REVIEW ARTICLE

# From Progressive Asthma to Intensive Care Unit Respiratory Failure: Nursing Approach to Patient Care

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## ABSTRACT

Asthma is a systemic inflammatory disease characterized by complex and reversible airflow obstruction resulting from various bronchial reactions triggered by a combination of genetic and environmental variables. Allergens, smoking, pollen and air pollution are all common causes, and asthma exacerbations are one of the more common reasons for intensive care unit (ICU) admission. Nurses have a significant effect on the care of patients with asthma via the use of particular teaching approaches and health promotion templates focused on the principles of the Ottawa Charter for Health Promotion.

By monitoring the patient's condition via physiologic exercise, nurses are able to provide therapeutic care based on the causes and types of asthmatic insufficiency. Respiratory nurse practitioners play an important role in ICU management, asthma control, inhaler training, asthma action plan planning and emergency room management. (*Altern Ther Health Med.* 2021;27(5):38-44).


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## INTRODUCTION

Asthma has been recognized since the time of the ancient Egyptians. The Ebers Papyrus (circa 1550 BC), discovered in Egypt in 1870, contains hieroglyphics that detail more than 700 treatments for asthmatic conditions. One of the treatments is to inhale the gases produced by boiling herb bricks. The term "asthma" comes from the Greek word "aazein," which means "to pant or breathe with one's mouth open." During the 1930s and 1950s, asthma was thought to be a psychosomatic disorder. The inflammation hypothesis, which emerged in the 1960s, disproved a neurologic cause and proved that asthma is a physical illness. Nonetheless, since that time, a connection has been established between psychological conditions and difficult-to-treat asthma.

Asthma is a systemic inflammatory disease characterized by complex and reversible airflow obstruction due to various bronchial reactions triggered by a combination of genetic and environmental variables.[1,2] According to the Global Initiative for Asthma, it is a chronic inflammatory airway disease with involvement of many cells and cellular elements which is associated with hyperactivity of the airways, causing recurrent wheezing, difficulty breathing, tightness in the chest and cough, especially during the night and/or at morning. These episodes are normally accompanied by a significant but unpredictable disruption of circulation in the lungs, which is usually treated spontaneously or reversibly.[3]

In the United States, 24 million people have asthma; it is becoming more common, affecting 3.1% of the US population in 1980 and 8.3% in 2016. Asthma is a common chronic childhood condition that disproportionately affects African Americans and people living in poverty. Asthma flare-ups result in missed school and work, hospitalizations, emergency room (ER) visits and more than 3000 deaths per year. Asthma management is a huge financial burden, and for people with poor asthma control and in low-income countries, the cost burden is significant.[4]

According to a World Health Organization (WHO) 2018 report, approximately 235 million people worldwide have asthma and low to middle income countries account for 80% of asthma-related deaths. According to a 2016 Asthma UK survey, approximately 5.4 million people in the UK are

treated for asthma, which equates to 1 of every 12 adults, and the British Lung Foundation reported in 2016 that asthma incidence is higher among women (51% vs 49%). Compared with current census statistics, the National Institute of Allergy and Infectious Diseases (NIAID) in the United States published comparable findings in 2017, estimating that in the United States approximately 24 million people have asthma. As a result of the cost of medical attention and premature mortality, the ratio of 1 in 13 people to the price the US pays for care is about 56 billion dollars yearly.[5-7]

The bulk of asthma cases that need medical attention are dealt with outside of the hospital or in the ER, althouth certain asthma exacerbations may be life-threatening and require hospitalization. Approximately 25 000 to 50 000 adult patients with asthma seen in the ER need intensive care unit (ICU)-level care, but the rest are not intubated or manually ventilated. Most acute asthma attacks that receive standard first-line care in the ER clear within 120 minutes of onset. Just 6% to 13% of patients with asthma exacerbations in Canada need hospitalization, where regardless of whether or not assisted ventilation is required, the number of patients admitted to the ICU is very small.[8-10]

