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Challenges and healthcare quality improvement strategies for asthma care for preschool children

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BOSTON UNIVERSITY
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Thesis

**CHALLENGES AND HEALTHCARE QUALITY IMPROVEMENT STRATEGIES
FOR ASTHMA CARE FOR PRESCHOOL CHILDREN**

by

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B.S., University of California, Santa Barbara, 2011

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ABSTRACT

Asthma is the most common chronic illness in children. Preschool children (age 0 to 5) in particular experience a disproportionate disease burden compared to all other age groups. Part of the puzzle is the diagnostic challenge presented in this age group, and another is the difficulties in the care and management of asthma. Compounding the issue are the well-documented racial disparities experienced by minorities. This paper reviews the literature documenting the difficulties and disparities facing minority preschoolers with respect to providing and receiving care for asthma and qualitative improvement strategies targeting healthcare. Due to the complexity of the disease, more research on evidence based strategies targeting this age group is needed as well as better documentation of implementation processes.

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LIST OF ABBREVIATIONS

ADLs.....	Activity of Daily Living
AHRQ	Agency for Health Research and Quality
API.....	Athma Predictive Index
ATS	American Thoracic Society
BHR.....	Bronchial Hyperresponsiveness
BPHC	Boston Public Health Commission
CDC.....	Centers for Disease Control and Prevention
FeNO.....	Fractional Exhaled Nitric Oxide
FEV1	Forced Expiratory Volume for one second
FVC	Forced Vital Capacity
GRACE.....	Geriatric Resource Assessment and Care for Elders
ICS	Inhaled Corticosteroids
LABA	Long Acting Beta2-Agonist
mAPI.....	Modified Predictive Index
MCS	Mental Component Summary
NAEPP	National Asthma Education and Prevention Program
NHIS.....	National Health Interview Survey
NHLBI.....	National Heart, Lung, and Blood Institute
NIH	National Institute of Health
NO	Nitric Oxide

PCS Physical Component Summary
PFT Pulmonary Function Tests
PIAMA Prevention and Incidence of Asthma and Mite Allergy
SABA Short Acting Beta2-Agonist

INTRODUCTION

Asthma is the most common chronic illness in children (CDC 2012). Preschool children (age 0 to 5) in particular experience a disproportionate disease burden compared to all other age groups. Part of the puzzle is the diagnostic challenge presented in this age group, and another is the difficulties in the care and management of asthma. Compounding the issue are the well-documented racial disparities experienced by minorities. To address the problem, one focus has been on developing qualitative improvement strategies to improve the many aspects of care. This paper will shed light on major barriers that the 0 to 5 age group encounters in receiving care as well as provide examples of a few quality improvements strategies aimed at improving the delivery of healthcare.

Background

Defining Asthma

Asthma is a chronic inflammatory illness affecting the airways. The most common symptoms include recurrent wheezing, shortness of breath, chronic cough, and chest tightness (Maslan & Mims, 2014). These symptoms are due to lower airway constriction, increased bronchial secretion, mucosal edema, and over time can lead to structural changes due to repeated cycles inflammation (Fireman, 2003). Symptoms can vary in severity from asymptomatic to life threatening episodes triggered by specific environmental allergens (NHLBI, 2014). As of 2013, over 22 million (7.3%) people in the United States had

asthma, over 6 million of these were children under 18 years old (CDC, 2013b). Asthma mortality has decreased over the years. In 2013, there were 3630 deaths from asthma in the United states (CDC, 2013b). Although asthma is not considered a leading cause of death, the burden of asthma is typically experienced through medical expenses (\$18 billion per year), emergency department visits (1.8 million per year), hospitalizations (439,400 per year), and days lost from school or work (Centers for Disease Control, 2013). In fact, asthma was the third leading cause for hospitalization among children under 18 years old in the United States and the leading cause of admission to the hospital after an emergency department visit (CDC, 2013b; Sullivan et al., 2011; Weiss, Wier, Stocks, & Blanchard, 2014).

Preschool children (children aged 0 to 5) experience particularly higher morbidities due to asthma than another other age group. According to the Centers for Disease Control (CDC), prevalence of asthma among children 0 to 4 is the lowest (6.3%) compared to children 5 to 9 (10%), 10 to 14 (9.4%) and adolescents (9.0%) (Centers for Disease Control, 2013), yet have the highest rates of emergency department use and hospitalizations due to asthma (Karaca-Mandic P, Jena AB, Joyce GF, & Goldman DP, 2012). In the Health of Boston 2014-2015 report from the Boston Public Health Commission (BPHC), despite seeing much improvement over the years, asthma related emergency department visit rate for the 3 to 5 age group was about 28 per 1000 people while the next highest age group rate, ages 6 to 17, was about 16 per 1000

people (See Figure 1) (Boston Public Health Commission, Research and Evaluation Office, 2015). These statistics call for further research to understand and close this disparity.

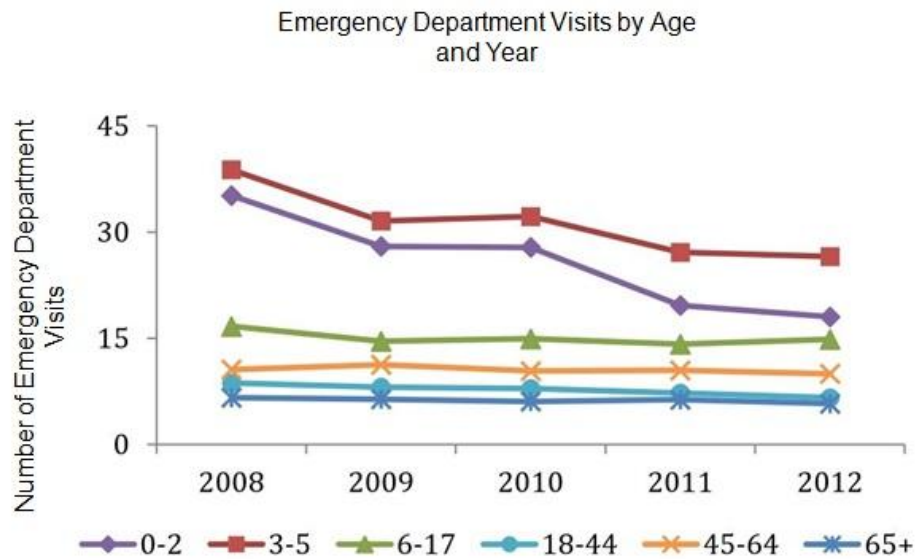


Figure 1: Emergency Visits by Age and Year in Boston. Figure amended from BPHC 2015.

Diagnosis

One principal reason that the 0 to 5 age group experiences such a heavy burden of asthma comes from the difficulty in making the diagnosis (Bacharier & Guilbert, 2012; Cave & Atkinson, 2014; Ducharme, Tse, & Chauhan, 2014). Diagnosing of asthma typically includes a variety of different tools and techniques. According to the National Heart, Lung, and Blood Institute (NHLBI), the current methods for diagnosing asthma in school-aged children, adolescents, and adults include the consideration of medical and family history, findings from a

physical exam, results from pulmonary tests, and additional lab tests (Maslan & Mims, 2014; National Asthma Education and Prevention Program, 2007).

When reviewing medical history, there are certain signs and symptoms which are indicative of asthma. These include a history of persistent or recurrent wheezing, cough, difficulty breathing, or chest tightness (National Asthma Education and Prevention Program, 2007). The likelihood of a diagnosis of asthma increases if these symptoms worsen in the event of exercise, viral infection, cold weather, or environmental exposures to pollen, pet dander, smoke, dust mites, or house pests. Symptoms worsening at night or upon waking can also be indicative of asthma. Family history is also a major risk factor for asthma (National Asthma Education and Prevention Program, 2007).

During physical examination indicators of asthma include hyper-expansion of the thorax, sounds of wheezing, prolonged exhalation or other signs of airflow obstruction, increased nasal secretion, nasal swelling, or polyps, eczema or other allergic skin conditions (National Asthma Education and Prevention Program, 2007). It is important to note that these signs may be absent even in the presence of asthma due to the episodic nature of the disease (National Asthma Education and Prevention Program, 2007).

The main quantitative tool utilized in the diagnosis of asthma are pulmonary function tests (PFTs). The most common of these is spirometry which is also considered the current gold standard for the diagnosis of asthma (Fuhlbrigge et al., 2001; National Asthma Education and Prevention Program,

2007). The specific measurements of interest with respect to asthma include "forced expiratory volume in one second (FEV1), forced expiratory volume in 6 seconds (FEV6), forced vital capacity (FVC), and FEV1/FVC - before and after the patient inhales ad short-acting bronchodilator" (Fuhlbrigge et al., 2001; National Asthma Education and Prevention Program, 2007). These measures allow physicians to objectively assess obstruction severity and bronchodilator reversibility as well as distinguish between asthma and chronic obstructive pulmonary disease (COPD) which, may share many signs and symptoms with asthma, but has a different regimen of treatments, medications, and management approach (Celli, 2000; Li & O'Connell, 1996). Unfortunately, these measurements require active participation from patients, which with children younger than five years old, is not typically possible.

More recently, a new tool which measures the fractional exhaled nitric oxide (FeNO) has been developed. In brief, a common variant of asthma results from eosinophilic airway inflammation (Cohn, Elias, & Chupp, 2004). In these cases, increased activation of T-helper cells (Th2) and mast cells increase the production of cytokines which in turn increase the production of nitric oxide (NO), a known inflammation mediator, in airway epithelium (Maslan & Mims, 2014). This NO is exhaled and can be measured to assess air way inflammation (Strunk et al., 2003). In this way FeNO can also be utilized as method to measure the underlying physiology how patients respond to steroidal treatment which aims to decrease inflammation.

