14:9–12.
56. Saxena T, Maheshwari S, Saxen M. Mild cool air—a risk factor for asthma exacerbations: results of a retrospective study. *J Assoc Physicians India* 2011; 59:624–628.
57. Surachmanto E. Prevalence of comorbidity of asthma acute exacerbation with typhoid fever. *Allergy* 2011; 66:304 (Abstract).
58. Tomita K, Sano H, Iwanaga T, Ishihara K, Ichinose M, Kawase I, Kimura H, Hirata K, Fujimura M, Mishima M, Tohda Y. Association between episodes of upper respiratory infection and exacerbations in adult patients with asthma. *J Asthma* 2012; 49:253–259.
59. Bener A, Safa W, Abdulhalik S, Lestringant GG. An analysis of skin prick test reactions in asthmatics in a hot climate and desert environment. *Allerg Immunol (Paris)* 2002; 34:281–286.
60. Chiang CH, Wu KM, Wu CP, Yan HC, Perng WC. Evaluation of risk factors for asthma in Taipei City. *J Chin Med Assoc* 2005; 68:204–209.
61. Krstev S, Ji BT, Shu XO, Blair A, Zheng W, Lubin J, Vermeulen R, Hauptmann M, Rothman N, Gao YT, Mustafa D, Chow WH. Occupation and adult-onset asthma among Chinese women in a population-based cohort. *Am J Ind Med* 2007; 50:265–273.
62. Sun B, Lai X, Gjesing B, Spangfort MD, Zhong N. The prevalence of sensitivity to cockroach allergens and IgE cross-reactivity between cockroach and house dust mite allergens in Chinese patients with allergic rhinitis and asthma. *Chest* 2011; 140:859A (Abstract).
63. Liangas G, Yates DH, Wu D, Henry RL, Thomas PS. Laughter-associated asthma. *J Asthma* 2004; 41:217–221.
64. Bugiani M, Carosso A, De Marco R. The European respiratory health survey and the Italian study on asthma in young adults: goals, design and main results up to date. *Italian J Allergy Clin Immunol* 2007; 17:100–111.
65. de Marco R, Poli A, Ferrari M, Accordini S, Giammanco G, Bugiani M, Villani S, Ponzio M, Bono R, Carrozzi L, Cavallini R, Cazzoletti L, Dallari R, Ginesu F, Lauriola P, Mandrioli P, Perfetti L, Pignato S, Pirina P, Struzzo P. The impact of climate and traffic-related NO₂ on the prevalence of asthma and allergic rhinitis in Italy. *Clin Exp Allergy* 2002; 32:1405–1412.
66. Chatzi L, Prokopoulos E, Tzanakis N, Alegakis A, Bizakis I, Siafakas N, Lionis C. Allergic rhinitis, asthma, and atopy among grape farmers in a rural population in Crete, Greece. *Chest* 2005; 127:372–378.
67. Demoly P, Bozonnet MC, Dacosta P, Daures JP. The diagnosis of asthma using a self-questionnaire in those suffering from allergic rhinitis: a pharmaco-epidemiological survey in everyday practice in France. *Allergy* 2006; 61:699–704.
68. Feo Brito F, Mur Gimeno P, Martinez C, Tobias A, Suarez L, Guerra F, Borja JM, Alonso AM. Air pollution and seasonal asthma during the pollen season. A cohort study in Puertollano and Ciudad Real (Spain). *Allergy* 2007; 62:1152–1157.
69. Kunzli N, Bridevaux PO, Liu LJ, Garcia-Esteban R, Schindler C, Gerbase MW, Sunyer J, Keidel D, Rochat T. Traffic-related air pollution correlates with adult-onset asthma among never-smokers. *Thorax* 2009; 64:664–670.
70. Arbes SJ Jr., Gergen PJ, Vaughn B, Zeldin DC. Asthma cases attributable to atopy: results from the Third National Health and Nutrition Examination Survey. *J Allergy Clin Immunol* 2007; 120:1139–1145.
71. Bang KM, Hnizdo E, Doney B. Prevalence of asthma by industry in the US population: a study of 2001 NHIS data. *Am J Ind Med* 2005; 47:500–508.
72. Eisner MD, Iribarren C. The influence of cigarette smoking on adult asthma outcomes. *Nicotine Tob Res* 2007; 9:53–56.
73. Jariwala SP, Kurada S, Moday H, Thanjan A, Bastone L, Khananashvili M, Fodeman J, Hudes G, Rosenstreich D. Association between tree pollen counts and asthma ED visits in a high-density urban center. *J Asthma* 2011; 48:442–448.
74. Backer V, Nepper-Christensen S, Porsbjerg C, von Linstow ML, Reersted P. Respiratory symptoms in Greenlanders living in Greenland and Denmark: a population-based study. *Ann Allergy Asthma Immunol* 2004; 93:76–82.
75. Favreau H, Labrecque ML, Bacon SL, Lavoie KL. Impact of panic disorder and panic-like anxiety on asthma control at 4 years follow-up. *Can Respir J* 2011; 18:e25 (Abstract).
76. Caldeira RD, Bettiol H, Barbieri MA, Terra-Filho J, Garcia CA, Vianna EO. Prevalence and risk factors for work related asthma in young adults. *Occup Environ Med* 2006; 63:694–699.

Copyright of Journal of Asthma is the property of Taylor & Francis Ltd and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.