Published in final edited form as:

J Allergy Clin Immunol. 2012 December ; 130(6): 1275–1281. doi:10.1016/j.jaci.2012.06.026.

Sleep and allergic disease: A summary of the literature and future directions for research

Daphne Koinis-Mitchell, PhD^a, Timothy Craig, DO^b, Cynthia A. Esteban, MSN, MPH^a, and Robert B. Klein, MD^a

^aDepartment of Psychiatry and Human Behavior and the Bradley/Hasbro Children's Research Center, Brown Medical School, Providence

^bHershey Medical Center, Penn State University, Hershey

Abstract

Atopic diseases, such as asthma and allergic rhinitis, are common conditions that can influence sleep and subsequent daytime functioning. Children and patients with allergic conditions from ethnic minority groups might be particularly vulnerable to poor sleep and compromised daytime functioning because of the prevalence of these illnesses in these groups and the high level of morbidity. Research over the past 10 years has shed light on the pathophysiologic mechanisms (eg, inflammatory mediators) involved in many atopic diseases that can underlie sleep disruptions as a consequence of the presence of nocturnal symptoms. Associations between nocturnal symptoms and sleep and poorer quality of life as a result of missed sleep have been demonstrated across studies. Patients with severe illness and poor control appear to bear the most burden in terms of sleep impairment. Sleep-disordered breathing is also more common in patients with allergic diseases. Upper and lower airway resistance can increase the risk for sleep-disordered breathing events. In patients with allergic rhinitis, nasal congestion is a risk factor for apnea and snoring. Finally, consistent and appropriate use of medications can minimize nocturnal asthma or allergic symptoms that might disrupt sleep. Despite these advances, there is much room for improvement in this area. A summary of the sleep and allergic disease literature is reviewed, with methodological, conceptual, and clinical suggestions presented for future research.

Keywords

Sleep; allergic disease; asthma; allergic rhinitis; atopic dermatitis

Sleep is important for all persons in promoting physical and mental health. High-quality sleep is crucial for learning and effective development in children. Deprivation in sleep can alter immune function in healthy subjects,¹ and it has been found to delay wound healing in animal models.² Conversely, adequate sleep can facilitate recovery from illness or injury

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Corresponding author: Daphne Koinis-Mitchell, PhD, Child and Family Psychiatry, Brown Medical School, Coro West 2nd Floor, 1 Hoppin St, Providence, RI 02903. Daphne_Koinis-Mitchell@Brown.edu.

Disclosure of potential conflict of interest: T. Craig is an Interest Section Leader for the American Academy of Allergy, Asthma & Immunology; is a board member for the American College of Allergy, Asthma & Immunology and the Joint Council of Allergy, Asthma & Immunology; has consultant arrangements with CSL Behring, Dyax, and Viropharma; has provided expert testimony in a case related to anaphylaxis; has received grants from Viropharma, CSL Behring, Shire, Dyax, Pharming, Forrest, Genentech, Merck, and GlaxoSmithKline; has received payment for lectures from Viropharma, CSL Behring, Dyax, Merck, Novartis, Shire, and Teva; and has received payment for development of educational presentations from the Vietnam Education Foundation. C. A. Esteban has received a grant from the National Institute of Child Health and Human Development. The rest of the authors declare that they have no relevant conflicts of interest.

through secretion of melatonin, which enhances the immune response, and growth hormone, which promotes healing.³ Patients with chronic disease are vulnerable to sleep disruptions caused by the presence of illness-related symptoms at night and the potential for poor illness control, both of which can affect sleep quality. Asthma and allergic diseases are common chronic conditions that, if not treated properly, can affect sleep in important ways.⁴

Asthma affects up to 8.2% (24.6 million persons)⁵ of persons in the United States, and it is the most prevalent childhood chronic disease. Allergic rhinitis (AR) is a common comorbid condition in asthmatic patients. For example, approximately 80% of all children with asthma have coexisting AR, and nearly 40% of those with AR have coexisting asthma.⁶ AR affects approximately 60 million persons in the United States,⁷ including up to 40% of children, and its prevalence is increasing.^{8,9} Similarly, other atopic diseases, such as atopic dermatitis (AD), are common and increasing in prevalence.¹⁰