For the this reason, the current NHLBI guidelines (2007) consider FeNO measurements to be useful in monitoring and assessing asthma (Dougherty et al., 2007), however several studies have found FeNO measurements to have higher sensitivity in regards to the diagnosis of asthma in certain cases (Deykin, Massaro, Drazen, & Israel, 2002; Dweik et al., 2011; Smith et al., 2004). In 2004, Smith et al. published a study comparing the efficacy of FeNO measurements to conventional methods (spirometry and peak flow meter) in the diagnosis of asthma (Smith et al., 2004). This study compared 47 patients of varying ages (8 to 75) who exhibited respiratory symptoms suggestive of asthma for six weeks prior (Smith et al., 2004). Researchers measured FeNO, FEV1 and FEV1/FVC before and after steroid (prednisone) treatment, bronchodilator reversibility, peak flow, sputum eosinophils, bronchial hyperresponsiveness (BHR). The diagnosis of asthma in these patients was based on, "relevant symptom history (present in all patients) using American Thoracic Society criteria, and a positive test for BHR and/or a positive response to bronchodilator" (Smith et al., 2004). Smith et al. found that spirometry had a sensitivity of 47%, while FeNO had a sensitivity of 88% (Smith et al., 2004). Furthermore, in 2011, the American Thoracic Society (ATS) published its official clinical practice guidelines which give evidence based interpretations of FeNO measurements for diagnosis, as well as other situations in which FeNO may be useful (Dweik et al., 2011).

Importantly, this method only requires relaxed tidal breathing (Castro-Rodriguez, 2010). Thus it has the potential to be used in younger children where

spirometry is not an option. FeNO measurement is a promising tool that can help physicians diagnose and treat asthma early, improving care for those 0 to 5.

Diagnostic Challenge

As mentioned above, the inability to use spirometry for preschoolers makes an accurate diagnosis a formidable challenge. This in turn leaves asthmatic preschoolers undiagnosed, unmonitored, and untreated while on the other end of the spectrum, transient wheezers (preschool children who wheeze but no longer do after age six) go over treated (Cave & Atkinson, 2014). The lack of available pulmonary function tests and laboratory tests appropriate for this age group limits diagnosis to primarily rely upon the recognition of symptoms by the parent and physician (Ducharme et al., 2014; National Asthma Education and Prevention Program, 2007).

The hallmark symptoms of wheezing and cough can be indicative of a number of conditions (Bacharier & Guilbert, 2012; Ducharme, Dell, Radhakrishnan, Grad, & Zelman, 2015; Ducharme et al., 2014). According to the 2007 NHLBI guidelines, differential diagnosis for wheezing in infants and children include,

"allergic rhinitis and sinusitis, foreign body obstruction, vocal cord dysfunction, vascular rings or laryngeal webs, laryngotracheomalacia, tracheal stenosis, bronchiostenosis, enlarged lymph nodes, tumors, viral bronchiolitis or obliterative bronchiolitis, cystic fibrosis, bronchopulmonary dysplasia, heart disease, recurrent cough not due to asthma, and aspiration from swallowing mechanism dysfunction or gastroesophageal reflux" (Dougherty et al., 2007) (See Table 1).

Table 1: Differential Diagnostic Possibilities for Preschoolers with Asthma. Table from NHLBI Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma 2007.

DIFFERENTIAL DIAGNOSTIC POSSIBILITIES FOR ASTHMA	
Infants and Children	
Upper airway diseases	
■	Allergic rhinitis and sinusitis
Obstructions involving large airways	
■	Foreign body in trachea or bronchus
■	Vocal cord dysfunction (VCD)
■	Vascular rings or laryngeal webs
■	Laryngotracheomalacia, tracheal stenosis, or bronchostenosis
■	Enlarged lymph nodes or tumor
Obstructions involving small airways	
■	Viral bronchiolitis or obliterative bronchiolitis
■	Cystic fibrosis
■	Bronchopulmonary dysplasia
■	Heart disease
Other causes	
■	Recurrent cough not due to asthma
■	Aspiration from swallowing mechanism dysfunction or gastroesophageal reflux

Out of these, the most common cause of wheezing besides asthma is bronchiolitis (Ducharme et al., 2014). Briefly bronchiolitis is the inflammation of the bronchioles usually due to respiratory syncytial virus (RSV)(KoeHoorn et al., 2008; Papadopoulos et al., 2002). While the treatments RSV bronchiolitis responds to are very different from asthma (ie bronchodilators, inhaled corticosteroids)(Ducharme et al., 2014), severe cases of bronchiolitis resulting

from RSV have been shown to be a powerful risk factor for asthma and allergic sensitization in early age (Sigurs, Bjarnason, Sigurbergsson, & Kjellman, 2000).

Further complicating the diagnosis of asthma in preschoolers is the fact that nearly half of preschool children wheeze yet 60% no longer do so after age six (transient wheezers) and fewer still go on to develop asthma (Martinez et al., 1995). One attempt to identifying preschool wheezers who are at risk for developing asthma has been to distinguish between wheeze phenotypes (Taussig et al., 2003). The Tucson Children's Respiratory Study followed 1246 newborns and their families to explore the relationships between potential risk factors, acute lower respiratory tract illnesses, and chronic lung disorders into childhood and early adulthood (Taussig et al., 2003). With regards to wheezing researchers identified three wheezing phenotypes. 1) Early transient wheezers (those who began wheezing before age three, but no longer did at the age of six) made up 20% of all children, 2) persistent wheezers (those who started wheezing before age three and continued to do so at age 6) made up 14% of all children, and 3) late-onset wheezers (children who started wheezing between ages three and six) made up 15% of all children (Taussig et al., 2003). Persistent wheezers and late-onset wheezers, especially those with additional risk factors were the most likely to continue on to experience asthma-like symptoms (Taussig et al., 2003).

Furthermore some physicians prefer to wait until quantitative pulmonary function tests (spirometry) to measure bronchodilator reversibility and bronchial

hyperresponsiveness are available to make the formal diagnosis of asthma (Celli, 2000; Ducharme et al., 2014; Fuhlbrigge et al., 2001; Li & O'Connell, 1996; National Asthma Education and Prevention Program, 2007). As a result the condition of many young children who have had few instances of wheezing may receive ambiguous labels "denoting a suggestive pathophysiology (eg, 'bronchospasm' or 'reactive airway disease'), symptoms (eg, 'wheeze' or 'chronic cough'), vague diagnoses ('wheezy bronchitis' or 'happy wheezer') or, possibly, inappropriate diagnoses (eg, repeated 'bronchiolitis' or 'recurrent bronchitis or pneumonia')" (Ducharme et al., 2015).

To aid in predicting preschoolers' risk of developing asthma, researchers developed the Asthma Predictive Index (API)(Castro-Rodriguez, 2010; Castro-Rodríguez, Holberg, Wright, & Martinez, 2000). The API, created in 2000, is comprised of major and minor criteria which are examined within the first three years of life (See Table 2).

"A positive API score requires recurrent episodes of wheezing during the first 3 years of life and 1 of 2 major criteria (physician-diagnosed eczema or parental asthma) or 2 of 3 minor criteria (physician-diagnosis allergic rhinitis, wheezing without colds, or peripheral eosinophilia $\geq 4\%$). A loose index (< 3 episodes/y and 1 of the major or 2 of the minor criteria) and a stringent index (≥ 3 episodes/y and 1 of the major or 2 of the minor criteria) were created. A positive stringent API score by the age of 3 years was associated with a 77% chance of active asthma from ages 6 to 13 years; children with a negative API score at the age of 3 years had less than a 3% chance of having active asthma during their school years" (Castro-Rodriguez, 2010).

When tested for its predictive values, the API had a sensitivity of 22%, specificity of 97%, positive predictive value of 77%, and negative predictive value of 90%. Due to these values, the API's true strengths lie in its ability to rule out asthma as a likely diagnosis in preschool children.

Recently, the API has been modified to include allergic sensitization to at least one aeroallergen as a major criteria, and allergic sensitization to milk, egg, or peanut has replaced allergic rhinitis as a minor criteria (Guilbert, 2010). Consideration of modified asthma predictive index (mAPI) scores has been included in the 2007 NAEPP guidelines as a step to initiating control therapy for children 0 to 4 (National Asthma Education and Prevention Program, 2007).

Other indices that rely upon different measures have also been developed such as the Isle of Wight from the United Kingdom (Kurukulaaratchy, Matthews, Holgate, & Arshad, 2003), and (Prevention and Incidence of Asthma and Mite Allergy (PIAMA) (Caudri et al., 2009), but so far have not been included in guidelines used within the United States.

Asthma Predictive Index (API) vs Modified Asthma Predictive Index (mAPI)

1. A history of ≥ 4 wheezing episodes with ≥ 1 physician's diagnosis. 2. In addition, the child must meet ≥ 1 of the following major criteria or ≥ 2 of the following minor criteria:	
mAPI: major criteria <ul style="list-style-type: none"> • Parental history of asthma • Doctor-diagnosed atopic dermatitis • Allergic sensitization to ≥ 1 aeroallergen 	Original API: major criteria <ul style="list-style-type: none"> • Parental history of asthma • Doctor-diagnosed atopic dermatitis
mAPI: minor criteria <ul style="list-style-type: none"> • Allergic sensitization to milk, egg, or peanut • Wheezing unrelated to colds • Blood eosinophils $\geq 4\%$ 	Original API: minor criteria <ul style="list-style-type: none"> • Doctor-diagnosed allergic rhinitis • Wheezing unrelated to colds • Blood eosinophils $\geq 4\%$

Table 2: Asthma Predictive Index (API) and Modified Asthma Predictive Index (mAPI). Table from Bacharier and Guilbert 2012.

Risk Factors:

Despite asthma's high prevalence and heavy burden on patients and the healthcare system, gaps in our knowledge of causes, pathways, and therapies remain. The cause of asthma remains unknown and no cure has been developed. As a result of these gaps, symptom control continues to be the primary means of reducing mortality and asthma burden (National Heart Lung and Blood Institute, 2012). While this strategy has seen success in reducing asthma mortality rates, it becomes clear that a better understanding of the causes and risk factors is necessary to develop and apply novel upstream preventative approaches. These primary preventative interventions will help to

reduce prevalence of asthma, reducing its burden on patients and healthcare system (Collaborators, 2015). Additionally, analyzing risk factors may not only give clues to understanding the underlying causes of asthma, but also may also help to improve the management of those currently with the illness.