Approximately one-third of patients with acute asthma admitted to the ICU require mechanical ventilation; the mortality rate is approximately 8% (95% CI, 0%-38%). Asthma is a disease in which clinicians may collaborate and discuss with patients' families how to provide a reliably high level of respiratory care, which is also delivered by skilled nursing personnel. However, in extreme asthma cases, patients deteriorate rapidly and need to be closely monitored. Ventilators are an effective tool for lowering carbon dioxide levels in the blood.[11]

Patients with severe respiratory disability in the ICU should receive compassionate treatment. The amount of health education and promotion programs incorporated into nursing practice has increased over the past decade. Nurses have a substantial impact by implementing specific educational methods and health promotion models based on the Ottawa Charter for Health Promotion's values (published by WHO in 1986). The Ottawa Charter provided a positive definition for health (something to pursue, rather than something to be avoided) and encouraged the collaborative approach to health promotion that aims to promote health by changing the social determinants of health. The asthma nurse's primary goal is to maximize patient management both in the ICU and at home.[12-14]

## METHODS

### Literature Selection

Literature was searched from PUBMED/Mendeley/ScienceDirect/Medline/Google Scholar/and SpringerLink using the terms asthma and intensive care unit in combination with other terms such as nursing care, hospital, inpatient, patient education. Only English-language journals were included in the search. Reference lists for related journals are not found in the initial search were also screened.

### Study Participants

Both male and female patients 16 years of age and older with asthma diagnosed by a physician in various clinical settings such as inpatient clinics included in the studies were selected as study participants. Educational interventions provided by primary or asthma nurses targeted for individual adults were utilized for this study. These interventions, which occur before and after hospital discharge, may take place in an ER, inpatient unit or the community. Interventions may include providing information, counseling, the use of home peak flow or signs and symptom monitoring, a written asthma action plan or a combination.

## ASTHMA PATHOPHYSIOLOGY

Asthma is a multifaceted and complex inflammatory respiratory disease that can cause recurring symptoms that aggravate the condition. It is a chronic condition in which many inflammatory cells in the lungs become activated. In untreated patients, eosinophils can be seen in the airways alongside mast cells, lymphocytes and other mononuclear cells. This inflammatory penetration is linked to major bronchial structural changes. The naked epithelial and hypothetical modifications, which are marked by deposition of collagen, smooth muscle hyperplasia and hypertrophy, are examples of these structural changes.[15,16] Allergens, cold weather, bacteria, hormones, systemic eosinophilia, cigarette smoking, genetic anomalies and exercise are all believed to cause prolonged airway inflammation, which may result in airway congestion and hyperresponsiveness.[17,18]

The immune pathophysiology of asthma includes stimulating chronic airway inflammation by the initiation of the adaptive immune systems and innate immune systems. Persistent airway inflammation, airway edema, prolonged mucus secretion, obstruction of mucus and remodeling of the airway are symptoms of asthma. Subepithelial fibrosis, angiogenesis, hyperplasia of the mucous secreting gland raised in a mass of airway smooth muscle and basement membrane thickening contribute to the airway remodeling phase, which leads to a wide range of structures permanent. Combining T helper (Th) 1, 2 and 17 reactions with possible genetic sensitivity, the pathophysiology of how these identified causes lead to irreversible structural differences in different asthma endotypes is revealed (see Figure 1).[19-21]