Clinical guidelines for asthma and AR^{9,11} have identified missed sleep caused by symptoms as a key indicator of illness-related morbidity. Furthermore, the National Center on Sleep Disorders Research has recognized sleep disturbance as an important factor contributing to racial/ethnic and socioeconomic disparities in health outcomes.¹² Poor sleep quality is an indicator that allergic disease is in poor control and has particular relevance for a patient's daytime functioning and overall quality of life.^{7,13–17}

Given the disparities in disease prevalence and outcomes that exist among certain groups with allergic diseases, such as asthma,^{18–20} and the potential for poor disease outcomes because of disrupted sleep, it is imperative that sleep be a focus of research when considering patients with allergic disorders. Asthma and allergic diseases can affect sleep through various levels of influence involving pathophysiologic (eg, inflammatory mediators), environmental (eg, poor trigger control in the home), individual (eg, nonadherence to medications), and family/cultural (eg, cultural beliefs) factors. This review summarizes results from the current literature that focus on either sleep and asthma or sleep and AR because these conditions are the most common allergic diseases. AD will be briefly addressed because it is also a common chronic skin disorder that can affect sleep quality. The review will evaluate the extent to which the current literature has considered these various pathways of influence between allergic disease and sleep described above and end with suggestions for further research.

To assist in furthering understanding of the association between allergic disease and sleep and the range of mechanisms that might account for this relationship, we propose a conceptual model whereby allergic disease affects sleep and *vice versa*, and this association can affect a patient's disease, behavioral, and academic outcomes (Fig 1). Furthermore, anatomic, pathophysiologic, and other biological factors, as well as environmental, individual, and family/cultural factors, in combination or on their own exert influence on both allergic disease and sleep, which can subsequently affect a patient's outcomes/functioning. The specific pathways by which these processes can influence allergic disease and sleep will be discussed in more detail below in the context of the current literature.

EFFECT OF ALLERGIC DISEASE ON SLEEP: PATHOPHYSIOLOGIC MECHANISMS

A large area of focus on sleep quality in patients with allergic diseases involves pathophysiologic mechanisms related to illness that might influence symptoms that can disrupt the sleep process. To briefly summarize, asthma and AR symptoms are frequently experienced during nighttime hours because of many factors, including a dip in cortisol levels at night that affects inflammatory cytokines and other mediators.²¹ In addition,

nighttime disturbances, such as airway obstruction in patients with asthma, nasal congestion in patients with AR, and an increased sensation of itching for patients with AD, might be related to circadian fluctuations in inflammatory mediators (ie, increase in inflammation during the night).^{22,23} For example, for patients with AR, circadian rhythms can lead to a peak in nasal congestion during the early morning hours, adversely affecting sleep quality.^{24,25} Furthermore, histamine, an inflammatory mediator released during allergic reactions, might contribute to disturbed sleep because it is involved in the regulation of the sleep-wake cycle and arousal but also can induce symptoms of rhinitis, directly leading to sleep disruption.²⁶ Typical sleep-related problems seen in patients with AR include sleep-disordered breathing, sleep apnea, and snoring, all of which are associated with nasal congestion/obstruction.²⁵ Further details regarding the mechanisms of sleep impairment involved in patients with AR are presented elsewhere.^{27,28}

Additional symptoms, such as coughing in patients with asthma and AR symptoms experienced at night (eg, rhinorrhea and postnasal drainage), can also increase discomfort and sleep disruption.²⁹ Sleep posture also facilitates an increase in mucus production for asthmatic patients and increased nasal congestion for patients with AR.²⁷ Additional factors in patients with asthma include increased airway resistance caused by increased allergen exposure (eg, pollen) during the night. For patients with AD, disease flare-ups associated with the complex interplay between defects in skin barrier function, environmental and infectious agents, and immune abnormalities can result in itching and discomfort for the patient, and as a result, sleep can be disrupted.^{23,30}