In a recent review published in 2015, Beasley et al. presents a comprehensive list of known risk factors and their association with asthma (Beasley, Semprini, & Mitchell, 2015) (See Table 3). In understanding risk factors it is important to distinguish between risk factors that are associated with the development of asthma and risk factors that are associated with the exacerbation of asthma symptoms once it has already be established. Beasley et al. as well as the guidelines for the National Heart, Lung, and Blood Institute report that the interplay between genetic factors and environmental exposures during immune system development are key elements in the onset and development of asthma (Beasley et al., 2015; Dougherty et al., 2007).

From the genetic standpoint, the link between genes and family history is both unclear and very complicated (Beasley et al., 2015; Maslan & Mims, 2014; National Asthma Education and Prevention Program, 2007). Multiple loci across multiple chromosomes have been found to be associated with development of asthma with varying degrees of risk, yet they lack a straight forward Mendelian pattern of inheritance, marking them as areas for further investigation (Beasley et al., 2015; Maslan & Mims, 2014).

	Association		Association
Demographics, developmental, lifestyle		(Continued from previous column)	
Age	Nonlinear	Diet	
Sex	Age dependent	Fruit and vegetables	Negative
Family history	Positive	Mediterranean diet	Negative
Genetics	Positive	Breastfeeding	Negative
Low gross national product	Negative	Raw milk	Negative
Agricultural subsistence	Negative	Probiotics	Negative
Urbanisation	Positive	Fast food	Positive
High-income lifestyle	Positive	Fish oils	Negative
High altitude	Negative	Selenium	Negative
Low birthweight or fast infant weight gain	Positive	Vitamin A	Negative
Preterm	Positive	Vitamin D	Negative
Caesarean delivery	Positive	Vitamin E	Negative
Atopic sensitisation	Positive	Magnesium	Negative
Rhinitis	Positive	Trans-fatty acids	Positive
Stress	Positive	Salt	Positive
Day care	Negative	Inhaled exposures	
High body-mass index	Positive	Maternal smoking	Positive
Sedentary behaviour	Positive	Paternal smoking	Positive
Infection related		Child smoking	Positive
Respiratory syncytial virus	Positive	Indoor air pollution	Positive
Rhinovirus	Positive	Outdoor air pollution	Positive
Pertussis	Positive	Occupational exposure	Positive
Medication		House dust mite	Positive
Paracetamol	Positive	Endotoxin	Negative
β agonists	Positive	Farm animals	Negative
Antibiotics	Positive	Cats	Variable
		Moulds	Positive

(Table 2 continues in next column)

Table 3: Risk Factors Association with Asthma. Taken from Beasley, 2015.

Preterm birth is also a well documented risk factor. In a meta-analysis of 147,252 European children by Sonnenschein-van der Voort et al. (Sonnenschein-van der Voort et al., 2014), younger gestational age at birth was highly associated with the development of asthma at school age. Researchers

reported that children born preterm with high infant weight gain were more likely to have childhood asthma (OR = 4.47, 95% CI, 2.56 to 7.76) and wheeze (OR= 1.34 95% CI, 1.25 to 1.43) than children born at full term (Sonnenschein-van der Voort et al., 2014). Earlier births increased the likelihood of both wheezing in preschoolers and childhood asthma (Sonnenschein-van der Voort et al., 2014). (See Figure 2).

See Table 1 for other risk factors.

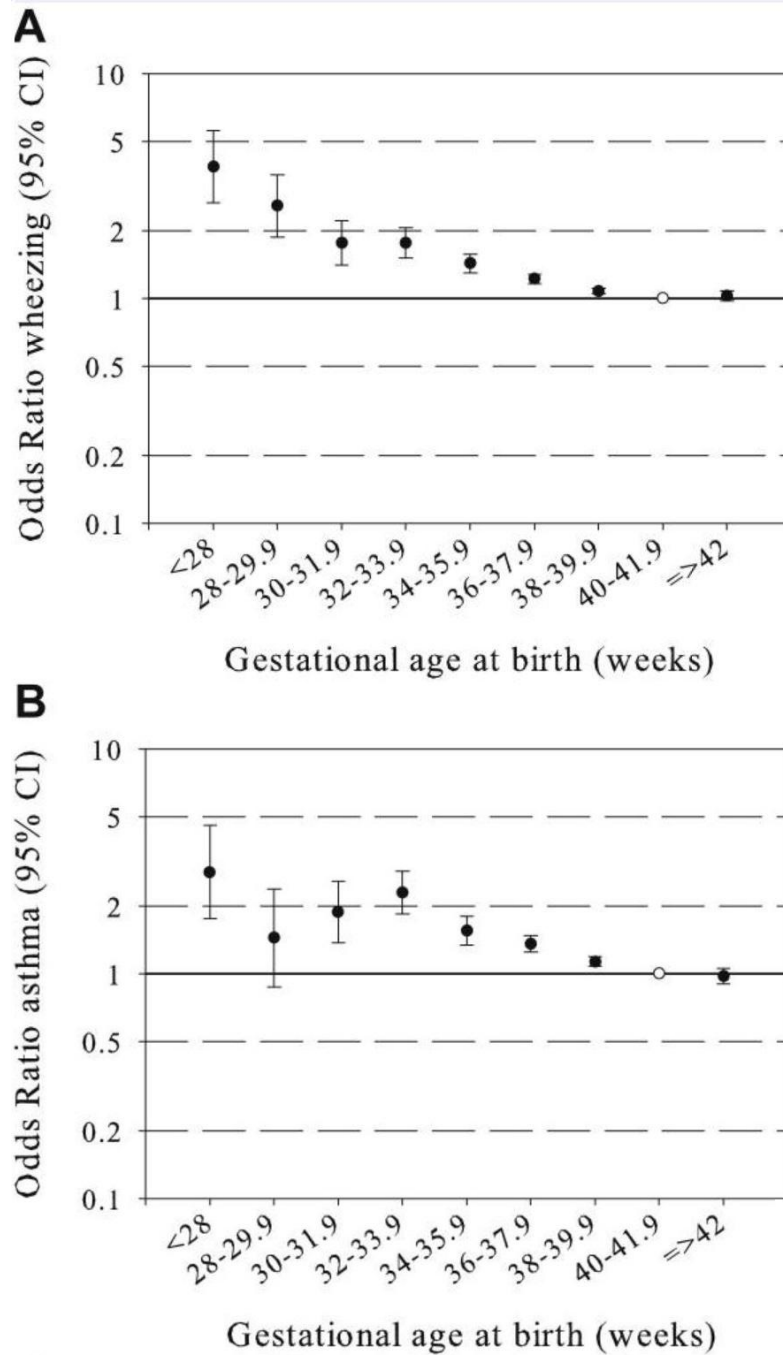


Figure 2: (A) Gestational Age at Birth and the Risk of Preschool Wheezing. (B) Gestation Age at Birth and the Risk of Childhood Asthma. Figure from Sonnenschein-van der Voort et al. 2014.

Controlling Asthma

Once the diagnosis of asthma has been established, since it cannot currently be cured, the goal of treatment is to control symptoms and prevent exacerbations. The NAEPP guidelines state that the four components to asthma management are: 1) assessment and monitoring, 2) education for partnership in care, 3) control of environmental factors and co-morbidities, and 4) medication (National Asthma Education and Prevention Program, 2007). Although each component is equally important in effective care, guideline recommendations for partnering and educating and patients (or caregivers) and controlling for environmental factors are the same among all age groups. Thus only the assessment and medication component will be discussed here.

Asthma Severity and Control Assessments

Currently, the NAEPP guidelines have severity of symptoms, nighttime awakenings, interference with normal activity, and short-acting beta2 - agonist (SABA) use for episodic symptom relief as components in determining severity and control (National Asthma Education and Prevention Program, 2007). Physicians also rely upon these components when deciding how to adjust therapy.

Example of generic questionnaire questions are, "How many days in the past week have you had chest tightness, cough, shortness of breath, or wheezing (whistling in your chest)? Have you had any unscheduled visits to a

doctor, including to the emergency department, since your last visit? What is the average number of puffs per day of quick-relief medication (short acting beta2-agonist)?" (National Asthma Education and Prevention Program, 2007).

To carry out assessments, questionnaires are commonly used to assess these components. Questionnaires include the Asthma Therapy Assessment Questionnaire (ATAQ) (Vollmer, 2004), the Asthma Control Questionnaire (ACQ) (Juniper, O'byrne, Guyatt, Ferrie, & King, 1999), and the Asthma Control Test (ACT) (Nathan et al., 2004). Each of these tools have been evaluated and validated for their efficacy in identifying patients at risk for adverse asthma outcomes in adults, but unfortunately these tools have not yet been validated in assessing asthma severity those under the age of five (Juniper et al., 1999; Nathan et al., 2004; Skinner et al., 2004; Vollmer, 2004).

The goal of assessing severity is to apply the correct treatment regimen. Depending on the severity, patients' asthma without medication is categorized into 1) intermittent, 2) mild, 3) moderate, or 4) severe. For children ages 0 to 4, intermittent asthma severity means two or less symptoms per week, zero night time awakenings, using short-acting beta2-agonists (SABAs), no interference with normal activities, one or less exacerbations requiring oral steroids. A child with between two and six symptom days per week, one or two nighttime awakenings per month, between two and six SABA usages per week, minor limitations in regular activity, and more than two episodes in six months requiring the use of oral steroids, OR four or more episodes of wheezing in the last year

that last longer than one day and has risk factors for persistent asthma has mild asthma. Moderate and severe asthma experience more frequent symptoms, more nighttime awakenings, more frequent SABA use, and increasing limitations to normal activities (National Asthma Education and Prevention Program, 2007) (See Table 4).

The NHBLI Guidelines have developed a stepwise treatment plan to help providers apply the appropriate therapy (National Asthma Education and Prevention Program, 2007). Once Severity has been established, the child can be started on the recommended corresponding step. (See Figure 5) The guidelines recommend children with intermittent asthma on step one, children with mild asthma on step 2, and moderate and severe on step 3 (National Asthma Education and Prevention Program, 2007). During assessments for control, if the child presents with similar symptoms to a mild severity or worse, the child's asthma is considered not well controlled and the provider is recommended to step-up therapy to the next step. If the child presents with intermittent severity, the child's asthma is considered well controlled and the provider is recommended to maintain the current step or consider step a step-down if control is maintained for 3 months (National Asthma Education and Prevention Program, 2007). It is important to note that if no improvement is found after four to six weeks of daily inhaled corticosteroid (ICS) use, it is recommended to consider alternate diagnoses.

