ABSTRACT

A Public Health Proposal to Improve Management of Childhood Asthma

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Asthma, the most common chronic disease in children, affects 12.7% of individuals under eighteen in the United States. Asthma causes airway constriction when certain triggers, such as mold or cat dander, are encountered. No cure exists for asthma, but proper management can significantly improve the quality of life of an affected individual. Unfortunately, it can be difficult for low-income individuals to maintain proper asthma care. This thesis examines potential methods for identifying children who might be struggling to manage asthma as well as interventions that have been attempted to improve asthma care in children. Chapter Four analyzes these interventions and proposes a comprehensive plan for improving asthma care, especially for children in low-income situations. This plan would engage school nurses, healthcare providers, and community health workers to ensure that children are receiving proper asthma care. Emergency departments and accountable care organizations might fund this plan because of its potential long-term financial benefit.

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A PUBLIC HEALTH PROPOSAL TO IMPROVE MANAGEMENT OF CHILDHOOD ASTHMA

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TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER ONE

Introduction

Asthma as a Chronic Problem

As the most common chronic disease in children worldwide, asthma is a pervasive issue in the modern world and it is perhaps more common than ever. A basic definition of asthma is airway constriction that causes breathing difficulties; specific details of the pathophysiology will be discussed in the next section. The frequency and severity of symptoms experienced by asthmatics differ greatly, depending on certain factors that will be discussed. According to the World Health Organization, most deaths related to asthma are in middle- and low-income countries; however, this does not mean that asthma does not kill in high-income countries as well (World Health Organization, 2013). The most recent National Health Interview Survey in the United States found that 12.7% of children under the age of 18 had been diagnosed with asthma at some point in their lifetime; therefore, in the average school classroom of 30 students, there will be three or four students diagnosed with asthma (Centers for Disease Control and Prevention [CDC], 2013a). Unfortunately, data collected by the Centers for Disease Control and Prevention have found that the proportion of individuals with asthma in the United States grew by 28% between 2001 and 2011; however, due to the difficulty in diagnosing asthma and the range of severity, this statistic likely underestimates the number of children struggling with asthma, especially in low-income areas (CDC, 2013b). Recent data shows that in the United States, 1.5 million households, including 3 million children, live on $2 per person each day (Edin & Shaefer, 2015). Additionally, asthma, along with

other allergic diseases, has been found to be increasing in developing countries as the process of civilization leads to characteristics such as a fast-paced, westernized lifestyle (Rutkowski, Sowa, Rutkowska-Talipska, Sulkowski, & Rutkowski, 2014).

Statistics such as those presented above are a call for change in how asthma is viewed and fought domestically and abroad, especially in children. There is no cure for asthma; however, proper treatment can help improve the quality of life of any individual struggling to control asthma symptoms. Some of the most formative years in an individual's life are the elementary school years; no child should be kept from having fun and learning in school by a disease for which cost-effective treatment exists. Children with asthma should be able to run and play with their friends without fear of a potentially deadly asthma attack or terrifying hospital visit. This fear could lead to a sedentary lifestyle that carries into adulthood and can have detrimental effects on health (Hadgraft et al., 2015). Without treatment, asthma morbidity manifests as repeated hospital visits due to exacerbations, interruptions in daily activities, and an overall daily breathing struggle which can lead to depression and anxiety that affect body mass index (BMI) and overall health (Ciprandi, Schiavetti, Rindone, & Ricciardolo, 2015). If children can learn how to control asthma at a young age, they will carry the responsibility of self-treatment into adulthood and improve their overall quality of life as well as improve their ability for self-care.

While there are many measures in the United States to fight asthma morbidity and mortality, in order to truly see an improvement much more must be done. A cohesive implementation of effective strategies must take place across the nation so that children can be children while also learning management strategies they can carry into adulthood.

Ideally, the United States will come forth with an action plan to diagnose all asthmatics and provide them with proper care. If the plan was successful, it could serve as a model for other nations around the globe to begin improving the quality of life for children living with asthma.

Such an action plan will be proposed throughout the course of this paper. By necessity, the strategies must focus at least in part on impoverished areas because children living in these conditions lack the access to healthcare that is more easily found in wealthier areas. There are many reasons that cause lower-income areas to be more susceptible to both asthma development and undiagnosed asthma; these reasons will be discussed in a later section.

The Pathophysiology of Asthma

The pathophysiology of asthma is very complex and produces a curious amalgamation of symptoms in patients. The main characteristics are inflammation, increased reactivity, and mucous secretions in the airways (Harver & Kotses, 2010). Put together, these processes cause symptoms such as wheezing, difficulty breathing, airway constriction, and ultimately breathing obstruction. There is still much to be learned about asthma, but it is known that there are a few types of asthma.

Atopic, or extrinsic, asthma, the most common type, is characterized by an excess of IgE antibodies that react to common allergens. Atopy is passed on through genetics in families and includes a predisposition to other allergic diseases such as eczema, allergic rhinitis, and hives. Atopic asthma is often developed in childhood and the allergens causing the reaction are generally common environmental antigens (Kumar, Abbas,

Aster, & Robbins, 2013). All of the processes involved in atopic asthma are related to the immune system. An individual is sensitized to common allergens, such as particular pollens or cat dander, which primes the immune system for future interactions with those allergens. Atopic individuals are prone to such sensitizations due to the way their immune systems produce IgE antibodies in response to allergen interaction. These IgE antibodies are then attached to mast cells throughout the body so that any future contact with the offending allergen leads to histamine release and an inflammatory response (Kumar et al., 2013). This process for normal allergies occurs all over the body and the symptoms can be widespread. When the mast cells located in the lower airways are involved in such an allergic reaction, the inflammatory response that ensues leads to increased levels of mucus and other fluids secreted into the airways as well as constriction of the airways due to smooth muscle contraction (Kumar et al., 2013). As this process occurs chronically in atopic individuals, breathing becomes more difficult over time, and eventually, airway remodeling can occur.

Non-atopic asthma, also referred to as intrinsic asthma, occurs in a few different manners. Occupational asthma is one such mechanism, in which an individual's chronic exposure to a particular substance over the course of a career leads to an increased sensitivity to the substance and thus increased immune reactions to the substance in question. Other common triggers of asthma include viral respiratory infections, certain pharmaceutical agents such as aspirin, and inhaled air pollutants such as ozone and various nitrogen oxides. The airway inflammation caused by these agents can change the immune balance in the airways, thus leading to future tendencies toward hyperreactivity to irritants. Some individuals have an increased sensitivity to certain pharmaceuticals,

especially aspirin, which can lead to the combination of allergic diseases seen in atopic individuals, although the exact process is less well known (Kumar et al., 2013).

One other form of asthma is exercise-induced asthma. As a form of intrinsic asthma, it is not triggered by allergens but instead by exercise. Individuals with exercise-induced asthma regularly experience difficulty breathing during exercise, more so than the average individual. This increased airway resistance is often triggered by the movement of large amounts of air through the lungs, as is associated with exercise (Harver & Kotses, 2010). The development of exercise-induced asthma is not fully understood but it is clear than as these individuals exercise, their airways undergo narrowing and bronchoconstriction that increases the difficulty of breathing. Exercise-induced asthma is commonly treated with the use of a rescue inhaler such as a bronchodilator before exercise (Harver & Kotses, 2010).

One of the hallmark features of asthma is its reversibility. Bronchoconstriction caused by allergen interaction will occasionally remedy itself, but often, a beta-2 agonist such as albuterol is needed to help reopen the airways. As allergic inflammation is repeated throughout an individual's life, the airway walls can undergo airway remodeling, a structural change characterized by excess smooth muscle, excess mucous glands, and increased levels of collagen at the subepithelial level (Kumar et al., 2013). Once airway remodeling occurs in an individual, asthma becomes more difficult to treat and the ease of breathing worsens due to the increased severity of the asthma.

Diagnosis and Treatment of Asthma

In order to diagnose asthma, a healthcare provider must identify the proper constellation of symptoms and may perform assessments to confirm the diagnosis. Following this process, the level of severity must be diagnosed as well. Figure 1 from the National Heart, Lung, and Blood Institute's "Asthma Care Quick Reference" provides a detailed description of the levels of severity.

INITIAL VISIT: CLASSIFYING ASTHMA SEVERITY AND INITIATING THERAPY
(in patients who are not currently taking long-term control medications)

Level of severity (Columns 2–5) is determined by events listed in Column 1 for both impairment (frequency and intensity of symptoms and functional limitations) and risk (of exacerbations). Assess impairment by patient's or caregiver's recall of events during the previous 2–4 weeks; assess risk over the last year. Recommendations for initiating therapy based on level of severity are presented in the last row.