NONADHERENCE TO TREATMENT

If patients with allergic disease do not adhere to treatment recommendations for medication use, whether it be daily use of topical corticosteroids³⁰ or controller asthma medications³¹ or avoid using rescue medication, this can result in increased symptoms during the nighttime hours and disrupted sleep. Thus, the importance of consistent medication use is crucial for high-quality sleep in patients with atopic diseases. Poor trigger control associated with AR and asthma in the home environment and, in particular, the bedroom might also influence symptoms during sleep, although this has not been studied. In general, if nighttime allergic symptoms are not well controlled, a patient can experience sleep loss and secondary daytime fatigue, which can contribute to missed schooldays, missed work for adults, diminished quality of life, decreased activity participation, decreased productivity, behavioral problems, and concentration and learning problems.^{10,32}

ASSOCIATIONS BETWEEN SLEEP AND ALLERGIC DISEASE

Sleep disruption: Asthma

Results from a few cross-sectional studies indicate that atopic diseases, such as asthma, can affect sleep quality through the disruption of sleep, likely in part because of the presence of nocturnal symptoms.³³ In one study including children with asthma, data from 1 night of polysomnography indicated that the primary sleep abnormality associated with nocturnal asthma symptoms is interruption in the continuity of sleep by frequent awakenings.³⁴ These sleep disruptions caused by nighttime symptoms can have negative consequences on daytime functioning. One study showed an association between an increased number of nighttime awakenings because of asthma symptoms (1–7 times per week) and poorer school performance.¹⁷ The presence of nocturnal asthma symptoms has also been shown to increase the number of school absences in children³⁵ and increase the risk for behavioral problems in urban children.³⁶ In studies including urban children, a greater risk for nighttime awakenings caused by nocturnal symptoms has also been associated with more severe asthma and atopy.^{37,38} For example, in one study including baseline data from a

school-based asthma management trial, caregiver reports of children's sleep quality assessed by using a validated questionnaire were worse for children with more nocturnal asthma symptoms compared with that seen in children with milder symptoms ($P < .03$).³⁸ Other questionnaire-based studies have shown cross-sectional associations among poor sleep quality caused by nighttime symptoms, poor asthma control,³⁹ and quality of life.⁴⁰

Sleep disruption: AR

Several survey studies have documented a link between AR and sleep impairment. One study showed sleep problems in up to 88% of a sample of children with AR.³² The Burden of Allergic Rhinitis study revealed that patients with AR had less adequate sleep quality compared with healthy control subjects (as measured by using a sleep-problems index).⁴¹ Furthermore, in a large survey of patients with AR, 68% of respondents with perennial AR and 48% with seasonal AR reported that their condition interfered with sleep.¹³ Finally, in the Pediatrics Allergies in America Survey sleep in patients with rhinitis was altered, with 40% reporting that allergies affected their sleep, 32% reporting difficulty getting to sleep, and 26% reporting awakening in the night because of symptoms.⁴²

The negative consequences of disrupted sleep caused by AR symptoms have also been documented. One study found that patients who often or almost always experience nighttime symptoms of rhinitis (≥ 5 nights per month) are more likely ($P < .0001$) to have chronic excessive daytime sleepiness or chronic nonrestorative sleep than those who rarely or never have such symptoms.⁴³ As indicated in some studies of asthma, sleep quality in patients with AR is found to be worse in patients with more severe disease.^{44,45}

Studies using objective methods to assess sleep disruption in patients with allergic disease are less common. One study using actigraphy (a wrist-worn watch to assess sleep quality) showed that adults with perennial AR had increased sleep disturbance compared with healthy control subjects ($P = .007$).⁴⁶ Another prospective study compared questionnaire responses to a sleepiness scale and polysomnographic results between children with AR and 25 control subjects.⁴⁷ Results indicated an association between increased daytime sleepiness and poorer quality of life, particularly in children with more severe AR.