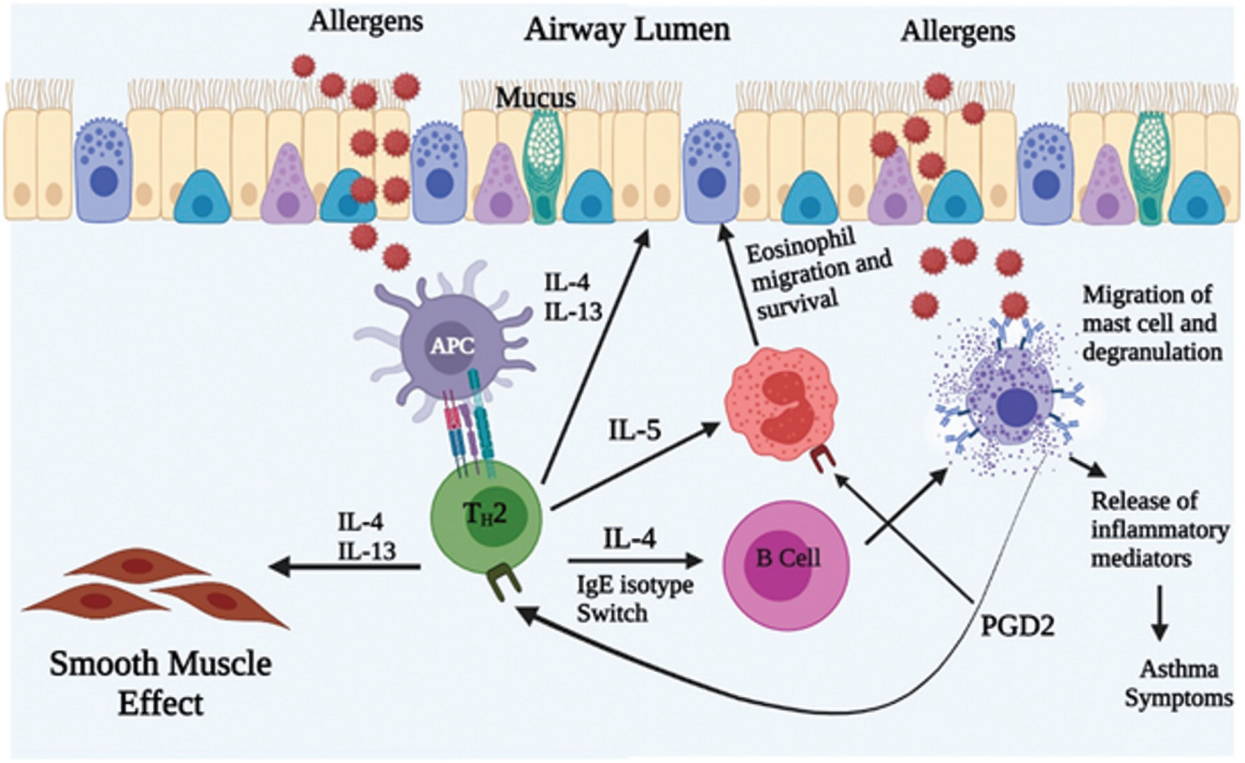
### Th1 Response

Infections, especially viruses, normally activate the Th1 response. Viruses increase the output of interleukin (IL) 27 and interferon-γ, which help in the removal of the pathogen but also contribute to airway inflammation.[22]

### Th2 Response

Dendritic cells in the airway present inhaled allergens to naïve T-cells, allowing them to turn into Th2 cells. IL-13, IL-5, IL-9 and IL-4 are Th2 cytokines released by Th2 cells. B cells are stimulated to release immunoglobulin E (IgE) by IL-13, IL-9 and IL-4. IgE causes bronchoconstriction by

**Figure 1.** Pathophysiology of asthma.




inducing mast cell degranulation and release of inflammatory mediators such as leukotrienes and histamine. Thymic stromal lymphopoietin, IL-33 and IL-25 are cytokines that aid in the maintenance of these pathways. IL-25 initiates the production of IL-9, IL-5, IL-13 and IL-4 in dendritic cells, while IL-33 initiates the development of IL-13 and IL-5 in dendritic cells. Eosinophils are maintained by IL-5, IL-9 and IL-13 aid mucous formation.[23-25]

### Th17 Response

Th17 cells produce both IL-17 and IL-22, which induce asthmatic airway remodeling. Although IL-17 promotes neutrophil penetration into the airways and morphologic transition from the airway epithelium to the interstitium, smooth muscle mass can be increased by IL-22.[26]