Components of Severity		Intermittent			Persistent								
					Mild			Moderate			Severe		
		Ages 0–4 years	Ages 5–11 years	Ages ≥12 years	Ages 0–4 years	Ages 5–11 years	Ages ≥12 years	Ages 0–4 years	Ages 5–11 years	Ages ≥12 years	Ages 0–4 years	Ages 5–11 years	Ages ≥12 years
Impairment	Symptoms	≤2 days/week			>2 days/week but not daily			Daily			Throughout the day		
	Nighttime awakenings	0	≤2x/month		1–2x/month	3–4x/month		3–4x/month	>1x/week but not nightly		>1x/week	Often 7x/week	
	SABA* use for symptom control (not to prevent EIB*)	≤2 days/week			>2 days/week but not daily	>2 days/week but not daily and not more than once on any day		Daily			Several times per day		
	Interference with normal activity	None			Minor limitation			Some limitation			Extremely limited		
	Lung function		Normal FEV, between exacerbations	Normal FEV, between exacerbations									
	➧ FEV,* (% predicted)	Not applicable	>80%	>80%	Not applicable	>80%	>80%	Not applicable	60–80%	60–80%	Not applicable	<60%	<60%
	➧ FEV,/FVC*		>85%	Normal†		>80%	Normal†		75–80%	Reduced 5%†		<75%	Reduced >5%†
Risk	Asthma exacerbations requiring oral systemic corticosteroids‡	0–1/year			≥2 exacerb. in 6 months, or wheezing ≥4x per year lasting >1 day AND risk factors for persistent asthma	≥2/year		Generally, more frequent and intense events indicate greater severity.			Generally, more frequent and intense events indicate greater severity.		
		*Consider severity and interval since last asthma exacerbation. Frequency and severity may fluctuate over time for patients in any severity category. Relative annual risk of exacerbations may be related to FEV,.**											
Recommended Step for Initiating Therapy *(See "Stepwise Approach for Managing Asthma Long Term," page 7)*		Step 1			Step 2			Step 3	Step 3 medium-dose ICS* option	Step 3	Step 3	Step 3 medium-dose ICS* option or Step 4	Step 4 or 5
The stepwise approach is meant to help, not replace, the clinical decisionmaking needed to meet individual patient needs.								*Consider short course of oral systemic corticosteroids.*					
		In 2–6 weeks, depending on severity, assess level of asthma control achieved and adjust therapy as needed. For children 0–4 years old, if no clear benefit is observed in 4–6 weeks, consider adjusting therapy or alternate diagnoses.											

* **Abbreviations:** EIB, exercise-induced bronchospasm; FEV_1, forced expiratory volume in 1 second; FVC, forced vital capacity; ICS, inhaled corticosteroid; SABA, short-acting $beta_2$-agonist.

† Normal FEV_1/FVC by age: 8–19 years, 85%; 20–39 years, 80%; 40–59 years, 75%; 60–80 years, 70%.

‡ Data are insufficient to link frequencies of exacerbations with different levels of asthma severity. Generally, more frequent and intense exacerbations (e.g., requiring urgent care, hospital or intensive care admission, and/or oral corticosteroids) indicate greater underlying disease severity. For treatment purposes, patients with ≥2 exacerbations may be considered to have persistent asthma, even in the absence of impairment levels consistent with persistent asthma.

Figure 1. From "Asthma Care Quick Reference," by National Heart, Lung, and Blood Institute, 2012, p. 5. Copyright 2012 by the Department of Health and Human Services.

Individuals with asthma commonly present with symptoms such as coughing, wheezing, breathlessness or difficulty breathing, and chest tightness, especially at night and in the early morning. In the presence of these symptoms, a healthcare provider can perform an assessment to determine the reversibility of the symptoms. For example, a

patient's medical history may show that the symptoms improved after relocation to an allergen-free area or with the use of a short-acting beta agonist. A physician can also perform spirometry (pulmonary function tests) to determine the reversibility of symptoms (a hallmark of asthma). Relevant values for pulmonary function test are provided as FEV_1 and FEV_1/FVC on the chart in Figure 1. Once a healthcare professional has diagnosed the patient with asthma, the chart in Figure 1 can assist the diagnosis of asthma severity.

Asthma is typically categorized into one of four different levels of severity: intermittent, mild persistent, moderate persistent, and severe persistent. As seen in Figure 1, intermittent asthma is characterized by the occurrence of symptoms a maximum of twice per week and no interference with normal activity. Mild persistent asthmatics experience symptoms between two and six days per week with only mild interference with regular activity and use of a short-acting beta agonist between two and six times per week. Moderate persistent asthma is characterized by daily symptoms and daily use of a short-acting beta agonist with some limitation of normal activities. Patients with the most restrictive form of asthma, severe persistent asthma, experience symptoms throughout each day and must use a short-acting beta agonist multiple times during any given day. Their activities are extremely restricted and they often are awakened by their asthma at night.

Current guidelines refer to step therapy that goes along with the levels of severity of asthma. The breakdown of these steps can be seen in Figure 2, as provided to physicians by the National Heart, Lung, and Blood Institute of the National Institutes of Health. Of particular interest in this thesis is the five to 11 age group. Step One is always

a short-acting beta agonist, also known as a rescue inhaler, such as albuterol. Step One correlates with intermittent asthma, although asthmatics of any severity should have a rescue inhaler that can be used when symptoms occur. Step Two consists of treatment with a low-dose inhaled corticosteroid such as budesonide or fluticasone, commonly known as Pulmicort and Flovent respectively. Patients with mild persistent asthma are typically well controlled with a Step Two intervention. Children aged five to 11 with moderate persistent asthma generally have Step Three interventions. This may consist of treatment with a low-dose inhaled corticosteroid and either a long-acting beta agonist, otherwise known as a bronchodilator, such as salmeterol (Serevent Diskus) or a leukotriene receptor agonist such as montelukast (Singulair). This can be provided in a combination inhaler such as Advair, which contains both fluticasone and salmeterol. The other option at Step Three is a medium-dose inhaled corticosteroid, which the guidelines prefer over the combination option for children aged five to eleven years. Step Four, usually correlated with severe persistent asthma, consists of both a medium-dose inhaled corticosteroid and a long-acting beta agonist, which can be achieved through a combination inhaler such as Advair or Symbicort. Severe persistent asthmatics that are not well controlled with Step Four may be moved up to Step Five or Step Six. Step Five is a high-dose inhaled corticosteroid and a long-acting beta agonist, while Step Six adds on an oral corticosteroid. In addition, patients with atopic (extrinsic) asthma may consider receiving immunotherapy such as allergy shots to reduce the sensitization to particular allergens.

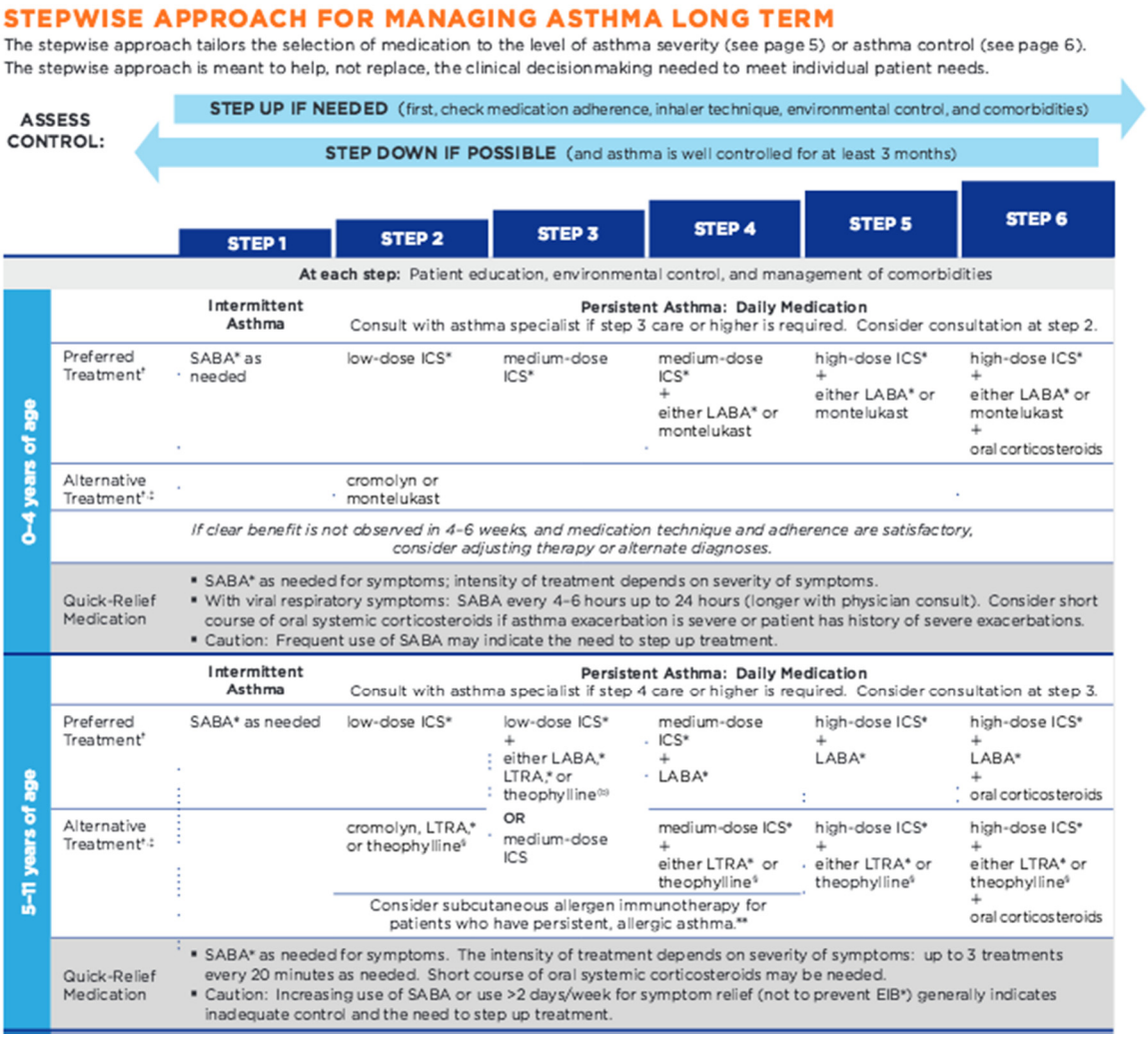

Figure 2. Adapted from "Asthma Care Quick Reference," by National Heart, Lung, and Blood Institute, 2012, p. 7. Copyright 2012 by the Department of Health and Human Services.