Components of Severity		Classifying Asthma Severity and Initiating Therapy in Children									
		Intermittent			Persistent						Severe
		Ages 0-4	Ages 5-11	Ages 0-4	Ages 5-11	Ages 0-4	Ages 5-11	Ages 0-4	Ages 5-11	Ages 0-4	Ages 5-11
Symptoms	≤2 days/week	>2 days/week but not daily	1-2x/month	3-4x/month	Daily	3-4x/month	>1x/week but not nightly	Throughout the day	>1x/week	Often 7x/week	
	0	≥2x/month	>2 days/week but not daily	Minor limitation	Some limitation	Extremely limited					
	None	Normal FEV ₁ between exacerbations	>80%	>80%	≥2x/year (see notes)	Relative annual risk may be related to FEV ₁					
Impairment	Short-acting beta ₂ -agonist use for symptom control	Interference with normal activity	Lung Function	• FEV ₁ (predicted) or peak flow (personal best)	• FEV ₁ /FVC						
	Exacerbations requiring oral systemic corticosteroids (consider severity and interval since last exacerbation)										
Risk	0-1/year (see notes)	≥2 exacerbations in 6 months requiring oral systemic corticosteroids, or ≥4 wheezing episodes/1 year lasting >1 day AND risk factors for persistent asthma									

Table 4: Assessing Asthma Severity in Children 0 to 5 and 5 to 11. Amended from NHLBI Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma 2007

		Step up if needed (first check inhaler technique, adherence, environmental control, and comorbid conditions) Assess control					
		Step down if possible (and asthma is well controlled at least 3 months)					
		Step 1	Step 2	Step 3	Step 4	Step 5	Step 6
		Persistent Asthma: Daily Medication					
		Consult with asthma specialist if step 3 care or higher is required. Consider consultation at step 2.					
Children 0–4 Years of Age	Preferred	Intermittent Asthma SABA PRN	Low-dose ICS	Medium-dose ICS	Medium-dose ICS + LABA or Montelukast	High-dose ICS + LABA or Montelukast	High-dose ICS + LABA or Montelukast + Oral corticosteroids ICS
	Alternative		Cromolyn or Montelukast				
		Each Step: Patient Education and Environmental Control					
Quick-Relief Medication		<ul style="list-style-type: none"> SABA as needed for symptoms. Intensity of treatment depends on severity of symptoms. With viral respiratory symptoms: SABA q 4–6 hours up to 24 hours (longer with physician consult). Consider short course of oral systemic corticosteroids if exacerbation is severe or patient has history of previous severe exacerbations. 					
		Caution: Frequent use of SABA may indicate the need to step up treatment. See text for recommendations on initiating daily long-term-control therapy.					

Figure 3: Stepwise Approach for Managing Asthma Therapy in Children 0 to 4. Amended from NHLBI Expert Panel 3: Guidelines for Diagnosing and Management of Asthma 2007

Corticosteroid Medications

One of the key pillars in managing asthma and controlling its symptoms is medication. Medications are typically divided into long-term controller medication, and short-term rescue medication. Controller medications are aimed at controlling airway inflammation. Typically controller medications include, "corticoid steroids (inhaled [ICSs] or oral), cromolyn sodium and nedocromil, immunomodulators, leukotriene modifiers, long-acting beta2-agonists (LABAs), and methylxanthines" (National Asthma Education and Prevention Program, 2007).

The most common of these are ICSs due to its relatively high efficacy (Castro-Rodriguez, Custovic, & Ducharme, 2016). A randomized control study by Guilbert et al. examined the effects of early ICSs use in preschool children at high risk for asthma (Guilbert et al., 2006). In this study, researchers randomized two groups of children. One group was given an ICS (fluticasone propionate [Flovent]) to take two 44ug puffs twice daily, the other group was given a similar placebo. Each group was also given rescue medication of albuterol in either puff inhaler or nebulizer and four day oral corticosteroid (prednisone) treatment to be taken during episodes of exacerbation (Guilbert et al., 2006). Two groups were monitored over the next two years, then treatment was discontinued from the experimental group and both were observed for an additional year. The main outcome was symptom free days. The results were that the treatment group

experienced more symptom free days (93.2%) than the placebo group (88.4%) during the first two treatment years (Guilbert et al., 2006). Importantly the treatment group experience no significant change in the proportion of episode free days during the treatment period (97% to 96%), while the control group experienced a decline (96% to 89%). During the observation year, the treatment group (86.8%) did not show any significant improvement over the placebo group (85.9%). In fact, both groups experienced a decreasing proportion of symptom free days (See Figure 6) (Guilbert et al., 2006). These findings support the theory that ICSs are effective in reducing asthma symptoms and thus the burden of disease in those with high risk for asthma. However, during the observational period, once ICS treatment was stopped, both groups had similar outcomes. This in particular shows that early ICS treatments only have symptomatic benefit but do not have a preventative effect on the development of asthma in high-risk children (Guilbert et al., 2006).

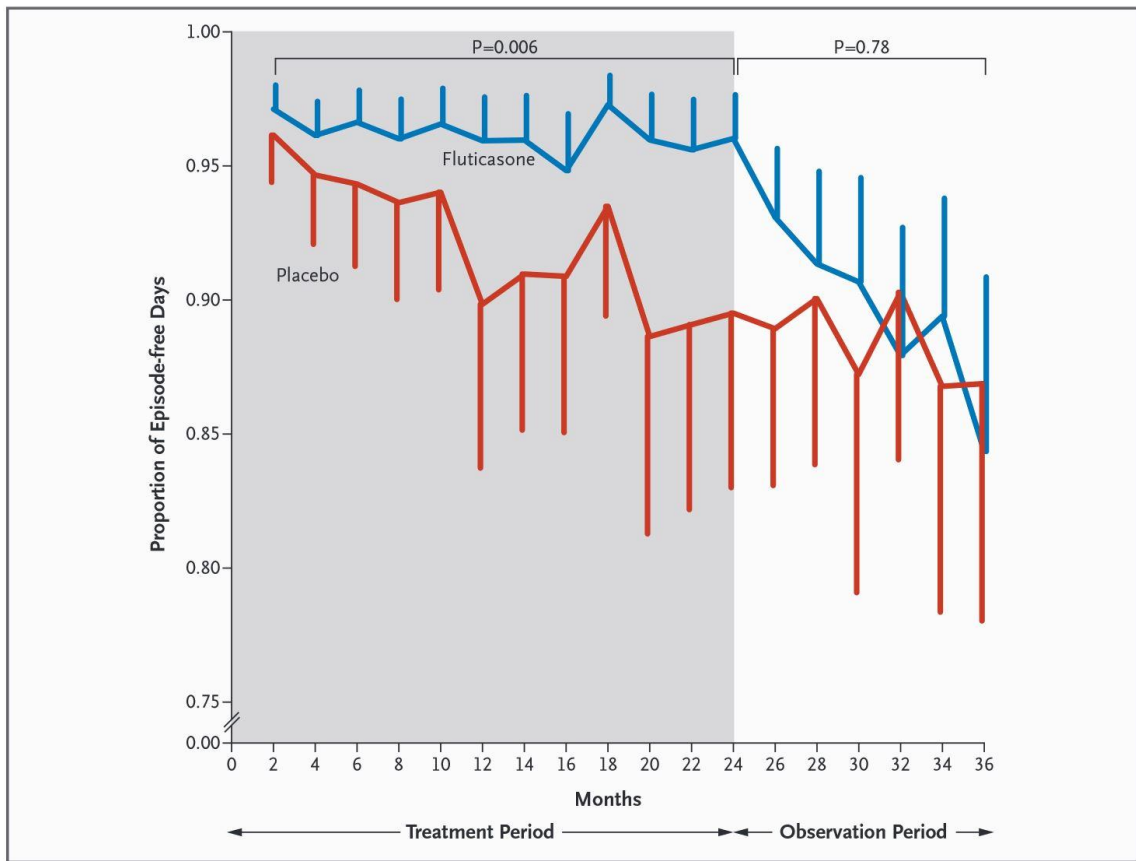


Figure 4: Proportion of Asthma Episode (Symptom) Free Days, ICS (Fluticasone) vs Control. During the two year treatment period, children in the treatment group (blue) experienced a significant higher proportion (93.2%, 95% CI= 91.1% to 94.9%) of asthma episode days when compared to the control group (red) (88.4%, 95% CI = 84.9 to 91.2%, P=0.006). More notably, the during the treatment period the proportion of episode free days remained unchanged for the intervention group over the two years (97% to 96%), while the control group experienced a decline (96% to 89%). During the observation period, the proportion of episode free days for the intervention group declined to match the control group. (Figure from Guilbert 2006)

Long term use of corticosteroids are well documented to have a wide range of side effects that vary from cataracts to hypertension. However, ICSs are typically recommended in doses low enough to avoid them or taken in conjunction with non-steroidal anti-inflammatory drugs such as LABAs or leukotriene

moderators, especially for mild to moderate asthma (Lipworth BJ, 1999; National Asthma Education and Prevention Program, 2007). It is important to note that increased dose, prolonged use (longer than one year), and oral systemic corticosteroids increase the risk of side effects such as cataracts and reduced bone density (Lipworth BJ, 1999; National Asthma Education and Prevention Program, 2007).

One side effect of ICSs that is of particular concern is decreased linear growth rates. Thus in the previously mentioned study by Guilbert et al. (Guilbert et al., 2006), researchers also examined the effect of early ICS on growth rates. They found children in the placebo group grew 1.1 cm more than those in the treatment group at the end of two year treatment phase, and 0.7 cm more at the end of the one year observation phase (Guilbert et al., 2006). A recent review of the various asthma treatments concluded that there is limited evidence that ICS use may be associated with growth suppression in preschoolers. The evidence supports that, "the growth suppression appears neither progressive nor regressive, and it is not cumulative beyond the first year of therapy" (Castro-Rodriguez et al., 2016). Also, some ICS are known to have more growth suppression effects than others. Thus, providers should prescribe the least growth suppressive medication at the lowest effective dose. Providers should also monitor growth of the children on ICS therapy since susceptibility can vary widely from person to person (Castro-Rodriguez et al., 2016).