## GENETIC PREDISPOSITION TO ASTHMA

Although asthma is known to run in families, pinpointing the exact genetic mechanism for asthma is difficult. PHF11, ADAM33, DPP10, SPINK5 and GPRA are some of the genes that have been linked to asthma. Independent of inflammation, ADAM33 is active in airway remodeling. PHF11 is related to the integrity of the epithelial structure and the function of the G protein-coupled receptor (GPRA) in the respiratory epithelium is unknown. Allergic clusters are also linked to a hereditary predisposition. A genetic biomarker for AERD is DPP10, for example, and SPINK5 polymorphisms are linked to asthma and atopic dermatitis.[27-29]

### Biomarkers

Standard asthma biomarkers include sputum neutrophils, eosinophils, IgE, IL-17, periostin, leukotrienes and exhaled nitric oxide fractions (FeNO). Many other biomarkers, such as volatile organic compounds, dipeptidyl peptidase-4 and cytokines, have been studied in asthma, but there is scant evidence for their utility in clinical practice. Biomarker testing in patients with asthma helps determine the final form of asthma, but biomarker-based management is still minimal and has only been effective in a few cases of severe asthma.[30-32]

### Sputum Neutrophil

Based on sputum induction and cytology, patients with asthma may be categorized as neutrophilic, pauci-granulocytic, eosinophilic or mixed. While airway neutrophilia has been well established in severe asthma exacerbations, in acute asthma exacerbations the prevalence is uncertain. In healthy individuals, macrophages and neutrophils lead to induced sputum (median neutrophil ratio 37% [10th and 90th percentile, 11% to 64%]). Sputum neutrophil counts are increased by cigarette smoke, infection, ozone and endotoxins. In asthma trials, the cut-off for a high sputum neutrophil count ranged from 40% to 76%. Sputum neutrophilia may be a permanent phenotype of severe asthma or a therapy reaction.[33-35] Cluster research found that patients with the lowest lung potential despite maximal bronchodilator therapy have the highest sputum neutrophil count. Other tests, however, also showed that inhaled

corticosteroid (ICS) use is linked to a rise in sputum neutrophils, with sputum neutrophilia decreasing once ICS is tapered. An increase is sputum neutrophils and eosinophils can indicate infection, and increases in sputum neutrophils and eosinophils can help doctors recognize asthma patients with poor lung function.[36]

**Eosinophils**

Eosinophil levels in the blood and sputum can be used to detect eosinophilic asthma, and can be high in both allergic and non-allergic asthma. Serum eosinophilia may be used as a proxy marker for sputum eosinophilia, but sputum eosinophilia is more precise. According to a meta-analysis published in 2010, a sputum eosinophil count can be used to direct treatment in patients who are asthmatic. The biochemical reaction to anti-IL-5 therapy can be monitored using serum eosinophilia in particular.[37] However, since IL-4 and IL-13 encourage vascular cell adhesion proteins on eosinophils, serum eosinophilia cannot be used to track the response to dupilumab therapy because the eosinophil count artificially increases with the therapy. Peripheral eosinophilia is linked to more severe asthma exacerbations in children with asthma. Of all the asthma biomarkers, a serum eosinophil count provides the most useful information for asthma endotyping.[38-40]

**IgE**

Serum IgE levels and allergic sensitization are elevated in all forms of allergic asthma. IgM class-switch recombination is promoted by the Th2 cytokines IL-13 and IL-4, resulting in increased IgE levels. Anti-IgE immunotherapy is a successful treatment for allergic asthma, but serum IgE levels are not regularly monitored to assess exposure to therapy.[41]