Populations Susceptible to Asthma Development

There are many documented risk factors for the development of asthma. Atopy, of course, is the most important risk factor for developing allergic asthma. As discussed previously, atopy is a heritable characteristic that predisposes certain individuals to developing increased sensitivity to allergens and thus hyperreactivity to such allergens. Atopic individuals spend their lives having allergic responses to commonly occurring allergens. As discussed earlier, having more allergic reactions leads to increased

inflammation in the airways that can lead to hyperreactivity of the lower airways, difficulty breathing, and eventually airway remodeling. The process of asthma development in atopic individuals was discussed previously; clearly atopic individuals are at a much higher risk than non-atopic individuals for developing asthma, especially allergic asthma.

Another important risk factor for developing asthma is cigarette smoking. While most young children do not smoke themselves, a recent study found that over 50% of asthmatic children in inner cities are exposed to secondhand smoke, a greater proportion than children living in other regions (Kanchongkittiphon, Gaffin, & Phipatanakul, 2014). Tobacco smoke in the lungs induces mucus production and inflammation akin to that experienced with allergies. As this chronically occurs in smokers or in those affected frequently by secondhand smoke, scarring can be induced, making breathing more difficult (Partners Healthcare, 2010). Eventually, scarring of the airways can lead to asthma and other respiratory problems such as emphysema and lung cancer. Children who are chronically exposed to secondhand cigarette smoke are more likely to develop asthma than children free from secondhand smoke (Partners Healthcare, 2010). Cigarette smoking is a major risk factor for the development of asthma and for poorly managed asthma in children.

Socioeconomic status can be a major risk factor for the development of asthma. It is often the case that children living at or below the federal poverty line are exposed to more risk factors than children living in wealthier homes. It is not only that low socioeconomic status children are exposed to more and different allergens, but it is also that families in these situations often have little means to change their situation and thus

protect their children from the allergens. Some common allergens in impoverished areas are cigarette smoke, cockroach, mouse and cat dander, dust mites, and in urban areas, pollution such as diesel particles (Keet et al., 2015). Chronic exposure to these allergens, especially for atopic children, can lead to the development of asthma. Unfortunately, many children in poverty are chronically exposed to many such allergens due to the nature of their circumstances. They lack the ability to change the allergens around them, and when asthma does develop, they also lack the ability to care properly for their asthma, which can cause increased numbers of hospital visits due to exacerbations.

Populations Susceptible to Undiagnosed and Poorly Managed Asthma

While populations can be prone to develop asthma due to both genetic and environmental factors, the primary factor driving the under-management of asthma in children is low socioeconomic status. According to the most recent census information, 14.5% of the population in the United States lives in poverty, meaning that the yearly income is under 100% of the federal poverty guidelines (DeNavas-Walt & Proctor, 2014). In addition, the prevalence of asthma in impoverished children is higher than that in children living in middle- or high-income homes (Ungar, Cope, Kozyrskyj, & Paterson, 2010). Children living in these homes may not have the means to properly manage their asthma or any other chronic illness they may have. Unfortunately, along with poorly managed asthma comes an increase in the number of exacerbations of asthma and consequently more visits to the emergency department for asthma exacerbations. One study conducted in Maine showed the existence of a socioeconomic status (SES) gradient relating to hospitalizations for asthma exacerbations: the lowest income groups

had the most hospitalizations compared to moderate- and high-income areas as seen in Figure 3 (McGrath, Stransky, & Seavey, 2010).

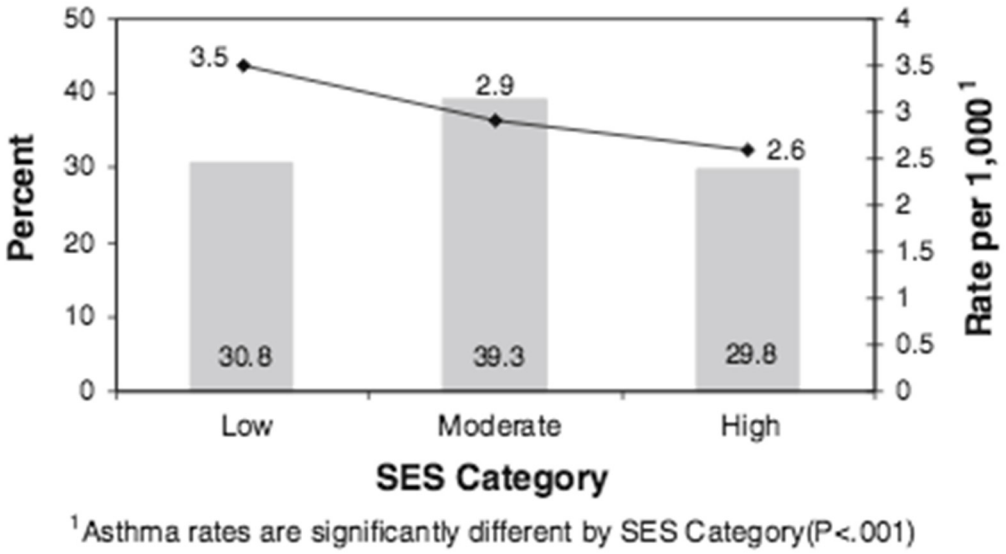

Figure 3. SES category and asthma hospitalization rates by all zip codes. From "The Impact of Socioeconomic Factors on Asthma Hospitalization Rates by Rural Classification," by R. J. McGrath, M. L. Stransky, and J. W. Seavey, 2010, *Journal of Community Health, 36,* p. 495-503. Copyright 2011 by the Journal of Community Health.

Oftentimes, parents of impoverished families must work multiple jobs to simply put food on the table for their children, meaning that there is rarely money left over for physician visits or medication, especially if insurance is not an option. Without insurance, it is highly unlikely that a family will be able to afford the medications necessary for properly controlling asthma due to the exorbitant costs and the frequent necessity of multiple medications as described by the stepwise interventions provided above. One study showed that parents would forego items such as clothing and eyeglasses to get asthma medication for their children and would sometimes try to stretch the length of time between prescriptions by using smaller doses (Ungar, MacDonald, & Cousins, 2005). While it is admirable that these parents work so hard to get asthma care

for their children, it is important that their children have regular physician visits and consistent medication at the proper dose.

Asthma is one disease for which it is crucial to maintain regular visits with a physician in order to keep the asthma under control. Without regular physician visits and consistent daily medication, a child with persistent asthma may be prone to a higher rate of asthma attacks and exacerbations. Depending on the child's location when these exacerbations occur, it is possible that they will be taken to the hospital in order to receive treatment and control the attack. The emergency department would likely give a child's caretaker a prescription for medication but often the prescriptions are not filled or refilled due to financial costs. In addition, an emergency department by nature cannot provide longitudinal care making it even more likely that the child's asthma will not improve. Again, the lack of money available for healthcare in poverty is a crucial missing piece that must be remedied.

One source of funding for medications for low-income children is The Children's Health Insurance Program, or CHIP, the equivalent of social security for impoverished children. Essentially, CHIP is a safety net that seeks to insure children in families with too much money to qualify for Medicaid. It covers well checks, prescriptions, immunizations, hospital care, emergency services, dental visits, vision care, and laboratory services, including x-rays (U.S. Department of Health and Human Services, U.S. Centers, 2015). The 2015 federal poverty guidelines label a family of four with an income less than or equal to $24,250 as impoverished in the contiguous United States (U.S. Department of Health and Human Services, 2015). While CHIP can be extremely beneficial for its recipients, especially those with chronic diseases, there are a few issues

with the program. One such issue with CHIP is that the program varies from state to state, with different requirements and benefits in each state. In most states, CHIP only costs a family $50 a year. Depending on the amount of funding allocated by each state for CHIP, the income level that determines eligibility may differ greatly. In Texas, children in a family of four with a yearly income between $33,000 and $49,000 are eligible for CHIP (Texas Health and Human Services Commission, 2015). Families with a yearly income less than $33,000 are eligible for Medicaid. This means that children in Texas living in a home with an income at less than 201% of the federal poverty level should be enrolled in either CHIP or Medicaid. However, even if a family has children that qualify for insurance under Medicaid or CHIP, it is possible that the family is unaware of the process and possibly incapable of completing the necessary steps to enroll in the program.

Another issue with CHIP is that in many states, including Texas, there is an inadequate safety net, meaning more children are in need of CHIP or Medicaid than can receive it due to inadequate funding. In some instances, states have not expanded Medicaid and also do not have enough funding to cover all of those who theoretically qualify due to their income level. Families in this situation do not have to pay the fee for being uninsured because they would have Medicaid if there were enough funding; however, they still must pay out of pocket for healthcare services as needed (U.S. Department of Health and Human Services, U.S. Centers, 2015). Unfortunately, states with unexpanded Medicaid and a lack of funding leave many children uninsured yet still in need of healthcare. Families may find it difficult to locate a physician willing to take Medicaid or CHIP. If this is the case, these families may go to emergency rooms because

such institutions cannot turn away patients in need of care. The primary consequence is that emergency rooms serving underinsured and uninsured populations accrue billions of dollars of bad debt from uncompensated care (American College of Emergency Physicians, n.d.). Despite the presence of government-based income for children, there are many who still cite financial problems for not visiting a physician. While CHIP certainly benefits its recipients, it is simply not enough to provide quality healthcare for impoverished children in the United States.