Some early studies point to nasal congestion associated with AR as a primary contributor to disrupted sleep and daytime fatigue, likely influenced by an increase in the number of microarousals and episodes of apnea.^{41,48,49} A common measure used to assess the effect of AR symptoms on quality of life is the Nocturnal Rhinoconjunctivitis Quality of Life Questionnaire.⁵⁰ Results from studies using this assessment have linked nasal congestion caused by AR with sleep disturbances.⁵⁰ Other symptoms, such as sneezing, itchy eyes, rhinorrhea, and nasal pruritus, can also contribute to sleep disturbances in patients with AR.⁵¹ Limited studies have examined sleep in patients with co-occurring asthma and AR. Results from a large population-based study of adults with asthma in northern Europe showed that the presence of AR was independently related to difficulties in inducing sleep and daytime sleepiness.⁵²

Sleep disruption: AD

Fewer studies have focused on sleep quality and AD. Disturbed sleep in patients with AD has been evidenced by several observational studies demonstrating that children with AD awaken more often and sleep less during the night than healthy control subjects, and adults with AD show a similar pattern.⁵³ One small study examined sleep efficiency and scratching based on results of polysomnography and actigraphy and self-report in 20 adults with AD.⁴⁵ Decreased sleep efficiency was related to disease severity and increased scratching. Associations between poorer sleep based on self-report and results of actigraphy and

increased daytime fatigue in adults with AD compared with healthy control subjects has also been shown.⁵⁴ In summary, patients with allergic disease are more susceptible to disrupted sleep because of the presence of potential nighttime symptoms, and those with more severe disease are at further risk for sleep impairment. Compared with studies including patients with asthma and AD, more research has been conducted in the area of AR and disrupted sleep.

Sleep disorders

Sleep-disordered breathing, snoring, and obstructive sleep apnea (OSA) are common sleep conditions in children and adults with asthma and AR.^{27,55} Larsson et al⁵⁶ identified a link between asthma and OSA, reporting witnessed apnea in 14% of their sample of adults given a diagnosis of asthma. Furthermore, a random sample survey of 1234 children aged 6 to 14 years in Belgium revealed a 2.0-fold increase in OSA symptoms among children with asthma symptoms.⁵⁷ Sleep-disordered breathing also appears to increase the risk for severe asthma⁵⁸ and behavioral problems.^{4,47} In one study children with sleep-disordered breathing had a 3.62-fold increased odds of having severe asthma.⁵⁹

With regard to AR, nasal obstruction associated with congestion has been found to be a risk factor for sleep-disordered breathing events, including apnea, hypopnea, and snoring.⁴³ Obstructive apneas were found to be longer and more frequent in patients with AR who have nasal obstruction than in those without obstruction when sleep was measured by means of polysomnography.⁴⁸ In another study, compared with healthy control subjects, patients with AR had 10 times more microarousals from sleep in association with periodic breathing and hypopneic and hyperpneic episodes.⁴¹ Furthermore, allergic patients with nasal congestion had a 1.8 times greater chance of moderate-to-severe sleep-disordered breathing than those without congestion.⁴³ Studies have also linked AR and allergic sensitization with snoring.^{60,61} Of children who snored habitually, 36% were sensitive to allergens, approximately 3 times the rate in nonsnoring children.⁶²

Moreover, current findings suggest wide racial and ethnic differences in sleep-related disorders. For example, in one study, sleep-disordered breathing (snoring, upper airway resistance, and OSA) is twice as likely in young African American children as in non-Latino white children.⁶³ Furthermore, parental reports of witnessed apneas, snoring, and excessive daytime sleepiness have been found to be significantly more likely in Latino than non-Latino white children.⁶⁴ However, these specific studies did not examine the incidence of asthma or AR in these samples or the severity of each condition. Further examination of these co-occurring conditions and the effect on sleep and subsequent functioning need to be examined in children and patients from ethnic minority backgrounds, given that morbidity might be higher in these groups.

Sleep duration and timing

Few studies have looked at sleep patterns in terms of bedtime and wake-up time and the amount of time patients with allergic diseases might sleep relative to their healthy counterparts. One small study showed that greater quantity of sleep (measured with a daily diary) predicted better peak expiratory flow the following day in children with asthma.⁶⁵ In the context of sleep practices, one study found daytime napping was more common among children with asthma than among healthy control subjects,⁶⁶ and ethnic minority children in the sample had later bedtimes and less nighttime sleep than non-Latino white children. These results are consistent with findings from studies of healthy children. Minority boys were found, on average, to sleep less than the recommended 9 hours and were more likely than nonminority children to have a bedtime of 11 PM or later.⁶⁷ Furthermore, black healthy children have been shown to nap significantly more days per week and have shorter average

nocturnal sleep durations compared with white children.⁶⁸ Further study is needed to determine the effects of quantity of sleep on upper and lower airway functioning and, in turn, daytime functioning, particularly in groups at risk for increased morbidity. Also, it is not known whether sleep behaviors, such as napping, are more common than expected in ethnic minority children with asthma, AR, or both to compensate for inadequate nighttime sleep caused by symptoms or severe disease.