Overall, despite the fact that our current guideline medications (inhaled corticosteroids) are neither preventative nor cures, our current body of evidence implies that early administration of such therapy can greatly diminish adverse outcomes for preschool children with asthma with relatively few side effects. This fact highlights the importance of improving awareness to reduce the under diagnosis of asthma in preschool children as well as adherence to prescribed therapies.

Racial Disparities and Asthma

Race also plays a key role in the outcomes of asthma. One of the issues surrounding asthma disparities is how it disproportionately burdens urban vs. rural, black and Hispanic vs. white, low income vs. high income, and youth vs. adults (Akinbami, Moorman, Simon, & Schoendorf, 2014) (See Figure 6). In the 2013 National Health Interview Survey (NHIS), asthma was found to be more prevalent in black and Puerto Rican children under 18 years old when compared to white children (13.4% and 20.7% compared to 7.5% respectively) (CDC, 2013a). With respect to income, asthma prevalence rates are inversely proportional to income. Of those living below 100% of the federal poverty level, 10.9% had asthma compared to 7.0% for those living between 100% and 250% of the poverty level and even lower prevalence for those with higher incomes (CDC, 2013a). To compound this disparity, minorities compared to whites not only experience higher prevalence but also more severe asthma and worse

health outcomes due to asthma. Blacks tend to fare far worse in a number of health indicators for asthma including of emergency department visits (254.4 compared to 77.9 per 10,000), hospitalizations (33.3 compared to 10.1 per 10,000), and deaths (8.6 compared to 1.2 per 10,000) when compared to whites (Akinbami et al., 2014).

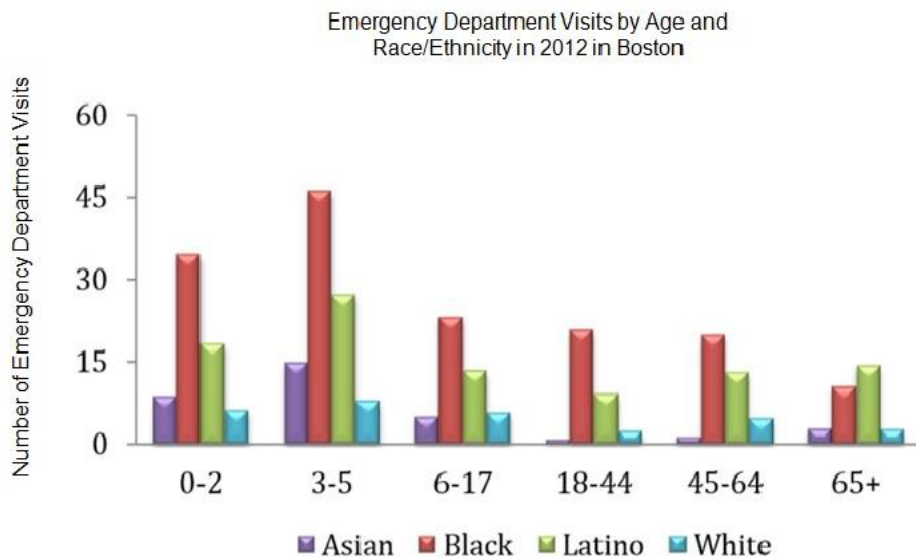


Figure 5: Emergency Department Visits by Age and Race/Ethnicity, Boston 2012. Amended from Health of Boston Report 2014-2105

Disparities in quality of care in young minority children with asthma is also an area that needs attention. A study by Finkelstein et al. (Finkelstein et al., 1995), examined the differences in quality of care by patient race and source of treatment in children age 1 to 6. Using discharge records from a tertiary hospital, researchers compared use of beta-agonists and anti-inflammatory medication (ICS or cromolyn) before admission as a proxy for quality of outpatient care,

intensity of beta-agonist therapy within the emergency department and length of stay as a proxy for quality of in-hospital care, and prescriptions for nebulizer at home as a proxy for the quality of post-hospital care. Payment methods were divided into three categories, public (medicaid), private, and "self pay" (uninsured.) The results indicated significant differences in quality of care based on race after adjusting for age, gender, source of payment, and prior hospitalizations. Compared to whites, Hispanics were found to be much less likely have received beta-agonists (OR = 6.3) or anti-inflammatory medications (OR = 4.9) prior to admission, and much less likely to receive a nebulizer upon discharge (OR 14.6). Blacks, on the other hand, were just as likely to receive beta-agonists but less likely to receive anti-inflammatory medication (OR = 3.9) before admission, and also less likely to receive nebulizers (OR = 4.5) upon discharge when compared to whites. It is important to not, however, that after adjusting for primary care practice type as well (e.g. hospital clinics, private practices, community health centers, private practice, or subspecialty practice), only differences in receiving nebulizers upon discharge were significantly different. No differences in in-hospital care were found (Finkelstein et al., 1995). Findings from this study show that post hospitalization care varies by race. Furthermore the study suggests that care for asthma in different primary care settings varies, and access to different settings based on race may play a role in the disparities in care received.

In a retrospective study by Ortega et al. (Ortega et al., 2002), researchers examined a number of factors including the impact of source of care on asthma medication use by race and ethnicity. Researchers reviewed parent-reported questionnaires from The Childhood Asthma Severity Study for children ages 12 and under with asthma in Connecticut and Massachusetts. Several analyses were done to adjust for "child's age, gender, insurance status, asthma severity, number of scheduled visits for asthma to the regular provider, number of urgent visits for asthma to the regular provider, family income, and maternal education, practice type", and site of care (Ortega et al., 2002). Results from this study showed a base level of inequalities. When compared to whites, blacks and Hispanics were much more likely to have lower income (7% compared to 52% and 62%), lower maternal education (78% having more than high school education compared to 43% and 25%), and less likely to be seen in private practices (92% compared to 52% and 40%). When comparing asthma medication use by type of practice, patients whose primary site of care was private practices were twice as likely to use inhaled steroids over 30 times in the last year (15%) when compared to those using ambulatory care centers (7%) or hospital based clinics (7%) (Ortega et al., 2002), agreeing with the results from the Finkelstein et al. study. Most importantly when the scope of analysis was narrowed to differences within just private practices, asthmatic black and Hispanic children were less likely to have used inhaled steroids in the past year (OR = 0.5 and 0.3 respectively) (Ortega et al., 2002). Overall researchers

concluded that minority children are less likely to receive the optimal asthma care compared to whites even after adjusting for other socioeconomic, healthcare statuses, and behaviors.

In addition to site and quality of care, it has been well documented that use of specialty care (e.g. allergist, pulmonologist) improves asthma outcomes in children (Diette et al., 2001; Schatz et al., 2005). To explore how access to specialist care, poverty, and quality of care affect the morbidity of asthma in urban minority children, Flores et al. performed a cross sectional study (Flores et al., 2009). In this study, participants were 220 black and hispanic children ages 2 to 18 who were admitted into the emergency department or inpatient ward for asthma. Researchers administered questionnaires to caregivers regarding sociodemographic and healthcare characteristics, and health status. "Primary study outcomes included (1) asthma exacerbations; (2) missed school days; (3) parental missed workdays; (4) asthma ED visits; (5) asthma hospitalizations; (6) asthma doctor visits; (7) used the ED as the usual asthma care source; (8) having an asthma specialist; and (9) having a written asthma care plan" (Flores et al., 2009). Findings from this study show significant advantages associated with having an asthma action plan, and having an asthma specialist, and significant disadvantages associated with being in poverty. Specifically, children with asthma action plans had on average 17 asthma exacerbations per year compared to an average of 27 exacerbations per year for children without action plans. Furthermore, children with specialists had on average half as many

asthma exacerbations (seven) as those without a specialist .(Flores et al., 2009). Meanwhile, "poor children were much less likely to have an asthma specialist than non-poor children (13% vs. 26%)" (Flores et al., 2009). These findings suggest the need for improved access to specialist care among minorities and impoverished and suggest that a relatively simple solution (providing more asthma action plans) may be readily available to help reduce morbidity.

It is important to note that while many studies address disparities within race, minority status, and socioeconomic status, only a small proportion include the age range 0 to 5 and none were found that had that age range as a focus despite a remarkably higher burden in that group as mentioned in previous sections. Furthermore, while many studies document the disparities, few examine underlying causes as to why they exist. Some proposed theories are lack of access to care, low health literacy, environmental injustices, low education attainment, exposure to violence or trauma, increased caregiver stress, and genetic factors (Beck et al., 2014; Williams, Sternthal, & Wright, 2009). Many of these are inevitably interrelated and tightly intertwined.

QUALITY IMPROVEMENT

To tackle some of the issues and disparities in care facing minority preschoolers with asthma, a multitude of interventions have been proposed and evaluated (Bravata et al., 2007; Bravata DM, Gienger AL, Holty JC, & et al, 2009;

Okelo et al., 2013). The categories that Agency for Healthcare Research and Quality (AHRQ) have used to organize quality improvement strategies are:

"1) Provide reminders [or decision support]- Information tied to a specific clinical encounter, provided verbally, in writing, or by computer, that is intended to prompt the clinician to recall information, or to consider performing a specific process of care.

2)Facilitated relay of clinical data to providers - Clinical information collected directly from patients is relayed to the provider in situations where the data are not generally collected during a patient visit, or when collected using a means other than the existing local medical record system.

3) Audit and Feedback - Any summary of a health care provider's clinical performance or an institution's clinical performance that is reported, either publicly or confidentially, to or about the clinician or institution.

4) Provider Education- Any intervention that includes one of the following sub-strategies: educational workshops, meetings, and lectures; educational outreach visits; or the distribution of educational materials

5) Patient Education - Patient education—for individuals or members of a patient group or community, presented either in person or via the distribution of printed or audio-visual educational materials.

6) Promotion of Self-monitoring or Self-management - The distribution of materials or access to resources that enhances patients' ability to manage their condition, the communication of clinical test data back to the patient, or follow up phone calls from the provider to the patient with recommended adjustments to care.

7) Patient reminders- Any effort directed toward patients that encourages them to keep appointments or adhere to other aspects of self-care" (Shojania, McDonald, Wachter, & Owens, 2004).