When parents in a low-income household are working multiple jobs, they are often not present to help their children care for their asthma. Children may not know how to work a nebulizer properly or may not have adequate access to medication they might need while their parents are at work. This could lead to poorly managed asthma in impoverished children. Parents in poverty may not even know that their child has asthma, especially if the child does not see a primary care physician regularly. If they are not home regularly to notice the breathing patterns and symptoms of their children, they may not even realize that there is a problem. Children who complain of symptoms may not be taken seriously and likely will not have the opportunity to visit a physician. It is imperative that children regularly see a health care provider so that they can receive treatment for conditions that may not seem like a serious issue, such as asthma.

Another consequence of working parents' absence from the home is decreased cleanliness in the home. Often, this can lead to homes that are not as clean as those of stay-at-home parents (Ungar et al., 2010). A home environment that is not kept clean can increase the levels of allergens to which children in the home are exposed. This can lead to the development of asthma, especially in atopic children, and to exacerbations in

children who have already developed asthma. It is very important to control the allergens that exist in the home, particularly when there are known asthmatics.

In another scenario, the caretaker may not understand the dangers of asthma as a chronic disease and thus the critical importance of the medication in controlling the child's asthma. Without proper education on the importance of using medication to control the effects of asthma, a caretaker may choose to spend limited funds on something other than the medication a child needs. It is important that caretakers are taught about asthma, its manifestations, and its consequences when a child is diagnosed and at every physician visit so that the caretakers can know to place importance on the maintenance of their child's asthma.

As previously addressed, smoking is an important risk factor for the development of asthma, particularly in low-income areas. It is extremely difficult for caretakers to work multiple jobs, care for children, and try to stay afloat economically. Studies show that individuals who experience non-specific psychological distress such as anxiety or depression are more likely to be smokers (Lawrence, Mitrou, & Zubrick, 2011). Unfortunately, despite any perceived benefit for the caretaker who smokes, secondhand smoke is very dangerous for children, especially those who have already developed asthma. Even when caretakers have been educated about the harmful effects of smoking on children who have asthma, it is often very difficult for them to quit due to their life circumstances, smoking's status as a coping mechanism for distress, and the addictive nature of cigarettes. However, adults with higher levels of psychological distress have a more difficult time quitting cigarette smoking than adults with less psychological distress (Lawrence et al., 2011). Sometimes, the best they can do is to agree only to smoke

outside the home. While this is slightly helpful for the child, it would be better if the caretaker could quit smoking altogether because it is so detrimental to children with asthma. Low socioeconomic status is a very important risk factor for poorly managed asthma in children due to the challenges faced by their caretakers.

Purpose of Thesis

Based upon the information previously provided, this thesis will encompass a review of the literature related to childhood asthma, particularly in impoverished areas, in order to identify successful tactics and strategies for identifying asthma and providing care to children lacking a comprehensive care plan for the treatment of their asthma. An assessment of the best strategies will be proposed as a method for reducing the amount of undiagnosed and poorly managed asthma in children. The proposed action plan is intended to be a recommendation for managing childhood asthma in poverty from a public health perspective.

CHAPTER TWO

Identifying Children with Asthma

It is clear that there is a great need for the identification of children struggling with asthma because it is impossible to provide quality asthma care to children that have not yet been identified as struggling with asthma (Liao, Morphew, Amaro, & Galant, 2006). There are many known risk factors for asthma that can be used to identify populations with a higher risk of poorly managed asthma including atopy, cigarette smoking, and socioeconomic status. As previously addressed, children in low-income homes are often exposed to asthma triggers that they cannot escape. For this reason, it is crucial that the identification methods to be discussed are applied aggressively in low-income areas, although they may be effective in other areas as well.

The most important location for asthma identification in children is the school. In some situations, extracurricular activities such as sports may be a potential site for asthma identification, especially for children in middle- or high-income areas. However, children in low-income situations are less likely to follow a routine schedule for extracurricular events. Fortunately, government-mandated education ensures that even low-income children will attend school consistently. In addition to the continuity provided by school attendance, students spend about 30% of each weekday at school, a significant amount of time during which educators could potentially identify children struggling with asthma (Lucas, Anderson, & Hill, 2012). Another method of identification is through the use of reports on housing code violations to determine regions where children may be exposed to a greater number of triggers.

School Nurse

A school nurse is the individual responsible for helping students manage illness at school, whether it is an acute illness like the flu or a chronic illness such as asthma. The nurse assists students requiring the administration of medicine during the day and also often works with students to allow them to participate in all the activities that peers do, such a recess, physical education, and field trips (Jones, Wheeler, Smith, & McManus, 2009). The nurse also works with teachers to help manage students' illness and can be a great resource for teachers needing more education about a particular condition a student may have. In addition to teachers, nurses within schools may also communicate with the parents of any child with an illness. In this way, the nurse acts as a sort of liaison between students, parents and teachers on the topic of illness. Nurses who recognize that a student is regularly struggling with an illness can encourage the child's parents to visit a physician as well.

These numerous roles fulfilled by school nurses would appear to tout the importance of having a school nurse that knows the students, especially those with chronic illness, in every school. However, data shows that there is a significant shortage of nurses in American schools. The Asthma Initiative of Michigan (AIM) determined that less than 16% of schools in the state employed a full-time school health professional while less than 23% of the schools employed either a full- or part-time school health professional (Goei et al., 2006). The 2006 national School Health Policies and Practices Study (SHPPS) measured adherence to the recommendations established by the NAEPP in "How Asthma-Friendly is Your School?" This study defined a school nurse as a full-time licensed practical nurse (LPN) or registered nurse (RN) who worked at least 30

hours each week in the month preceding the study. It was found that 35.7% of all schools had a full-time nurse and that the percentage of elementary schools with a full-time nurse (30.3%) was less than that of middle schools (39.7%) and high schools (44.1%) nationally (Jones et al., 2009). This low statistic leaves much room for improvement in the percentage of schools employing a full-time school nurse. Chapter Three will continue to address the significance and potential impact of school nurses and roles that nurses can play in improving the management of asthma.

Classroom Teachers

Students, especially those in elementary school, spend the majority of their time with one classroom teacher. This provides the teacher with a unique opportunity to watch for symptoms of illness in children and bring them to the attention of the school nurse, and if the school lacks a nurse, the child's parents can be notified. While the majority of the time a teacher spends with the students is within the classroom, at some schools, classroom teachers supervise recess. This provides an opportunity for the teacher to observe the students at play and potentially recognize when a student is acting unusually or struggling to breathe. For example, a child that has previously spent every recess playing tag may abruptly begin participating in activities that require less exertion. It is possible that the student has developed asthma and simply cannot handle the exertion required to play games such as tag during recess. The teacher can discuss this change with the student and determine whether any action should be taken and whether the school nurse should be notified. This is just one example of how a teacher might identify a child struggling with asthma.

While classroom teachers have a great opportunity to identify children struggling with asthma both in the classroom and during recess, not all teachers are fully prepared or adequately educated on asthma to make such observations. A study conducted in Illinois elementary schools found that only 32.4% of the teachers questioned had received training on asthma from their current employer and 85.3% of the teachers felt that they would benefit from educational sessions on asthma. Further, the questionnaire assessed the teachers' confidence in managing an asthma attack: 50% of the teachers felt incapable of handling an attack and 29% were unsure in their ability to handle an asthma attack (Lucas, Anderson, & Hill, 2012). The questionnaire included a twenty-five-question test of asthma knowledge. The average score on the test was 75% and the highest score was 92% (Lucas et al., 2012). A similar study conducted in Ontario, Canada found that 80% of teachers were not confident in their ability to handle asthma (Cicutto et al., 2006). These studies show that teachers may not be able to properly manage an asthma attack in a student. If this is the case, it is unlikely that teachers will be able to identify children struggling with the milder symptoms of asthma. Potential methods of improving asthma education in teachers will be discussed in Chapter Three.

Physical Education Instructors

While physical education (PE) teachers do not spend nearly as much time with each student as a classroom teacher, they do see students in a more vulnerable state for asthma. Activities done during physical education have the potential to cause and exacerbate symptoms in a child with asthma. PE instructors are important in identifying children struggling with asthma because they have numerous opportunities to observe

how exercise and certain triggers, such as dust in a gymnasium or pollen outside, might decrease the ease with which a child breathes. Similar to a classroom teacher who may be observing recess, a PE instructor can identify a child struggling with asthma during physical activity and ask the child about the problem. The instructor can also notify the classroom teacher and school nurse to keep a closer eye on the child and ensure that proper care is received.

Once again, despite the critical role PE instructors can play in identifying children struggling with asthma, not all instructors are fully competent or confident in their abilities to manage physical activities for children with asthma (Sandsund, Thomasson, Reinertsen, & Steinshamn, 2011). One study discovered that of all required physical education classes assessed, only 43.6% of them had a teacher who had received staff development in the previous two years (Jones et al., 2009). Another questionnaire-based study found that even among teachers with basic knowledge about asthma, most were unsure what to do in the case of an asthma attack (Soto, Martínez, Mac-Kay, & Barra, 2014). It was also determined that many PE instructors felt they would benefit from training on asthma and would also like communication from the child's physician describing any limitations the child may have (Sandsund et al., 2011).