FUTURE DIRECTIONS FOR RESEARCH

The current literature on sleep and allergic disease supports many of the proposed associations depicted in our conceptual model (Fig 1). Some areas have received more attention than others. For example, much is known about the pathophysiologic mechanisms that contribute to allergic symptoms that occur during the night and might disrupt sleep in patients with allergic diseases. Although studies have furthered our understanding of the effect of these conditions on sleep quality, there are many important avenues to pursue in future research. Given the risk for poorer outcomes in patients with concomitant atopic conditions,³⁰ further examination of how pathophysiologic mechanisms (eg, inflammatory mediators) might interact to directly affect sleep impairment is an important research priority to determine how to reduce the effect of each disease and identify appropriate and specific targets for intervention (eg, decreasing nasal congestion associated with rhinitis and identifying what to treat first based on specific symptoms). In addition, studying the influence of sleep quality on cytokine production and *vice versa* is essential to fully understand which interventions are needed.

Many of the studies reviewed tend to be cross-sectional in nature and involve short time periods of assessment. There is a need for prospective studies examining the co-occurrence of symptoms and sleep patterns in patients to provide more causal evidence for the effects of allergic disease on sleep. Furthermore, more focus on the consequences of impaired sleep on different areas of functioning relevant to various developmental levels beyond quality of life are needed. For example, more research needs to assess the effect of sleep on academic functioning, concentration and attention, work productivity, and behavioral outcomes.

Studies reviewed tend to use a range of terminology to describe sleep affected by nighttime symptoms, such as “sleep impairment,” “sleep disturbances,” “sleep problems,” “sleep efficiency,” and “sleep quality.” This is likely influenced by the range of methods used to assess sleep (subjective vs objective methods) and the specific issues relevant to these illnesses (eg, sleep disruptions or number of awakenings caused by symptoms). More clarity is needed on how sleep is defined and measured because each term used has a specific meaning and might have a different effect on health outcomes. As noted in the sleep medicine literature, sleep quality has not been rigorously defined and can involve several indicators that summarize normative sleep patterns, such as an appropriate amount of sleep depending on the patient’s age, with the majority to all of the sleep time spent asleep in bed. This can also be referred to as “sleep efficiency” and quantitatively defined as the proportion of the night spent asleep (minutes at night spent asleep minus minutes at night spent awake).

Most methods for assessing both symptoms and sleep rely on self-report assessments, which are subject to poor recall and bias. There are several subjective assessments used to assess sleep that contribute to the range of terminology used. These include assessments of daily atopic symptoms, sleep problems, daytime somnolence, fatigue, and quality of life.⁶⁹ Disease-specific quality-of-life measures, such as the Rhinitis Quality of Life Questionnaire, include a domain that measures the effects of disease on sleep.⁷⁰ The Nighttime Rhinitis Quality of Life Questionnaire assesses the functional impairments problematic for patients with nocturnal symptoms,⁵⁰ including sleep problems and symptoms during sleep. Other

sleep questionnaires exist (eg, the Epworth sleepiness scale)⁷¹; however, these instruments assess 1 potential indicator of sleep quality, daytime sleepiness, and lack the sensitivity needed to assess sleep disturbance. There are benefits to using these instruments; subjective questionnaires are easy to use and inexpensive and have demonstrated reliability, validity, and reproducibility.

The use of more objective assessments of sleep quality in the form of actigraphy and polysomnography is less common. Although these approaches are expensive and increase the burden to participants and the burden on study resources, they do allow for more sophisticated indicators that are relevant to asthma and allergic disease (frequency and duration of nighttime awakenings lasting a particular length of time and number of minutes spent asleep). These methods also allow for a more precise assessment of changes in sleep quality across specific sleep periods (sleep onset latency, rest period, and sleep period). Objective assessments of asthma (spirometry to assess FEV₁) and AR (eg, peak nasal inspiratory flow through a nasal flow meter) symptoms in real time are also used less frequently in sleep research because studies tend to use self-report assessments of symptoms. Allergy testing and evaluation of IgE levels to identify the effect of specific allergic triggers pertinent to the nighttime sleep environment (eg, dust mites in the bedding) are also relevant.