Although there are many aspects of asthma care and interventions are typically designed to be multifaceted to encompass the many aspects, they can

be categorized by the general domains they target: provider/healthcare, family, home environment, community/policy. Below are a few select interventions aimed at the healthcare side of asthma.

A well documented provider side problem is a lack of physician adherence to established guidelines for asthma care (Cabana et al., 2000; Cabana MD, Rand CS, Becher OJ, & Rubin HR, 2001; Doerschug, Peterson, Dayton, & Kline, 1999; Okelo et al., 2013; Picken, Greenfield, Teres, Hirway, & Landis, 1998). There is a wide range of documented barriers which vary from lack familiarity or agreement with the guidelines to lack of effective communication with caregivers (Cabana et al., 2000).

Decision Support

One example of an intervention targeting these barriers utilized the "decision support" and "facilitated relay of clinical data to providers" strategies. It was evaluated in a randomized control trial by Kattan et al. (Kattan et al., 2006). In this study participants were children with mild to severe asthma recruited from low income census tracts (at least 20% of households with incomes below the federal poverty line) in large urban cities within the United States. For all participants, the child's caretaker was interviewed over the phone every two months to collect data such as asthma symptoms, use of medical services (emergency department visits, physician visits, etc.), and use of asthma medications. Data from these calls was used to create a feedback letter containing a brief summary of the data collected from the interview, a one-

sentence recommendation based on severity classification according to the National Asthma Education Prevention Program (NAEPP) guidelines, and information to encourage the physician to contact the patient (Kattan et al., 2006). Recommendations were either to step up, down, or make no changes to the child's treatments. These letters were mailed to the child's primary care physician in the intervention group, no letters were sent to physicians in the control group. Physicians were interviewed at the conclusion of the study to determine how letters affected asthma care and barriers to following recommendations (Kattan et al., 2006).

Children in the intervention group experienced fewer emergency department visits when compared to children in the control group (0.87 compared to 1.14 visits per year, $P=0.013$) (Kattan et al., 2006). Other outcome measures such as symptom days, hospitalizations, and missed school days showed no statistically significant differences between groups. Out of the step-up letters, 17.1% were followed by a scheduled medical visit in the following 2 months in the intervention group compared to 12.3% in the control group ($P= 0.005$). Of these visits, 46% resulted in a medication step-up in the intervention group compared to 35.6% in the control group (Kattan et al., 2006). In a subgroup analysis of these results to determine the effects of earlier step-up medication, the interventions group experienced "fewer asthma symptom days per two weeks (3.92 vs 5.03 $P=0.02$), fewer school absences (0.77 vs 1.24 $P=0.004$), and fewer

unscheduled clinic visits during the year (0.47 vs 0.73 P=0.56)" (Kattan et al., 2006) (See table 5).

Table 5: Comparison Between Intervention Group and Control Group of a Decision Support Intervention. SE = standard error. Table from Kattan et al. 2006.

Intention-to-Treat Analysis	Physician Feedback Group (N = 466)		Control Group (N = 463)		P ^a
	Mean	SE	Mean	SE	
Symptoms because of asthma per 2 wk					
Maximum symptom days	3.43	0.11	3.52	0.11	.54
Days limited in activities for more than half day	1.42	0.07	1.60	0.08	.09
School days missed	0.67	0.04	0.72	0.04	.38
Use because of asthma per year					
Number of ED visits	0.87	0.07	1.14	0.08	.013
Number of unscheduled clinic visits	1.14	0.08	1.31	0.08	.14
Number of hospitalizations	0.22	0.03	0.24	0.03	.56

^a For 2-week measures, mixed linear model adjusting over available time points was used for site and baseline level. For 1-year measures, analysis of covariance, adjusting for site and baseline use, was used.

In a simple cost-effective analysis on the intervention, researchers estimated the cost to be about \$69.20 per child for the year based on typical clerical wage rates and number of calls made that year. This amount was added to the cost of health service utilization over the year in the intervention group and compared to the costs of health service utilization in the control group. Researchers reported that there was an estimated \$337 saved per child saved by the intervention (Kattan et al., 2006).

Unfortunately researchers did not measure the providers' perspective on the intervention. However, they did monitor physician behavior upon receiving a step-up letter. Physicians reported sometimes or always read the feedback letter

99% of the time, and 82% of physicians sometimes or always reviewed the patient's charts chart after receiving a step-up letter (Kattan et al., 2006). Furthermore, 73% of physicians attempted to contact the patient and 28% of physicians reported that their patients would not make follow up appointments. Only 9.4% of physicians disagreed with the letters (Kattan et al., 2006).

Provider Asthma Education:

An example of an intervention that uses the provider education strategy can be found in a randomized control study by Clark et al. (Clark et al., 2000). In this intervention, investigators introduced an interactive seminar to practicing pediatric physicians to examine any resulting changes in behaviors with regards to their administering clinical treatment of asthma, teaching and communicating with patients, and patient outcomes (Clark et al., 1998). The intervention was based on the theory of self-regulation, and aimed to encourage physicians to develop partnerships with their patients. The two main components were promoting NAEPP guideline adherence and improving patient teaching and communication (Clark et al., 1998). These aims were carried out through the use of lectures, video examples, case studies, providing patient communication self-assessment protocols, and patient teaching messages and tools. Patient caregivers and their physicians were surveyed before the physician was randomly placed in to either the control or program group. Physicians completed follow-up surveys after 5 months and caregivers were interviewed after their first visits (Clark et al., 1998). Physicians and caregivers in the intervention group self

reported improvement over the control group in a number of fields. The study found that physicians in the program group were more likely to prescribe anti-inflammatory therapies, provide education, and be reassuring, fear-reducing, and informative. Moreover, parents in the intervention group on average felt more prepared to manage asthma at home. They rated their physicians more favorably despite physicians reporting spending less time with patients (Clark et al., 1998) (See Table 6). It is also important to note that ED visits overall did not decrease between groups but for low income children (family income <\$20,000 per year), program group had .57 visits per year compared to 1.57 in the control group (Clark et al., 1998).

Provider education may seem like one of the more obvious, simple, and inexpensive methods to improve provider adherence to guideline care. However, many have implemented and evaluated this strategy with mixed results (Bravata et al., 2009; Brown et al., 2004; Okelo et al., 2013; Weingarten et al., 2002). One systematic review of interventions that used provider education strategies to improve chronic disease care by Weingarten et al. (Weingarten et al., 2002) found that 12 out of 24 studies (50%) improved adherence measures. A separate systematic review of quality improvement strategies for asthma care by Bravata et al. (Bravata et al., 2009) found that out of seven studies, "all but 1 study found statistically significant improvements in use of medications (most often increases in the use of inhaled controller medications).

Table 6: Patient Survey Response about Clinician (top) and Patient Healthcare Utilization (bottom). T=Treatment Group, C= Control Group. NS= non-significant. Survey responses used Likert-type scores where 1= strongly disagree, 6= strongly agree, unless otherwise noted. Table from Clark et al. 1998.

Clinician:	T	C	P Value
Was reassuring and encouraging	4.63	4.42	.006
Looked into how family managed day to day	3.98	3.69	.02
Described how child should be fully active	71%	59%	.007
Described at least one of three goals: child should sleep through the night; have no symptoms when active; be fully active	75%	64%	.07
Gave information to relieve specific worries	4.1	3.9	.007
Enabled family to know how to make asthma-management decisions	4.3	4.2	.07
Patient:	T	C	P Value
Number of scheduled doctor office visits	1.24	2.25	.005
Number of follow-up doctors office visits after an episode of symptoms	.94	1.61	.005
Number of ED visits	.65	.67	NS
Number of hospitalizations	.081	.076	NS

Several found improvements in asthma symptoms and reductions in emergency department use" (Bravata DM et al., 2009). However they cite that,

"Given the small number and heterogeneity of these studies, we cannot evaluate the specific provider education intervention characteristics most likely associated with improvements in clinical outcomes" (Bravata DM et al., 2009).

The first point of having a small sample size may tie in with the second point regarding the heterogeneity of studies, as diversity in study design and chosen

measured outcomes may render some incomparable. This is a common issue encountered when evaluating programs and meta-analyses. The heterogeneity is in reference to both measured outcomes which can make interventions difficult to compare, but also is in regards to the programs themselves. For example programs that use the strategy of "provider education" vary on a multitude of factors from dose, material (eg care guidelines, communication skills, or cultural competency), and quality of teaching (eg one-on-one lectures or group interactive sessions).

Care Coordination

Care coordination is also key quality improvement strategy. The AHRQ offers a definition for care coordination:

"Care coordination is the deliberate organization of patient care activities between two or more participants (including the patient) involved in a patient's care to facilitate the appropriate delivery of health care services. Organizing care involves the marshalling of personnel and other resources needed to carry out all required patient care activities, and is often managed by the exchange of information among participants responsible for different aspects of care" (McDonald et al., 2007).

Although care coordination is not exclusively a provider side intervention, it is often incorporated into the healthcare setting and carried out between healthcare providers or, if a case manager is involved, by a healthcare worker (eg nurse, nurse practitioner). Reasons for this vary from sustainability, to ease of implementation and financial incentives (Stoll et al., 2015; Taylor et al., 2013; Woods et al., 2012).

This is coordination of care is particularly important to asthma when considering the variety of services commonly used by asthmatics. Services include primary care physicians, specialists such as pulmonologists and allergenists, urgent care clinics and emergency department, and intensive care units when hospitalized. Just within the healthcare system, the lack of communication between services and between patients can lead to missed follow ups, or confusion over medications (Butz et al., 2012; Fredrickson, Molgaard, Dismuke, Schukman, & Walling, 2004; Leickly et al., 1998; Peláez et al., 2015; Swartz, Banasiak, & Meadows-Oliver, 2005). Coordination is not only important within the clinic setting, there are public services and resources that require referral to receive. Examples from Boston are the Boston Asthma Home Visit Collaborative, and Breathe Easy at Home.

The Boston Asthma Home Visit Collaborative is a Boston Public Health Commission program that trains Community Health Workers to conduct home visits. During these visits, the community health workers provide asthma education, environmental assessments, and additional referrals to other

programs including smoking cessation programs, Healthy Baby Health Child, Breathe Easy at Home, etc (Boston Public Health Commission, 2016).