Housing Code Violation Density

While schools can be crucial in allowing for the identification of children with asthma, they are not the only method of identification. A geomarker can be defined as "any objective, contextual, or geographic measure that informs additional assessments and interventions for patients who are affected by chronic illnesses that are sensitive to

the surrounding environment," such as asthma (Beck, Huang, Chundur, & Kahn, 2014). One such geomarker is Housing Code Violation Density. The violation of housing codes can lead to indoor environmental conditions that can exacerbate asthma, such as pests, water damage, and mold (Beck, Huang, Chundur, & Kahn, 2014). A study on housing code violation density in Cincinnati, Ohio found a very high correlation between areas with a high density of housing code violations and poverty as well as utilization of hospital services (Beck, Huang, Chundur, & Kahn, 2014). For this study, utilization was defined as any asthma-related emergency department visit or hospitalization. The study found that housing code violation density accounted for 22% of the total variance in the asthma-related utilization of hospital services population-wide (Beck, Huang, Chundur, & Kahn, 2014). Census tract data was used in the study, making this process something that could be used in the future for identifying areas where there may be a high percentage of children struggling with asthma. In addition, because of the high correlation between poverty and areas with many housing code violations, any children struggling with symptoms of asthma are unlikely to be receiving proper care for their asthma. Chapter Three will further discuss potential uses for data describing areas with a high density of housing code violations that could improve the care received by asthmatic children in these areas.

Potential Challenges in Identification

While the methods of identification addressed should provide a significant start in improving the quality of life for children with asthma, there are some potential challenges that remain to be addressed. A significant challenge is the lack of school nurses in

American elementary schools. Children in elementary school require more assistance with administration of medication than children in middle school or high school; it seems there should be more full-time nurses in elementary schools than in secondary schools. Even in schools with nurses, there may be gaps in the knowledge of the nurses that inhibits the proper care of asthmatic children at their schools. Nurses who only work part-time may fail to sufficiently grasp the illnesses in each of the students in the school. These situations related to school nurses may inhibit the identification of students within the school that have either undiagnosed or poorly managed asthma.

Classroom teachers have a significant opportunity to identify students struggling with asthma because of the vast amounts of time they spend together. However, as previously stated, many teachers are uncomfortable in their ability to handle asthma attacks in children who have already been diagnosed. If this is the case, teachers cannot reasonably be expected to watch for earlier, milder symptoms of asthma. A major challenge in identification by classroom teachers is the lack of asthma education. Teachers are often too busy to attend information sessions outside of the typical workday. Chapter Three will discuss potential methods of ensuring that teachers are comfortable with handling asthma attacks should they occur as well as capable of identifying children struggling with asthma in the classroom. One challenge faced by physical education instructors is that it can be challenging to determine whether a child is struggling with an illness such as asthma or if the child is simply not motivated to participate in the activities (Soto, Martínez, Mac-Kay, & Barra, 2014). Education geared towards physical education instructors will also be discussed in Chapter Three.

Another significant challenge in schools is the lack of funding for education. It may be nearly impossible for all elementary schools to employ a full-time nurse due to the expense of having another employee, even if the school administrators realize the importance of having a nurse on the campus every day. There also could be a lack of funding for staff education on asthma. However, there are ways to provide asthma education for educators without significant cost to the school. One final effect of a lack of funding is the removal of physical education in schools. Despite the value of physical education instructors as identifiers of children with asthma, they may not be able to have such an impact in the future. Unfortunately, in some schools, budget cuts have led to the removal of physical education despite the many benefits of physical activity in children (Trost & van der Mars, 2010). In some situations, the size of physical education classes increased dramatically, a solution to funding problems that decreases physical education instructors' ability to watch all students closely for signs of asthma (Spark, n.d.). Some potential solutions to budget cuts in education will be discussed in Chapter Three.

One final challenge that may be faced in the identification of children is the potential lack of data on housing code violations. In the study discussed previously, census tract data was used. It is possible that recent data on particular regions may be lacking because census data is only collected every ten years, which would seriously decrease the potential use of geomarkers to identify children with asthma in those regions. However, there may be other, locally collected sets of data that can be utilized in the identification process. In addition, individuals receiving the census survey must complete it according to federal law, so at a minimum, there should not be any significant gaps in the census tract data. These potential challenges will surely present themselves in

some situations, but with planning, these challenges will not significantly deter the identification of asthmatic children.

CHAPTER THREE

Previously Attempted Interventions

Stepping into Schools

Schools are a valuable location for potential asthma interventions for reasons discussed in Chapter Two. During the school day, teachers, nurses, community health workers, and other invested adults have the opportunity to see many children and address potential issues.

Comprehensive School-Based Plans

There have been many attempts at implementing a comprehensive plan in schools to improve asthma management. A randomized control trial in Detroit public schools measured the efficacy of a comprehensive school-based asthma plan. Children with asthma were enrolled in the program, which had six portions: "Open Airways for Schools," which is an asthma management training program for the enrolled students, classroom activities for all students, asthma awareness training for school counselors and principals, training on possible triggers within the school, school fairs to provide asthma awareness for students and caregivers, and written communication with the child's healthcare provider to request an action plan (Clark et al., 2004). Children in the intervention group experienced a significant decrease in daytime symptoms compared to children in the control group for both intermittent and persistent asthma. Nighttime symptoms were reduced in the intervention group compared to the control group for persistent asthma, but students with intermittent asthma in the intervention group had

twice the nighttime symptoms of those in the control group (Clark et al., 2004). The authors of this study say this discrepancy may be due to the increased awareness of asthma symptoms in families with a child with intermittent asthma. The study found an increased ability to manage asthma in the intervention group compared to the control group as well (Clark et al., 2004). One outcome measured in this study was academic performance; the only significant result was higher science grades in the intervention group compared to the control group. There was not a significant difference in the number of school days missed between the control and intervention groups; this could be due to relatively high rates of absenteeism already present in the schools (Clark et al., 2004). One challenge faced in this study was the sixth facet: communication between schools and clinicians. The schools were unable to reach the clinicians in most cases, which suggests that access to better healthcare may have added to the benefits seen by the intervention program (Clark et al., 2004).

The Public Health School Asthma Pilot Project to create asthma-friendly schools was implemented in Ontario schools. This intervention used a school-based education program for students with asthma called The Roaring Adventures of Puff for six weekly one hour sessions along with a Creating Asthma-Friendly Schools Resource Kit meant to improve the school's overall management of asthma (Cicutto et al., 2006). The student education program attempted to improve the students' knowledge about asthma as well as their ability to manage their disease. The resource kit introduces a set of seven goals for schools: have an annual process to identify children with asthma, provide easy access to inhalers, implement a school-wide process for managing asthma including steps to be taken during an asthma attack, identify and reduce environmental triggers, encourage

participation in all activities by children with asthma, provide learning opportunities to school staff, students, and parents, and communication among schools, healthcare providers and families (Cicutto et al., 2006). Public health nurses implemented the resource kit because there are no school nurses in Ontario schools. The study showed that the most commonly used resources were posters explaining how to handle asthma episodes, newsletter articles, managing-asthma-in-schools forms, and asthma questions on registration forms (Cicutto et al., 2006). Approximately 85% of teachers attended the in-service trainings on asthma and gave favorable reviews to these programs. In addition, the school staff and principals expressed a need for assistance from school boards, parents, and students in implementing such policies, especially in allowing students easy access to inhalers (Cicutto et al., 2006).

A randomized control trial in New York City tested the efficacy of a comprehensive asthma prevention program that involved schools and primary care providers. The intervention involved using a school health team consisting of a teacher or administrator, a parent, a full-time school nurse, a school physician available two days each month, and a public health assistant available two or three days each week (Bruzzese et al., 2006). The team was trained and then worked with Columbia University to train the teachers in the schools on asthma. In addition, the students' primary care providers were trained on prevention, communication with parents, and cooperation with schools (Bruzzese et al., 2006). The school health team then worked to develop asthma management plans by contacting families and primary care providers. School nurses contacted caregivers to learn about the child's asthma, contacted primary care providers to receive a treatment plan while also providing a sample one to the primary care

provider, encouraged both primary care providers and families to complete forms necessary for using medication at school, and referred students to receive medical care when it was deemed appropriate (Bruzzese et al., 2006). The school nurses also explained to teachers each student's asthma management plan. One goal of this program was to become a self-sufficient program after two years. The study showed that the daily work of the school nurses was not significantly altered in either the intervention or the control group. Primary care providers were generally uncooperative with the schools: 25% completed training and even fewer provided management plans to schools, some of which included treatment inconsistent with the NAEPP guidelines (Bruzzese et al., 2006). One year after the intervention, the only significant differences between the intervention and control groups were fewer days per week with symptoms and fewer school absences due to asthma in the intervention group. However, two years after the intervention, the only difference between the groups was fewer hospitalizations for asthma in the intervention group (Bruzzese et al., 2006).