An accurate diagnosis of asthma, AR, or both and classification of disease severity and control are necessary to inform the most appropriate therapeutic interventions determined by using guidelines-based approaches. In studies including patients with AR, an evaluation of nasal patency and physiology in patients with rhinitis can aid in the diagnosis and provide a complete nasal evaluation and assessment of symptoms over time.⁶⁹ This might seem rigorous and oftentimes not possible; however, many studies do not confirm each condition or classify the severity of each condition by using guideline-based approaches. Some studies have shown that urban and ethnic minority children with asthma might not receive a diagnosis AR, not be treated, or both.⁷² Health care system barriers, such as difficulty meeting with a consistent health care provider for asthma and accessing and using specialty care, have been linked with more asthma morbidity in ethnic minority children.⁷³ For families facing increased urban and health care system barriers, the potential for AR symptoms to disrupt sleep might be higher, especially in patients with severe asthma. The tendency in these circumstances might be for families to treat the asthma, whereas the AR symptoms are unappreciated.

Sample sizes in the studies reviewed tend to be small and not representative of specific ethnic groups at high risk for illness-related morbidity. Further study of differences in sleep patterns, timing and duration of sleep, sleep disruptions, and sleep disorders in specific ethnic groups is needed. Mechanisms across multiple levels (pathophysiologic, cultural/family, individual/psychological, and environmental levels) that might underlie ethnic and racial differences in sleep in patients with allergic disease need to be pursued in further depth to guide more tailored interventions. For example, although the adverse effect of living in disadvantaged urban environments might, in part, affect decrements in sleep duration and quality,⁷⁴ parents' level of stress, lack of social support, and neighborhood disadvantage and safety could affect the overall family environment and climate of the household and subsequent sleep behaviors of the child (eg, inconsistent sleep routines). Behavioral intervention approaches that consider sleep hygiene and specific family/child stressors need to be integrated with guidelines-based approaches to manage allergic diseases to enhance sleep quality.

Furthermore, studies have consistently shown independent associations between race and/or ethnicity, low SES, and sleep problems in healthy ethnic minority children.^{75,76} Inner-city

children with allergic diseases face conditions (eg, low-quality housing and exposure to allergens) that challenge families' abilities to control symptoms, which might result in an increased risk for nocturnal symptoms, poor disease management, and/or disrupted sleep. Although such conditions have been found to be associated with higher levels of psychological distress in caregivers and more frequent symptoms, which can complicate effective management behaviors,⁷⁷ the role of sleep in this context has been understudied.

Sociocontextual factors or beliefs about sleep can also influence sleep practices. For example, because of a crowded living area or concerns about neighborhood safety, parents might make a decision to have their children sleep together in one room or with them, which could influence sleep routines, sleep disturbances, sleep hygiene, and sleep behaviors. In addition, given that sleep behaviors are highly variable across the developmental period, studies should focus on whether sleep disruptions or patterns differ across specific age groups in patients with allergic disease. For example, younger children can be monitored more closely by caregivers, and bed sharing might be more common in families in which children have more persistent disease.

Psychological problems are also more prevalent in children who have atopic conditions such as asthma, yet they have been overlooked in sleep research.⁷⁸ Studies emphasize a specific relation between asthma, anxiety, and depressive symptoms in urban children.^{79–81} Furthermore, a relation between the perceptual accuracy of asthma symptoms and attention has been shown in children.⁸² Sleep problems can also exacerbate existing behavioral difficulties of children with nocturnal asthma.³⁴ Future research is needed to examine whether illness-related symptoms can influence the presence of psychological conditions and, in turn, affect quality of sleep. Medications used to treat conditions such as attention deficit hyperactivity disorder (eg, stimulants) need to also be considered.