**Interleukin-17**

Psoriasis and ankylosing spondylitis are 2 diseases in which IL-17 can induce neutrophilic inflammation. Researchers have found elevated IL-17 levels in activated bronchoalveolar lavage (BAL) tests, bronchial biopsies and sputum in patients with acute asthma. Although a randomized trial of IL-17 blockade with brodalumab, a humanized anti-IL17RA monoclonal antibody, was negative in moderate to medium asthma, it is unknown whether IL-17 is a causative factor in severe asthma. IL-17–producing cells and an IL-17-related gene expression signature have recently been identified in acute asthma, and this IL-17 signature is orthogonal to type 2 inflammation. Other research suggests that when type 2 inflammation in acute asthma is plugged, IL-17 activation in the airways increases. If that is indeed the case, a treatment that targets both Th2 cytokines and IL-17 may help people with serious asthma.[42]

**Periostin**

Fibroblasts, epithelial cells and eosinophils contain periostin, an extracellular matrix protein that plays a part in Th2-type allergic disease. Eosinophils are activated by IL-13 and IL-4 cytokines, which release periostin, which serves as a positive feedback loop to promote increased eosinophil production. Periostin is generated by fibroblasts and epithelial cells in response to IL-13, TGF-β and IL-4. Periostin also stimulates the development of NF-κB by fibroblasts and epithelial cells, which promotes fibrosis and airway remodeling. Periostin has been identified as a biomarker for asthmatic exacerbations. However, the clinical effectiveness of periostin in children is skewed by genetically elevated periostin levels due to bone turnover early in life.[43]

**FeNO**

Nitric oxide (NO) synthetases are enzymes that produce NO. Exhaled NO levels in asthma patients are high, which is thought to be due to airway inflammation upregulating inducible NOS in airway epithelial cells. NO concentrations in the gas phase can be measured using chemiluminescence analyzers. Fractional exhaled nitric oxide (FeNO) of exhaled breath should be expressed in parts per billion, according to the guideline. Asthma causes an increase in FeNO, which is reduced by inhaled steroids. The FeNO value distribution is skewed to the right, with a lot of variation between patients with asthma and healthy controls. The distribution of FeNO values is influenced by cigarette smoking, age, atrophy, etc.[44]