School Policy & Inhalers

In order for comprehensive school-based plans to be effective at managing asthma in schools, a cooperative school health policy is necessary. It must facilitate education and other programs initiated by the comprehensive plan. Examples of productive school policies include those related to smoking, nutrition, and physical education: within these categories, rules are made that benefit students' health without room for lenience (McGhan, Reutter, Hessel, Melvin, & Wilson, 2002). The primary policy that facilitates asthma care in schools determines whether students are allowed to carry asthma

medication with them and self-administer the medication when it is necessary (Jones & Wheeler, 2004). 79.6% of schools surveyed in the CDC's School Health Policies and Programs Study (SHPPS) allow students to carry and self-administer a rescue inhaler; however, it is often decided on a case-by-case basis, meaning there are scenarios in which the inhaler must be kept in the nurse's office and can only be used under supervision (Jones, Wheeler, Smith, & McManus, 2009). It is much easier for students to manage their asthma when they have ready access to their medication. If supervision is required for self-administration of medication, it would be easier for the students if all school staff were capable of supervising because the nurse may be in a different wing of the school and thus inaccessible in such a short period of time.

The National Asthma Education and Prevention Program recommends that in addition to being able to carry an inhaler, all students with asthma should have a written asthma action plan from their primary healthcare provider (Jones et al., 2009). As of 2009, SHPPS reported that 91.6% of schools maintain asthma action plans for students (Jones et al., 2009). This figure is much higher than the figure reported in 2006 in New York City Schools. This drastic difference may be due to the specific nature of the study compared to a general survey of the nation, but there is still room for improvement.

Partnership with Healthcare Providers

Whether or not a comprehensive school-based plan is involved, a partnership between schools and hospitals can be quite beneficial. In Yonkers, New York, a school district partnered with a local hospital's asthma center after a student died due to an asthma attack at school. The hospital provided education and equipment for 55 schools

in order to make them capable of treating asthma attacks, especially when a student's rescue inhaler was not available (Byrne, Schreiber, & Nguyen, 2006). Results after one year of intervention showed that 12.7% of schools were using a peak flow meter and 45.4% were using nebulizers. In addition, of the 937 treatments in the first year, students were able to return to class 95.3% of the time, were sent home 3.9% of the time, and were sent to the emergency department only 0.8% of the time; this is significant because it shows an 80% decrease in students both sent home and sent to the emergency department (Byrne et al., 2006). These results over the first year led to a growth in the partnership to include 276 schools by the conclusion of the study. Approximately halfway through the study, the hospital added asthma education programs within the schools and a program social worker to act as a liaison between the school nurses and the asthma center (Byrne et al., 2006). The social worker set up appointments for students at the asthma center after a referral by the school nurse so that those children were able to see a specialist and receive proper treatment. Some barriers to this program included the high cost and the difficulty of receiving consent for treatment at school from parents (Byrne et al., 2006). Implementation of the social worker addressed the communication challenge between the nurses and the parents, especially the difficulty in receiving treatment consent forms from the parents. For funding, this study used grants and donations as well as the use of a compressor to reduce costs of nebulizer treatment (Byrne et al., 2006).

Mobile Clinics

One potential intervention with a moderate amount of success is the use of mobile clinics to treat asthma patients. In southern California, a local children's hospital

supported a mobile asthma clinic, The Breathmobile™, that routinely visited more than twenty elementary and secondary schools that were strategically chosen based on their location in low-income areas and level of identified medical need (Liao, Morphew, Amaro, & Galant, 2006). Contracts were made with each school and each student had to obtain written parental consent before participating in the clinic. In addition, continuity of care was maintained because the mobile clinic returned to schools regularly (Liao et al., 2006). Many methods of recruiting students were employed: referrals from school nurses, emergency departments, and public health clinics, asthma questionnaires, and advertisements through the schools (Liao et al., 2006). With a bilingual staff including a driver capable of enrolling individuals in low-cost healthcare insurance, an allergist, registered nurse, and a community health worker to perform home visits, The Breathmobile was capable of diagnosing asthma, prescribing medication, providing education, facilitating insurance receipt, maintaining medical records, and providing home visits to manage the indoor environment and improve upon prior asthma education (Liao et al., 2006). Children in need of a daily medication received a prescription or regular sample medications if insurance was lacking.

In about three and a half years, the Breathmobile program diagnosed 1112 children (84% of all children tested) with asthma (Liao et al., 2006). The diagnosis included the level of severity of the asthma as described in Chapter One. Initial visits found that only 24% of the children diagnosed with persistent asthma used a daily anti-inflammatory medication, but the mobile clinic raised this statistic to 78% and maintained these high levels in future visits (Liao et al., 2006). Improvement was also seen in all three measures of morbidity used: hospitalizations decreased from 19% to 3%,

utilization of emergency departments decreased from 38% to 16% (repeated utilization of emergency departments decreased from 23% to 6%) and school absences longer than 10 days decreased from 27% to 1% (Liao et al., 2006). The greatest improvements were seen in children diagnosed with severe persistent asthma (Liao et al., 2006). The Breathmobile was able to provide continuous care for children with asthma while reducing barriers that are commonly faced by low-income individuals and without requiring schools to provide clinic space, equipment, and staff. However, some challenges with this program include difficulty in monitoring compliance and symptoms, reliance on donated sample medication, and potential difficulty in maintaining funding (Liao et al., 2006). Despite these limitations, use of a mobile clinic such as The Breathmobile may be an effective method of providing quality treatment to children with asthma.

Healthcare Providers

Some interventions have been attempted in physician offices and hospitals. One study focused on improving primary care provider adherence to the NAEPP's guidelines, particularly the regular use of anti-inflammatory medication for patients with persistent asthma. The study implemented Easy Breathing, an organized disease management plan that encourages primary care providers to diagnose, determine the severity, prescribe proper treatment, and provide an asthma action plan for patients with asthma (Cloutier, Hall, Wakefield, & Bailit, 2005). In addition, this program used a series of four questions to aid the healthcare provider in diagnosing asthma; value is added to this method because the questions are asked regardless of the child's chief complaint. This allows for

the potential diagnosis of asthma in any child, even if symptoms are not present at the time of the appointment (Cloutier et al., 2005). If the responses to the initial four questions indicate the possible presence of asthma, the healthcare provider can turn to another short list of questions to determine whether asthma is present. From this point, the healthcare provider determines severity, prescribes medication, and provides a written action plan to the family (Cloutier et al., 2009). The study was done for approximately four years in a hospital in Hartford, Connecticut located in an area with many low-income patients. By the end of the study, 96% of children with persistent asthma were using an anti-inflammatory drug as recommended by the NAEPP guidelines (Cloutier et al., 2009). The Easy Breathing program also resulted in a 27% decrease in emergency department visits for asthma as well as a 35% decrease in hospitalization that was sustained through the study. Furthermore, overall adherence to the NAEPP guidelines by primary care providers increased from 38% to 96% due to the implementation of the Easy Breathing program (Cloutier et al., 2009). Despite limitations such as difficulty measuring patient adherence and a non-random study sample, this study shows that the Easy Breathing program significantly improved primary care providers' adherence to the NAEPP guidelines (Cloutier et al., 2009).

Another method of intervention used an emergency department employee to schedule follow-up visits with children with asthma in order to make sure they received proper long-term care. Once again, this study was measuring adherence to a NAEPP guideline; this particular guideline recommends that a child with asthma have a follow-up visit with a primary care provider three to five days after an emergency department visit in order to ensure that proper care is being received (Zorc et al., 2003). Patients in the

control group were discharged with instructions to follow up with a primary care provider within that time period. In the intervention group, study staff worked with the parent or guardian to obtain a follow-up appointment with a primary care provider before the patient was discharged (Zorc et al., 2003). Follow-up phone interviews showed that 77% of patients in the intervention group followed up with a primary care provider while 51% of patients in the control group did not. The most commonly reported reasons for lack of a follow-up visit were difficulty in scheduling an appointment and that a follow-up appointment was seen to be unnecessary (Zorc et al., 2003). Despite the improvement in follow-up visits, the study did not report an improvement in adherence to medication use or in short-term outcomes and suggested that further research is necessary to improve these measures. However, providing assistance in scheduling follow-up appointments while the patient is still in the emergency department may be a valuable intervention, particularly if combined with other interventions.

Education

While education may be included within other programs, it is so important that occasionally it is the only facet of an intervention. Once again, schools are recognized as a valuable location for interventions. One study focusing on educators used a collection of three surveys sent to school workers and families in Michigan public schools found three key issues affecting asthma education in educators and then addressed these issues with a packet to be distributed to schools: the Michigan Asthma School Packet (MASP). One such issue was that many educators did not perceive asthma as a prevalent threat for children in the school (Goei et al., 2006). Teachers who were aware of students with

asthma were unconcerned about how it might affect the students' academic activities. In response to this dismissal of asthma, the MASP provided a variety of advertisements, some of which were tailored to specific positions, such as teachers. However, all of the advertisements included a logo reading, "Asthma, it's more serious than you think" (Goei et al., 2006). The surveys also found that educators tended to have a false sense of confidence in their abilities to handle asthma; many were confident in treatments that were likely to harm the student. This tendency was found in school workers of all positions, except school nurses (Goei et al., 2006). The MASP provided a self-administered quiz to determine "Asthma IQ" and a list of proper steps to take to handle asthma symptoms in both paper and magnet form (Goei et al., 2006). The final issue was information overload due to the vast amount of health information given to educators due to supposed legal penalties for failing to provide adequate information. The MASP responded to this issue by creating a set of four small booklets containing the most important information about asthma in the form of text accompanied with infographics and advertisements (Goei et al., 2006). Each book was targeted to a specific group of school workers such as administration staff or teachers and it included quiz questions, a reference list, and a checklist showing recommended behaviors. Along with the booklet, school workers were given a magnet detailing a proper course of action, an asthma action plan, and a copy Michigan State Board of Education asthma policy, including the policy defining proper inhaler use within the school (Goei et al., 2006).