Breathe Easy at Home is a city run program and part of Inspectional Services designed to help tenants resolve substandard housing conditions with special attention to issues that exacerbate asthma such as mold, cockroaches, and mice (City of Boston, 2014).

These programs directly align with the NAEPP guidelines which highlight patient education and controlling environmental factors and pillars as two of the four components of care (Dougherty et al., 2007). Recruitment of these programs require referral from a provider which proved to be a challenge along with connecting with patients to schedule visits (NHLBI, 2013).

One strategy to address problems with coordination is to involve case managers, community health workers, or other support teams who can coordinate the various health care and social services as well as act as patient advocates to ensure patients receive the appropriate care.

The AHRQ outlines the components of care coordination to be:

"1) Identifying and assessing the patient, 2) Develop care plan, 3) Identify participants in care and specify roles, 4) Communicate to patients and all other participants, 5) Execute care plan, 6) Monitor and adjust care, and 7) Evaluate health outcomes" (McDonald et al., 2007).

The example the AHRQ gives as an program that contains many components of care coordination is the Geriatric Resource Assessment and Care for Elders (Counsell, Callahan, Buttar, Clark, & Frank, 2006; McDonald et al.,

2007) (See table 7). Although geriatric care and asthma care may seem widely different and the target age groups are on opposite sides of the spectrum, many of the same components and themes used in the GRACE intervention have been used to improve care for asthma. These include targeting low-income minority patients, home visits for assessment and education (City of Boston, 2014; NHLBI, 2013; Shani et al., 2015), coordinating specialty care (pulmonologist, allergists) (Diette et al., 2001; Schatz et al., 2005), improving self-management of chronic conditions, reducing emergency and acute care use, improving follow-up rates with PCPs after acute care use (Butz et al., 2012), promoting preventative care (Fredrickson et al., 2004), and integration with community services (City of Boston, 2014; Findley et al., 2011; NHLBI, 2013) to name a few. Indeed there have been many interventions aimed at providing or improving care coordination for pediatric patients with asthma and other chronic diseases that have shown promising results (Bravata DM et al., 2009; Findley et al., 2011; Loskutova et al., 2016; Woods et al., 2012).

The overarching goals of the GRACE intervention was to optimize the, "quality of care and quality of life, decrease excess healthcare use, and prevent long-term nursing home placement" (Counsell et al., 2006). The GRACE intervention used support teams of a nurse practitioner and clinical social worker to partner with low income seniors. The support team would make an initial assessment in the patients home which included a medical history, psychosocial evaluation, medication review, function assessment, assessment of the patients

social support system, and a home evaluation. They would then meet with a GRACE interdisciplinary team which included a, "geriatrician, pharmacist, physical therapist, mental health social worker, and community-based services liaison" to create an individually tailored care plan (Counsell et al., 2006).

The GRACE support team would then meet with the patient's PCP to present the results from the assessment and discuss and modify the proposed plan to align with the patient's healthcare goals. The plan was then implemented. Patients receive continued support and case management/coordination from the GRACE support team, which in turn was supported with an electronic medical record system. This system was also used to longitudinally record and monitor outcomes.

Over all, the GRACE support team was responsible for helping to create and carry out a care plan, at least monthly phone calls to check on patients, annual reassessments and follow-up visits, home visits after emergency department visits or hospitalizations, coordination between multiple providers and sites of care, remaining available to be contacted by their patients via phone, and to act as a contact for information or assistance with follow-up care for other providers/sites of care (emergency department, specialty care, primary care) (Counsell et al., 2006).

The creation of the tailored care plan is with respect to GRACE protocols. These protocols are specific recommendations to address specific geriatric

conditions to target for quality improvement (Counsell et al., 2006; Sloss et al., 2000). Target conditions were developed by an expert panel based on,

"(1) prevalence, (2) impact on health and quality of life, (3) effectiveness of interventions in improving mortality and quality of life, (4) disparity in the quality of care across providers and geographic areas, and (5) feasibility of obtaining the data needed to test compliance with quality indicators" (Sloss et al., 2000).

The conditions chosen to compose the GRACE protocols are:

"advance care planning, health maintenance, medication management, difficulty walking/falls, chronic pain, urinary incontinence, depression, malnutrition/weight loss, visual impairment, hearing loss, dementia, and caregiver burden" (Counsell et al., 2006).

Assessment of these conditions were included during the initial and subsequent patient assessments.

The authors specifically highlight that, the underlying theme of the GRACE intervention was to improve coordination and access to care for each patient as a whole rather than focusing on individual diseases. In pursuit of this goal, implementers sought to,

"provide patient education, help in improving patient self-management, and aid in linking the patient with existing health-system and community-based services. The innovation of GRACE is the integration of care across multiple chronic conditions and across the continuum of care" (Counsell et al., 2006).

The GRACE program was evaluated in a randomized control trial by Counsell et al (Counsell SR, Callahan CM, Clark DO, & et al, 2007). For outcomes measures, researchers used, "The Medical Outcomes 36-Item Short-Form (SF-36) scales and summary measures; instrumental and basic activities of

daily living (ADLs); and ED visits and hospitalizations. Patient health-related quality of life was assessed using the 8 SF-36 scales (physical functioning, role-physical, bodily pain, general health, vitality, social functioning, role-emotional, and mental health) (Ware & Sherbourne, 1992) which were aggregated into a Physical Component Summary (PCS) and a Mental Component Summary (MCS),... Days in bed due to illness or injury over the prior 6 months (more than half the day) not counting hospital and nursing home stays were also assessed, and Patients' overall satisfaction" (Counsell SR et al., 2007). Evaluations were made at baseline and then at every six months for two years by phone call by interviewers separate from the intervention process (Counsell SR et al., 2007).

The intervention group experienced higher quality of care and process of care measures such as more electronic medical record documentation, reception of specialty care, and provision of appropriate information or treatment, adherence to preventative care, medical care etc (Counsell SR et al., 2007). Interestingly, the results from overall comparisons of patient outcomes showed differences in only some of the measures after two years. Out of the eight measures from the 36 - SF scales, only four showed significant differences between treatment and control groups measured by changes in scores from intervention group minus changes in scores from control group. General health (2.5 (P= 0.045)), vitality (5.1 (P <0.001)), social functioning (5.3 (P= 0.008), and mental health (3.9 (P= 0.001) (Counsell SR et al., 2007). When comparing acute care utilizations rates, researchers found similar emergency department visit

rates per 1000 patients per year and similar hospitalizations per 1000 patients per year for the two years. However when researchers performed a subgroup analysis of patients identified as high-risk at baseline, they found significant lower rates in the second year for both emergency department visits (848 vs 1314 (P= 0.03)) and hospitalizations (396 vs 705, P= 0.03)) (See Figure 6) (Counsell SR et al., 2007)

Table 7: GRACE Intervention Components and AHRQ Care Coordination Components. Amended from McDonald 2007.

<i>Intervention Description</i>	<i>Component Categorization</i>	<i>Rationale</i>
GRACE support team acts as catalyst, provides care management, and consists of a nurse practitioner and a social worker	Identify Participants/ Specify Roles	Support team members specified and given role of coordinator
Upon enrollment, the GRACE support team meets with the patient in the home to conduct an initial comprehensive geriatric assessment	Assess Patient	Comprehensive assessment anticipates social, medical and other needs for coordination
The support team meets with GRACE interdisciplinary team (including a geriatrician, pharmacist, physical therapist, mental health social worker, and community-based services liaison) to develop an individualized care plan including activation of GRACE care protocols for common geriatric conditions	Identify Participants	Interdisciplinary team members identified explicitly
	Develop Care Plan	Standard protocols are tools to support coordination with primary care physician and other participants
The GRACE support team meets with the patient's primary care physician (PCP) to discuss and modify the plan	Communicate/ Ensure Information Exchange Across Care Interfaces	Primary care-specialty care interface addressed with a technique— a meeting
Collaborating with the PCP, the support team implements the plan	Execute Care Plan	

<p>With support of electronic medical record and longitudinal Web-based care management tracking system, the GRACE support team provides ongoing care management and coordination of care across geriatric syndromes, providers, and care sites</p>	<p>Monitor and Adjust Care/ Monitor and Address Coordination Failures</p>	<p>Electronic medical record (info system), a tracking tool (tool) and support team (technique) used to monitor coordination across providers and settings</p>
<p>The goal of the GRACE model is to optimize health and functional status, decrease excess healthcare use, and prevent long-term nursing home placement</p>	<p>Evaluate Health Outcomes</p>	<p>Evaluation built into model, including measures to flag coordination issues</p>