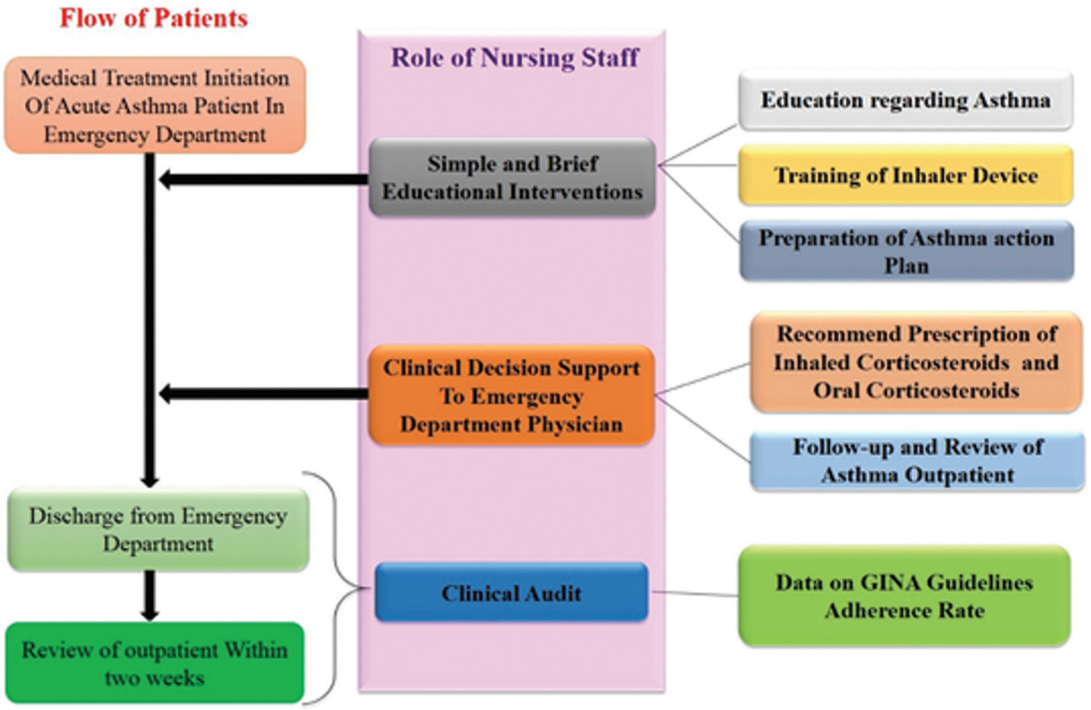
**Leukotrienes**

Inflammatory cells, such as mast cells, produce Cys-LT, leukotrienes generated by the intracellular 5-lipoxygenase enzyme. When leukotrienes are produced, the immune system's Th2 response is triggered. Urinary leukotriene E4 has many drawbacks, including the difficulty of obtaining a 24-hour specimen, the lack of readily available testing and the possibility of concomitant administration of leukotriene receptor antagonists affecting results.[45]

## THE ROLE OF NURSES IN THE MANAGEMENT AND REHABILITATION OF PATIENTS WITH ASTHMA

Asthma is a chronic illness, and good self-management is vital. Practice nurses are critical in assessing and systematically reviewing how well patients are managing their condition. Specialist and non-specialist nurses provide most of the care that patients get at the main, intermediate and tertiary levels of asthma, and they play an indispensable role in the majority of clinical services, while prescribing nurses make medical choices and adjustments in other environments. Nurses are also on the front lines of asthma healthcare, evaluating asthma management and agreeing on the right treatment options in consultation with the patient and physician.[18,46] Most facets of asthma management, including diagnosis, examination and monitoring of disease development and treatment effectiveness and instruction on therapy adjustment when necessary, are handled by nurses. According to the National Asthma Education Prevention Plan recommendations, healthcare professionals, including nurses, can establish a strong partnership with their patients by communicating effectively, addressing queries and assisting with disease control. Nurses are in a unique position

**Figure 2.** Role of nursing staff in manegment of patients with asthma.




to understand inadequate disease prevention and offer better treatment or expert referrals for high-risk patients as a result of these collaborations.[47]

**Nursing Staff Actions:**

- Before prescribing drugs, get a history of allergic reactions to medications.
- To assess the patient's respiratory status, keep track of the magnitude of asthma symptoms, breathing sounds, pulse oximetry, peak flow and vital signs.
- Find out what medications the patient is currently taking. If the patient has a persistent respiratory infection, give medications (such as antibiotics) as prescribed and keep an eye on how the patient reacts to them.
- Administer medications as prescribed and monitor the patient's response.
- Give the patient water if they are dehydrated.

Patients first receive asthma counseling from the nurse, which would include inhaler system instruction and the development of individualized formal action plans. The nurse also provides face-to-face professional judgment assistance to the ED practitioner when patients are physically fit to be discharged from the ED.[48,49]

**Nursing staff can help patients with asthma by:**

- Assisting them with correct inhaler techniques
- Providing guidance and advice to help them prevent asthma, including smoking cessation
- Developing a personalized asthma action plan in collaboration with patients (see Figure 2)

**Role of Nurses in Inhaler Technique Education**

Inhalers, which are engineered to deliver inhaled drugs straight to the lungs with no systemic adverse events, are the cornerstone of asthma therapy. This method can be used to administer all of the most effective medications. The effectiveness of therapy and health effects, on the other hand, is dependent on a patient's ability to follow their dosing schedule and use their system correctly. Pressurized metered dose inhalers (pMDIs) are the devices most often used for asthma, but they can be difficult to use since a high degree of coordination is needed to unlock the system when taking a long and intense inhalation.[50] Many patients lack the inspiratory capacity to inhale deeply and forcefully, which is a key requirement of the dry powder inhalers (DPI) and affects the particle size, which influences drug deposition and effectiveness. Patient errors can lead to a loss of disease control and an increase in healthcare use. Despite advances in inhaler design and instruction, the high occurrence of inappropriate inhaler technique has remained consistent over the last 40 years.[51]

Nurses are in a unique position to better treat asthma due to the regular nurse-patient/caregiver contact at various levels of disease control. In asthma, nurse-led patient assessment and inhaler education are linked to better technique, compliance and patient trust, and these will last for a long time. In a survey of patients with asthma, nurse-led patient education was shown to greatly improve inhaler proficiency and reduce treatment noncompliance. Such advances should increase treatment outcomes and potentially decrease disease morbidity and hospital admissions.