A study based in Toronto measured the effectiveness of student asthma education program in elementary schools. Students with asthma and their parents were divided into an experimental and a control group where the experiment was an hour-long education

program weekly for six weeks: the "Roaring Adventures of Puff" (Cicutto et al., 2005). Methods conducive to learning in children were used to convey information such as peak flow meter and inhaler use, triggers, symptom recognition, and lifestyle. Two months after the intervention, families in the experimental group reported both a greater ability to self-manage their asthma and a greater quality of life than families in the control group (Cicutto et al., 2005). Within the following year, children in the experimental group had 32% less urgent care visits for asthma compared to the control group. In addition, the experimental group had fewer missed days of schools as well as fewer reported days of stifled activity than the control group (Cicutto et al., 2005). The study did not take baseline measures of self-efficacy or quality of life so it is difficult to determine the improvement made by each individual student; however, the use of certified asthma instructors to educate children while at school did show an improvement (Cicutto et al., 2005).

Another key location for patient education is emergency departments. One study enrolled children visiting the emergency department for acute asthma symptoms in either a control group or an experimental group that received an education intervention program (Sockrider et al., 2006). The education program was tailored to patients based on asthma severity, computer-based, and focused on self-regulation and building confidence in asthma management. After the educator completed the thirty-minute program with the patient and family, an action plan was provided to the family along with a written summary highlighting the key points of the program (Sockrider et al., 2006). In addition, an asthma hotline number was provided to the family; however, it only received five calls over the course of the study (Sockrider et al., 2006). The baseline questionnaire

demonstrated a greater rate of regular physician visits for asthma in the control group; however, nine months after the intervention, the patients in the experimental groups had significantly more well asthma visits than the control group. There was not a significant change in missed school days in either the control or the experimental group over the course of the study (Sockrider et al., 2006). After two weeks, the intervention group experienced a significant increase in caregiver confidence in preventing asthma symptoms while the control group did not. Both of the groups reported an improved quality of life two weeks after the emergency department visit, possibly due to the resolution of the acute asthma episode that required an emergency department visit (Sockrider et al., 2006). While this study was not entirely successful in changing behavior following an emergency department visit, it laid a foundation for future educational interventions in emergency departments.

Coalitions

An asthma coalition is an organization that works to improve health outcomes for individuals with asthma through the use of collaboration, community organization, and sometimes changes in policy. There are over 200 asthma coalitions in the United States (Harver & Kotses, 2010). A coalition can be especially helpful when current attempts to change the asthma situation are not cohesive and the different interventions are fighting for funding (Krieger et al., 2006). Various Allies Against Asthma (Allies) coalitions around the country worked to integrate both services and systems currently at play in the fight against pediatric asthma. Some examples of services managed by Allies include assisting healthcare providers to follow national guidelines, cross-referrals between

different programs currently in existence, data sharing, and cohesive use of community health workers (Krieger et al., 2006). Examples of systems integrated by Allies are creating a shared vision, group decision-making regarding funding, standardization of tools such as asthma action plans, resource sharing, and shared agendas for potential policy changes. The study found that coalitions could more easily coordinate service functions than systems, but that systems integration may take a longer period of time (Krieger et al., 2006).

One study measured the effectiveness of a five-year effort by seven coalitions to improve childhood asthma. Parents with an asthmatic child in the midst of the coalition efforts (intervention group) were compared to parents with an asthmatic child in a different area of the community, where the coalition efforts were sparse or nonexistent (control group). These parents were interviewed before the coalition activities began and then after one year (Clark et al., 2010). The coalitions made a total 89 important changes over the course of the five years in the seven communities combined in the form of policy or systems changes. At baseline, children in both groups had similar rates of symptoms; however, during follow-up, children in the intervention group had significantly less daytime and nighttime symptoms (Clark et al., 2010). Parents in the intervention group demonstrated less fear during a child's symptoms and more concern about particular medications and side effects than parents of the control group, showing that the parents of the intervention group were likely more informed and concerned as a result of the intervention. One limitation of this study is that the health outcomes measured cannot be attributed to a particular change made by a coalition because of the sheer quantity and

speed of the changes made (Clark et al., 2010). However, these coalitions did see positive health outcomes, showing some level of benefit.

Policy

As previously mentioned, policy is one area in which coalitions often work to achieve a change. A national study used a committee of childhood asthma experts to rate various policy recommendations on the basis of five criteria: improvement of overall outcomes, feasibility of implementation, reduction of inequalities, reduction of net costs, and support by evidence (Lara et al., 2002). The rating of the policy recommendations led to the formation of an overarching objective and six policy goals. The objective states that asthma-friendly communities should be promoted nationwide (Lara et al., 2002). The first policy goal is to improve access to and quality of asthma health care services and the second is to improve knowledge about asthma among asthmatics as well as the general population (Lara et al., 2002). The third goal urges the implementation of asthma-friendly schools while the fourth seeks to promote asthma-safe homes. Finally, the fifth goal is to encourage new methods of asthma management and prevention and the sixth goal is to reduce socioeconomic inequalities in childhood asthma outcomes (Lara et al., 2002). These goals exemplify the key needs as seen by experts in childhood asthma and are good goals for coalitions and future interventions.

Indoor Environment

There have been many studies measuring the effectiveness of various methods of reducing triggers in the home. Some studies have measured the efficacy of using various

types of filters to reduce triggers. In one study, participants were grouped into a control group, an intervention group, and an enhanced intervention group. The control group received community health worker (CHW) education visits and the intervention group received CHW visits along with HEPA filters to be placed in the child's bedroom (Batterman et al., 2013). Use of the HEPA filter was monitored and data showed an overall decrease in filter use as the study continued. Overall, this study found a low and inconsistent use of provided filters (Batterman et al., 2013). Another study measured the effectiveness of forced air ventilation filters in removing triggers from the air through the use of simulations and modeling. The highest performing filter, a five inch pleated sheet, had a removal efficiency of 97% for particles associated with asthma triggers, such as cat allergen (Brown et al., 2014). Unfortunately, the annual upkeep cost for this filter is $98, higher than some of the other, less effective filters that are more common. The fiberglass filter is the most commonly used filter despite its meager removal efficiency of 4% (Brown et al., 2014).

Another method of removing triggers from the home involves sending a CHW to provide education, support, and resources for families to use. More often than not, CHWs are implemented in low-income communities where access to education and resources may not be as readily available. The effectiveness of a CHW-based intervention was measured in Seattle. CHWs initially provided basic education, delivered bedding encasements, conducted an environment assessment, and worked with the participant to create an action plan for remediating triggers (Krieger, Takaro, Song, & Weaver, 2005). Participants in the low-intervention group did not receive any further visits, but participants in the high-intervention group received additional visits for

education, encouragement, and to deliver resources such as vacuums, cleaning kits, and rodent traps. Upon initial analysis, 75% of homes had at least one asthma trigger present (Krieger et al., 2005). Data showed that the high-intensity intervention group had a significantly greater decrease in use of emergency healthcare services than the low-intensity group over time. In addition, the high-intensity group showed statistically significant improvement over time in symptom days and caregiver quality of life. In addition, the high-intensity intervention group saved between $57 and $80 in urgent care costs over the course of two months for each child in the study (Krieger et al., 2005). A similar study used research assistants to carry out home visits instead of CHWs in order to test the feasibility of an intervention addressing multiple triggers in the home. Data showed that the intervention group had fewer symptom days and a greater decrease in allergen levels compared to the control group (Morgan et al., 2004). This study estimated the average cost of the intervention to be between $750 and $1,000 for each year of equipment and personnel (Morgan et al., 2004). Another comparable study measured the relative importance of cleaning visits and educational visits. Data showed that overall levels of house dust and fungus were significantly reduced, but there were not significant changes in levels of cat allergen or cockroaches (Adgate, Ramachandran, Cho, Ryan, & Grengs, 2007). The study was unable to determine whether education, cleaning, or a combination of the two caused the positive effects, although it seems likely that results were due to a combination because of the study design (Adgate et al., 2007).

Outdoor Environment

While the indoor environment is often easy to clean and control, the outdoor environment is very challenging because there are so many factors involved. One study attempted to control a small part of the outdoor environment at schools with the hopes of making an improvement in students' health. The school district adopted a policy that required bus drivers to turn off engines when idling for more than five minutes (Mazer, Jacobson Vann, Lamanna, & Davison, 2014). While the study did not document specific health outcomes, it is known that diesel exhaust is a lung irritant and asthma trigger, so it can be assumed that a decrease in diesel exhaust exposure would be beneficial for the students.

Additionally, one study in southern California compared declining air pollution levels with lung function in three separate cohorts of children both with and without asthma over twenty years. Children's lung function was measured annually for four years and then compared to that of cohorts in later or earlier years (Gauderman et al., 2015). Air pollution was also measured over the course of the study; nitrogen dioxide and $PM_{2.5}$ (particulate matter less than 2.5 micrometers in diameter) declined greatly while ozone and PM_{10} (particulate matter less than 10 micrometers in diameter) declined at a slower rate. The FEV_1 for children in each cohort increased over the four-year period, as did the FVC (Gauderman et al., 2015). Many potential confounders were accounted for, but the results remained clear: as the air pollution levels in the communities decreased, the lung function of children increased over time, both as a group and for each child. Improving air quality may be a valuable way to improve the health of children, especially for those with asthma or another respiratory disease.

Chapter Four will analyze and synthesize the interventions presented in order to propose a solution to childhood asthma problems.