Treatments that improve symptoms, particularly nasal congestion in patients with AR, such as intranasal corticosteroids,^{83,84} have been shown to improve patients' sleep²⁷ and might improve daytime sleepiness and quality of life.⁸⁵ Lower levels of sleep problems for children have been reported by caregivers during time periods when controller medications have been used.³¹ In contrast, sedating antihistamines can increase daytime sedation and fatigue,⁸⁶ worsening productivity and performance. In general, the role of effective management behaviors in promoting high-quality sleep practices in patients with allergic disease needs to be studied further in research. Although adherence to medications in low-income urban samples of children with asthma has been examined,⁸⁷ less work has focused on the effect of medication adherence on sleep quality in patients with allergic diseases who are at increased risk (ie, have more severe disease and poorer morbidity). For patients who have overlapping asthma and AR symptoms, balancing the management of both disorders through effective trigger control and continued medication adherence might be key to preventing impairments in sleep and improving daytime functioning. Consideration of the use of medications, the extent of patients' adherence to them, and their potential side effects is clearly warranted in research assessing sleep and subsequent functioning in patients with allergic diseases.

Focusing sleep research on other comorbidities of asthma and AR, such as obesity, which seems to be linked to sleep-disordered breathing, is an important area for further research.⁸⁸ It might be that the daytime fatigue caused by poor sleep can affect the level of activity, which can promote obesity and predispose patients to metabolic syndromes later in life. Furthermore, chronic cough and its link with OSA and potential effect on sleep warrant further research.⁸⁹ Treating these comorbidities, such as sleep-disordered breathing, might improve asthma morbidity and sleep.

One example of an ongoing study that is considering some of the limitations noted above is Project NAPS (Nocturnal Asthma and Performance in School; R01 HD057220, Koinis Mitchell). This project examines the co-occurrence of asthma and allergic rhinitis symptoms, sleep quality, school absences, and academic performance in a large sample of urban children (aged 7–9 years) with persistent asthma and a healthy control group over the course of an academic year. Real-time objective approaches through state-of-the-art methods are used to confirm asthma and allergic rhinitis and classify severity^{9,11} and to assess ongoing asthma symptoms (FEV₁ through home spirometry), nasal symptoms (peak nasal inspiratory flow through a nasal peak flow meter), sleep quality (actigraphy through actigraphy), and psychological and academic functioning throughout the school year. Preliminary results have shown associations between increased asthma and nasal symptoms through daily diary reports over the academic year and lower sleep efficiency in this sample of urban children.⁹⁰

CONCLUSIONS

In summary, sleep impairment associated with allergic diseases, such as asthma, AR, and AD, can have a significant effect on the patient's quality of life and functioning in specific areas. The sleep disturbance can be caused by congestion, symptoms of the underlying disease, and inflammatory cytokines and other mediators that can directly disturb sleep and cause daytime somnolence, fatigue, decreased cognitive and psychomotor abilities, and increased difficulty concentrating.⁹¹ More research needs to be done in this area to address the methodological, conceptual, and clinical limitations highlighted above, with continued research on environmental, individual, and family/culture-related mechanism that underlie the association between allergic disease and sleep and subsequent functioning (Fig 1).

Therapeutic interventions have demonstrated improvement in symptoms and quality of life through subjective and objective reports. Bolstering adherence to specific treatment recommendations that might be particularly relevant to sleep (medication use and trigger control) is important for future interventions with this group, particularly those with more severe disease or comorbid atopic conditions. A host of factors associated with allergic disease and treatment behaviors (eg, severity and adherence to treatment), as well as a patient's cultural background and context (eg, factors related to urban poverty and family sleep practices), can disrupt sleep and affect sleep patterns and need to be considered when working with patients who have allergic disorders.⁷⁴ Multidisciplinary interventions that focus on improving adherence to treatment recommendations, enhancing sleep hygiene and behaviors related to sleep quality through behavioral approaches, and attending to family and environmental factors that might affect sleep are necessary given the multidetermined nature of asthma and the array of consequences that sleep can have on a patient's functioning.

Acknowledgments

Supported by the Eunice Kennedy Shriver National Institute of Child Health and Human Development (R01 HD057220 to D.K.M.).

Abbreviations used

AD	Atopic dermatitis
AR	Allergic rhinitis
OSA	Obstructive sleep apnea

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FIG 1.
Conceptual model of the association between allergic disease and sleep. *SES*,
Socioeconomic status.