**To ensure effective inhaler technique, nurses:**

- Clearly explain to patients how the device works
- Educate patients on proper technique
- Assess technique regularly using inhaler competency standards and rectifying bad habits as required[52]

### Nursing Management in Critical Care of Patients with Asthma

The importance of a nurse's role in the treatment of an acute asthma attack cannot be overstated. A timely and accurate assessment of the patient's condition is important to prevent further exacerbation of the attack, increased morbidity and death. Perform a simple appraisal and encourage the patient to respond with a single syllable, a smile or a head shake or nod.

**Nurses also:**

- Estimate the patient's oxygenation level and provide oxygen if necessary.
- Keep an eye on oxygen saturation.
- Place the patient in a high Fowler's position, gently leaning forward with arm resting on an overbed table, which might be more comfortable.[53]
- At all times, keep an eye on the patient's respiratory and cardiovascular status.
- Continuous oxygen saturation monitoring and continuous cardiac monitoring are important. Keep in mind that hypoxemia can cause heart arrhythmias, which can lead to cardiovascular failure and death; a quiet chest could indicate respiratory failure.
- To control the duration of the episode and response to therapy, obtain the patient's peak expiratory flow rate as often as possible. Checking peak expiratory flow rate is a useful method for predicting potential attacks, gauging therapy response and determining the magnitude of an attack.
- Administer medicine as directed and keep an eye out for desirable and undesirable effects.[54]
- Most ERs have procedures in place for patients with asthma. If the patient's health does not change and/or deteriorates, they may need to intubate them.
- Maintain the level of care while a patient is intubated and on artificial ventilation. Keep an eye out for injuries from the electric ventilator.
- Patients and their families must also be trained by critical care nurses to better monitor asthma and avoid hospitalizations.[55]

### Nursing Staff Role in Designing an Asthma Action Plan

Asthma, if left untreated, will lead to a lower standard of life and even death. While there is no cure for asthma, there are well-established therapeutic guidelines for asthma treatment, such as asthma action plans (AAPs), that provide important home-care information including how to monitor airflow, administer maintenance and rescue medications, assess the severity of an injury, call a physician and go to the ER. "A written or electronic record decided upon by a patient and their health professional(s) with personalized advice about what action(s) to take when their asthma deteriorates" is how an asthma action plan was described in a study by Isik, et al in 2020.[56] According to the study, combining a written AAP with patient self-management advice resulted in a 27% reduction in the relative likelihood of exacerbations, a 40% percent reduction in hospital admissions and a 40% reduction in ER visits. Over the last 20 years, action plans have been suggested as a good asthma treatment, but they have been under-promoted and under-used for reasons that are poorly understood.

To address this problem, a hospital nurse developed a class that used simulations of standardized parent characters to teach staff nurses how to inform families about asthma medication and the use of an AAP to improve the care of patients with asthma. Although the research hospital's nurse-led simulation classes improved nurse knowledge of AAPs and interest in teaching them to patients and their families, there is no evidence in the literature that simulation preparation would improve provider knowledge of AAPs or experience teaching them to patients and families.[57-59]

## CONCLUSION

Asthma is one of the most common reasons for hospital admission. By informing patients and their families about asthma self-management and supporting and training other multidisciplinary members of an inpatient team to offer asthma diagnosis and guidance, nursing staff has been shown to play an important role in the clinical treatment of patients with asthma in hospitals. Respiratory nurse practitioners play a vital part in ICU management, the treatment of patients with asthma, providing training on inhaler use, preparing asthma action plans and assisting in ER management of patients with asthma.

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