CHAPTER FOUR

Analysis and Proposal

Childhood asthma in low-income populations is a growing problem that must be faced. This is confirmed by a recent news story: in Killeen, Texas, in January 2016, a middle school female suffered an asthma attack in class. The teacher instructed the students to remain calm while she sent an email to the school nurse for instructions. Fortunately, another student disobeyed the teacher and carried his classmate to the nurse's office. If he had not done this, his classmate may have stopped breathing (Shaw, 2016). Unfortunately, it is all too common that classroom teachers are uncomfortable and incapable of handling medical situations in the classroom. Further, teachers comprise only a portion of the problem that must be addressed in order to ensure that children with asthma are receiving proper care. It is clear from the magnitude of the issue that a multi-faceted intervention must be employed to combat childhood asthma in poverty. The best course of action includes using school nurses to educate school staff and students, encouraging healthcare providers to follow NAEPP guidelines, and implementing community health workers to complement the work of the school and healthcare providers. Potential sources of funding will be suggested.

School Nurses

The solution must begin in the schools; the first step is to employ more school nurses. Ideally, there would be a nurse at every school, especially for elementary schools. However, moving forward, it might be sufficient for a nurse to evenly split time

between two schools until enough funding can be attained and nurses can be hired. The nurses should be responsible for maintaining a current asthma action plan for students, maintaining open communication with caregivers, leading educational seminars for teachers and staff, implementing biannual educational classroom activities for students, and, of course, assist students with asthma attacks and other healthcare needs as necessary. In order to ensure the nurses' ability to fulfill these responsibilities, they should be trained initially by an asthma expert, perhaps an employee of the state health department, local hospital, or local asthma coalition. Continuing training should take the format of an annual online program as well as the distribution of current asthma information packets by the state public health department to school nurses for reference throughout the year. The school nurses must be well educated on asthma symptoms, treatment, and prevention so that they can lead educational events for others and be valuable resources for students, caregivers, teachers, and other school staff.

Teachers

The school nurse should provide biannual training for teachers so that all teachers are capable of handling asthma should an exacerbation occur in the classroom. Ideally, such a training program would allow all teachers and school staff to be legal supervisors for when students must self-administer their inhalers under adult supervision. This training should take the format of a seminar led by the school nurse, perhaps during a teacher in-service day, accompanied by a packet of handouts for teachers to keep as a reference. These handouts should follow the format as used successfully in the Michigan Asthma School Packet as described in Chapter Three. A similar packet should be

provided to administrators and other school staff so that all school personnel are prepared to manage an asthma emergency. The packets for these individuals should be targeted toward their role within the school so that it remains easily accessible yet informative.

In addition to attending the training for classroom teachers and receiving a packet of information, physical education (PE) instructors should receive hands-on, practical training so that they are fully capable of assisting a student having an asthma attack. PE teachers should also be briefed on each asthmatic student's action plan and exercise capabilities so that students are not expected to exercise harder than their asthma action plan will allow. This will allow the PE teachers to plan alternate activities when necessary for children who are struggling to breathe as well as provide adequate care and supervision for students managing asthma symptoms during PE class.

Students

The school nurse should also lead a brief, biannual educational lesson in each classroom so that all students are made aware of asthma and so that empathy for peers with asthma is developed. In addition, it will be beneficial if students understand the disease so that they can assist peers who are having symptoms when necessary.

It is also important that schools provide programs specifically for students affected with asthma. The school nurse should be able to successfully lead such a program such as The Roaring Adventures of Puff, described in Chapter Three, for students so that stigma can be decreased, empathy and awareness can be increased, and students can have an improved ability to manage their own asthma.

Healthcare Providers

Healthcare providers have a significant responsibility regarding asthma. Providers must ensure that patients with asthma are prescribed proper medication so that asthma can be managed without visits to the emergency department. It is critical that healthcare providers follow the NAEPP guidelines to make certain that patients with persistent asthma have access to a daily anti-inflammatory medication and that families receive written action plans. A program such as Easy Breathing, as described in Chapter Three, should be implemented in all primary care offices, especially in low-income areas, so that all children with asthma have an action plan and receive proper treatment.

Community Health Worker

Even if every individual described above fully completed their proposed tasks in order to alleviate suffering due to asthma, there would still be some gaps in the plan. A specialized individual, such as a community health worker (CHW), should be employed in order to fill in these holes. There should be a CHW for every couple of schools in a particular region. The roles of the CHW will be to facilitate communication between the school nurse, caregivers, and healthcare providers, to ensure that any students who do not have insurance can be registered to receive it, and to make home visits for children who are really struggling with asthma management. When a student with asthma has not provided an action plan for the school, the CHW can communicate with the caregivers and physicians to make sure this happens. If a school nurse recognizes asthma in a student who has not been diagnosed, the CHW can be contacted and will be able to explain this to the parents in a way that promotes trust and understanding.

Ideally, the CHW would be trained and capable of enrolling children for insurance when they do not already have it. In the case that the parent does not have an insurance provider, the child can be enrolled for insurance with CHIP. This will improve the healthcare received by the child because the child will be able to see primary care providers instead of solely visiting the emergency department. In effect, this will reduce the amount of bad debt faced by emergency departments as a result of treating patients with no ability to pay while also ensuring that the children can receive the prescription medications they need. The CHW would be able to complete this task in the schools or with the caregivers during a home visit. Home visits made by the CHW will specifically target children who are struggling to manage their asthma. The CHW will go into the home to teach the caregivers how to help the child with symptoms, how to maintain an asthma-friendly indoor environment, and to provide emotional support to caregivers who are struggling to manage all of their responsibilities.

The CHWs will split time between the schools in their region while also visiting the homes of students with particular difficulty in managing asthma. Of course, all CHWs will have to be cleared with background checks so that they are able to work in the schools, especially if they are technically employed by local hospitals, as will be proposed. It would be most beneficial if the healthcare providers in the area updated the CHW on the healthcare activity of their students so that the CHW can assist in ensuring proper care by following up with families. For example, NAEPP guidelines recommend that a follow-up visit be made with a primary care provider after a visit to the emergency department for an asthma exacerbation. The hospital should notify the CHW when any of the students in the region are admitted to the emergency department so that the CHW

can assist the family with making a follow-up appointment with a primary care provider. One specific benefit of using CHWs for this intervention is that they are a part of the community, meaning they will enter situations with a higher level of trust than an outsider to the community might. In addition, they will have a deeper understanding of the cultural values at stake, will effectively communicate the importance of asthma management, and will be able to help families find the best way to manage asthma while maintaining their beliefs and customs.

Finances

This may seem like a very expensive comprehensive plan. It is commonly recognized that schools struggle to maintain adequate funding for educational purposes, leaving little funding for providing healthcare to students. The average emergency department visit for asthma costs $1,502, which in 2008 was about 7% of a family's income if it was at 200% of the federal poverty line (Wang, Srebotnjak, Brownell, & Hsia, 2015). Studies have shown that asthma is the cause for over 25% of emergency department visits for children under ten years old and 17.8% of visits for children between ten and fourteen (U.S. Department of Health and Human Services, Agency for Healthcare Research and Quality, 2013). In 2012, 6.1%, or $45.9 billion, of annual hospital expenses were due to uncompensated care (American Hospital Association, 2014). The EMTALA (Emergency Medical Treatment and Active Labor Act) requires that all patients be treated regardless of their ability to pay in the emergency department (Fosmire, 2009). This aspect of the emergency department means that the vast majority of the $45.9 billion of bad debt accumulated in a hospital comes from patients seen in the

emergency department. If emergency departments funded the placement of school nurses in local schools, asthma care for children would improve and there would be fewer visits to the emergency department for asthma, especially in low-income areas. This would decrease the amount of bad debt that the emergency departments faced while also improving health in the community and conserving money in school districts that cannot afford to put a nurse in every school.

Accountable care organizations (ACOs) are another option for funding. These organizations profit by decreasing the overall cost of patient care. This incentive by the government encourages healthcare providers to communicate and work together across all settings to ensure quality care for the patients while also decreasing the overall cost of providing for these patients (U.S. Department of Health and Human Services, 2011). It may be possible to have ACOs incentivize primary care providers to provide patients and families with asthma action plans. Another possibility is to have ACOs fund school nurses, community health workers, and other asthma programs because they will decrease emergency department visits due to asthma exacerbations, thus decreasing the overall cost of care.

The best plan of action for funding may be to employ both emergency departments and ACOs as sources of funding. Any excess funding can be saved for future use or can be used to provide extra assistance to a certain area that is struggling with asthma in children.

Conclusion

It is clear that childhood asthma is a serious and growing problem that must be addressed, especially in low-income areas, due to the high rate of morbidity associated with poorly managed asthma. Many interventions have been attempted, some more successfully than others. The best course of action is a comprehensive, multi-faceted plan that puts a nurse in every school to educate teachers and students, incentivizes primary care providers for following NAEPP guidelines for asthma and providing action plans to families, and implements CHWs to facilitate communication between all parties, enroll children in health insurance, and complete home visits for families with asthma so triggers can be reduced in the home. This plan should begin in a few low-income regions and then expanded to include all schools in the United States. Funding might come from emergency departments, ACOs, and potentially coalitions who fundraise for asthma care. With such a plan, it is likely that the percentage of children diagnosed with asthma and receiving proper care is vastly increased and that emergency department visits for asthma are greatly decreased. The success of this plan in the United States might encourage other countries to attempt similar solutions to face asthma in their communities.

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