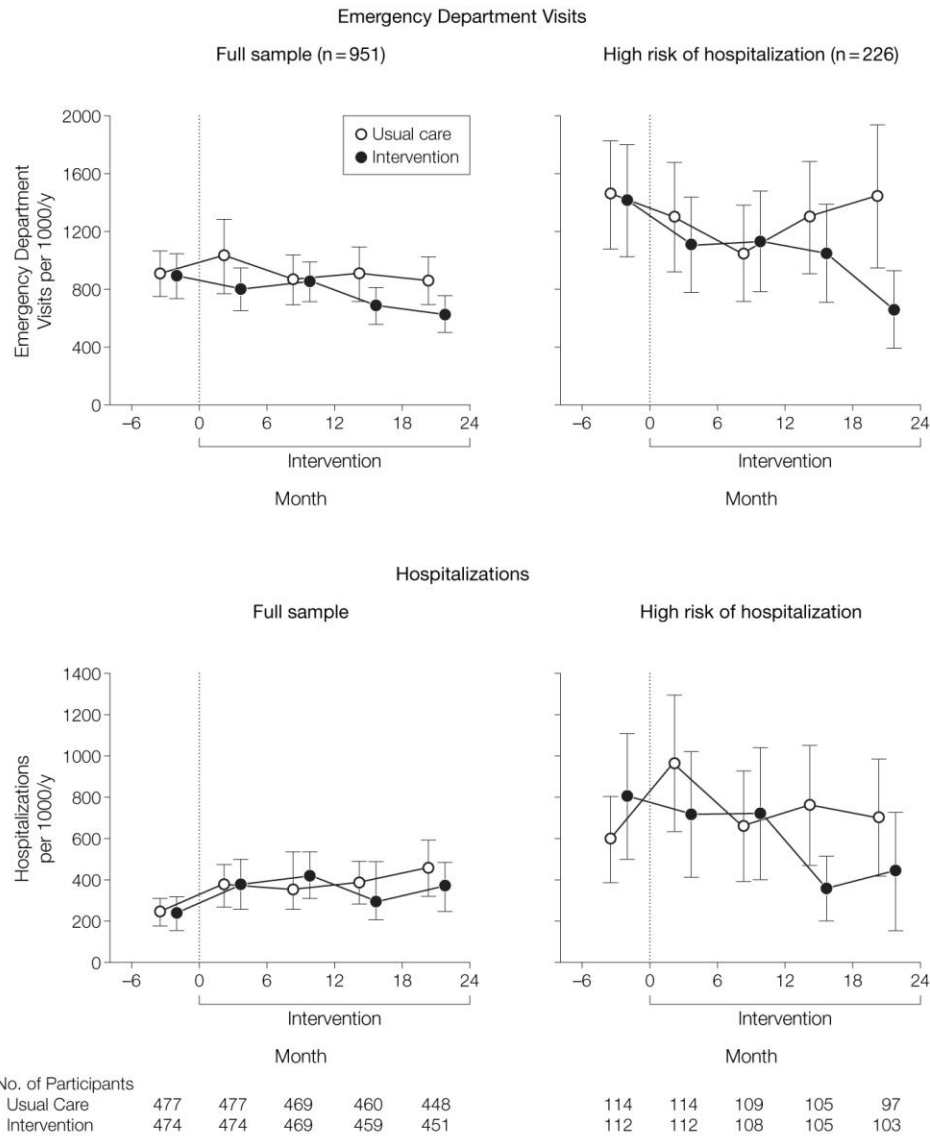


Figure 6: Acute Care Utilization Rates from Baseline to Year 2, High-risk Subgroup Analysis. When comparing emergency department visits per 1000 per year for the two years of follow-up, the intervention group was lower than the control group (usual care) (1445 vs 1748, $P= 0.03$). Rates were comparable in the first year (823 vs 937, $P= 0.22$), but significantly lower for the intervention group in the second year (643 vs. 841, $P= 0.01$) (top left). Hospitalizations rates over both years did not differ significantly between intervention and control groups in year one or two (bottom left). When analyzing only high-risk patients, emergency department visit rates were did not differ between the intervention and control group in the first year, but were significantly lower in the second year (848 vs 1314, $P= 0.03$) (top right). Comparison of hospitalization rates of high risk patients also showed similar between intervention and control groups in the first year, but significantly lower rates in the second year (396 vs 705, $P= 0.03$) (bottom right). Figure from Counsell 2007.

DISCUSSION AND CONCLUSION

In conclusion, asthma care is difficult especially for minority preschoolers due to the lack of our current knowledge of the illness' natural history, technical limitations in making an accurate diagnosis, as well as social and economical factors. The role of race and socioeconomic factors continues to be pervasive throughout aspects of life and manifests itself in many forms, one being the burden of asthma. In recent decades, there has been uplifting progress to close the disparities in care but much work is left to be done.

Continued advancements in basic science research and technology will help overcome the diagnostic challenges and will hopefully one day provide a cure and prevention strategies. However, along with advances in care, further quality improvement strategies and intervention studies aimed at closing disparity gaps are necessary to improve delivery and access to that care.

A review of the literature highlights a number of common obstacles in the evaluation of quality improvement programs, in particular complex, multi-level campaigns. Using asthma as an example, there are a great number of process measures (eg. controller medication prescriptions, asthma action plans distributed, patient education) and clinical outcomes (eg. emergency department visits, hospitalizations, symptom days, missed days of work/school, etc.) that can be recorded. There is some consensus on using emergency visits and prescribing controller medications as common measures but the lack of a standard indicator makes it difficult to compare studies to each other. Many

studies measure some of these outcomes but not others rendering met-analyses difficult to conduct or conclude (Okelo et al., 2013).

Furthermore, many studies were found to use similar strategies with disparate results. The complexity of interventions, environmental and cultural contexts, and diversity of healthcare and personal settings, highlight the importance of implementation science and context conscious intervention planning to ensure accurate strategy evaluation, program fidelity, and the translation of proven interventions from a controlled scientific setting to a dynamic and messy real world. In other words, when designing an intervention, describing the underlying theories of change and recording measures of implementation processes are necessary to understand *why* an intervention does or does not work - was success or failure due to the intended approach/strategy of the intervention or the implementation of it? Answering this question will help direct future research as well as allow for scaling up and adoption of successful programs to different settings.

The beginning sections of this paper was designed to be a brief overview of select aspects of asthma care for children ages zero to five. By focusing on the 0 to 5 age group, this paper examined the aspects of diagnosis, assessment, and medications particular to this group. Due to the scope, no overview of the NAEPP guidelines was provided for the components of partnering with/educating patients (or in this case caregivers) to facilitate self-management, and the role of managing environmental triggers which do not vary across age groups. However,

these two areas are also targets for quality improvement strategies and should also receive increased attention in future studies.

The last section focused only on provider side quality improvement interventions. Although many improvements need to be made to increase the access, quality, and efficiency of care, interventions that utilized a combination of quality improvement strategies or used multi-level approaches - included interventions targeting the community and caregiver as well as provider- were more often successful than interventions that only included a single strategy (Bravata et al., 2007; Findley et al., 2011; To, Cicutto, Degani, McLimont, & Beyene, 2008; Woods et al., 2012). All in all, asthma care for preschoolers is complex and wrought with barriers that cause an increased morbidity. Continued research into comprehensive interventions that combine multiple strategies is required to reduce the burden of disease in preschool minorities.

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CURRICULUM VITAE

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Year of Birth 1989

EDUCATION

Boston University Expected Graduation May 2016
Masters of Science in Medical Sciences
Masters of Public Health

University of California, Santa Barbara Sept. 2007 - June 2011
Bachelor of Science in Biological Sciences

LABORATORY/RESEARCH EXPERIENCE

Staff Research Associate I April 2012 - April 2014

UCSF - Dept. of Surgery

- Collection and storing specimens for, and maintenance of the Thoracic Oncology Tissue Bank
- Update and maintenance of the Thoracic Oncology Database to reflect current patient clinical information
- Collaboration with fellow researchers to provide them clinical information
- Research projects utilizing various molecular and microscopy techniques
- Educate high school interns on molecular assays and cancer biology
- Collection of blood from patients in clinic for current and future studies via venipuncture

AAUS Certified Research Diver Jan. 2008-Sept. 2011

SBC Long Term Ecol. Research

- Assisted LTER staff and graduate students with sub-tidal and laboratory research projects
- Surveyed common kelp forest algae, invertebrates, and fish using SCUBA
- Laboratory processing of algae and invertebrate tissue samples in preparation for chemical analysis
- Computer entry and quality assurance of project data
- Trained and supervised new interns, including creating PowerPoint presentations for orientation

Lab Assistant III June 2008 - Sept. 2009

UCSF - Dept. of Ophthalmology

- Assisted in development of a genetic test for retinoblastoma, now offered to patients nationwide
- Amplified genomic DNA from patient blood using PCR

- Evaluated PCR yields using gel electrophoresis
- Performed high-throughput Sanger resequencing of the human RB1 gene
- Identified pathogenic mutations that cause retinoblastoma, using Sequencer software
- Maintained and operated an Applied Biosystems 3130xl genetic analyzer
- Programmed Biomek automated liquid handling systems, and validated performance
- Purchased laboratory supplies and ordered equipment repairs

GENERAL WORK AND VOLUNTEER EXPERIENCE

Event Staff

Feb. 2015 - Present

Central Rock Gym, Watertown

- Provide customer service and maintain a fun and safe environment for guests and members to enjoy the sport of climbing
- Assist in coaching a non-competitive youth climbing team
- Host events and provide belay for guests
- Cleaning and tidying of facility

Phlebotomy Intern

October 2013

SFGH Womens' Health Clinic

- Fulfilled blood draw requisition orders
- Maintained supply of equipment stocks
- Called patients to confirm appointments

Guest Services Representative

June 2011 - Sept. 2011

UCSB Housing & Res. Services

- Provided guests with hospitality services and information about the UCSB campus and Santa Barbara area in a welcoming and professional manner
- Checked-in and out guests upon arrival/departure in a timely and efficient manner
- Provided transportation between the UCSB campus and Santa Barbara Airport.

ReStore Volunteer

Jan. 2011 - Sept. 2011

Santa Barbara Habitat for Humanity ReStore

- Received, cleaned, and organized donated items including pick-ups off location
- Assisted patrons in locating, moving, and purchasing items
- Assisted in set-up and break-down of fundraising events
- Served refreshments to attendees at fundraising events

POSTERS AND PUBLICATIONS

1. Mallory K. Mest, David W. Collins, Gregory Jew, Joey Perez and Joan M. O'Brien. "Manipulating Primer Position and Mass Dramatically Improves Quality of *RB1* Exon Sequencing". Presentation abstract, annual meeting of the Association for Research in Vision and Ophthalmology (ARVO, May 2011).

2. Li Tai Fang, Sharon Lee, Helen Choi, Hong Kwan Kim, Gregory Jew, Hio Chung Kang, Lin Chen, David Jablons, and Il-Jin Kim. "Comprehensive genomic analyses of a metastatic colon cancer to the lung by whole exome sequencing and gene expression analysis" *International Journal of Oncology* 44.1 (2013): 211-221. Spandidos Publications. Web. 31 Jan. 2014
3. Woodard GA, Gubens MA, Jahan TM, Jones KD, Kukreja J, Theodore PR, Cardozo S, Jew G, Clary-Macy C, Jablons DM, Mann MJ. "Prognostic molecular assay might improve identification of patients at risk for recurrence in early-stage non-small-cell lung cancer." *Clin Lung Cancer*. 2014 Nov;15(6):426-32. doi: 10.1016/j.clcc.2014.07.004. Epub 2014 Aug 15.