UNIVERSITY OF CALIFORNIA SAN DIEGO

A Descriptive Study of Patient Profiles and Treatment Response at the Severe Asthma Clinic (SAC) at a Tertiary Pediatric Hospital

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by

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The thesis of Suzan Mahdai is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

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DEDICATION

This thesis is dedicated to my children, Taim and Sophia, my husband and colleague Haider Aldiwani, my parents, Atifa and Qussay, and sisters Hiba and Arwa who took care of our kids while we pursued our MPH and worked as full-time physicians during the COVID-19 pandemic.

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Chapters 2, 3, and 4, in full, are currently being prepared for journal publication. Dr. Leibel is the primary investigator and the author of this thesis is the first author, working with co-authors Dr. Mills, Andrew Defante[1], Euyhyun Lee[1], Jacob Parker[1], Manaswitha Khare MD[3], and Sydney Leibel MD, MPH [1,2,4].

ABSTRACT OF THE THESIS

A Descriptive Study of Patient Profiles and Treatment Response at the Severe Asthma Clinic (SAC) at a Tertiary Pediatric Hospital

by

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Master of Public Health

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Asthma is the leading chronic disease among the pediatric population. Rady Children's Hospital in San Diego established the Severe Asthma Clinic (SAC), a multidisciplinary clinic, with the goal to reduce asthma healthcare utilization and improve the quality of life for patients with severe asthma. This study aims to 1) describe the SAC patients' demographics, 2) assess the frequency of ED visits, hospitalizations, and

systemic steroid prescriptions post-SAC visit, and 3) investigate changes in Asthma Therapy Assessment Questionnaire (ATAQ) scores and pulmonary function test (PFT) results with each SAC visit.

A retrospect’ve analysis was performed on patients seen at the clinic from 2015 to 2020. Measures were compared using paired Wilcoxon Signed-Rank tests, and a linear mixed-effects model with a random intercept structure. Results were reported in median and quartile (Q1-Q3) format. A total of 153 patients were included with a median age of 9.85 (6.57- 13.80) at the first SAC visit. With an increase in time by one-month post-SAC, there was improved asthma control and improved lung function (see Figure 3.1). Multidisciplinary care at the SAC was associated with significant decrease in healthcare utilization (ED visits, hospitalizations) and improvement in asthma control for pediatric patients with severe asthma.

CHAPTER 1: INTRODUCTION

Asthma, a disease that causes breathing difficulties, is among the most prevalent chronic illnesses during childhood[1,2]. Defined as a chronic airway inflammatory disease, asthma manifests through symptoms like shortness of breath, wheezing, coughing, and chest tightness[3]. Despite underreporting and underdiagnosis, the global prevalence of asthma has escalated over the last forty years[4]. In addition to health symptoms, it imposes substantial economic costs and contributes to substantial school absences[5,6,7]. Asthma prevalence worldwide varies between 1% and 18%. In comparison, the United States currently stands at 7% (5,104,410 patients), with 44% of people experiencing one or more severe asthma attacks (defined by the presence of at least one sign of clinical severity during the attack[8]) annually. These attacks result in approximately 1.6 million emergency department (E.D.) visits with asthma as the primary diagnosis[9].

Asthma is typically confirmed by the reversibility of airway obstruction, established through clinical tests such as pulmonary function tests (PFTs), a detailed history of symptoms, and exclusion of other diagnoses[10]. PFTs are crucial for managing patients with suspected or pre-diagnosed respiratory diseases, aiding diagnosis, treatment response monitoring, and guiding decisions on further treatment and interventions[11]. The severity of asthma can be categorized as mild intermittent, mild persistent, moderate persistent, or severe persistent, depending on symptom intensity, daily activity limitation, and medication frequency. Severe asthma is diagnosed when an asthmatic patient necessitates medium to high-dose inhaled corticosteroids in conjunction with long-acting medications[12]. The primary aim of asthma management is

optimizing symptom control and mitigating the risk of exacerbation, hospital admissions, and adverse effects from medications.

Rady Children's Hospital in San Diego, the only pediatric tertiary care center in the region with a close location to the Mexican border and a unique demographic compared to other states, launched the Severe Asthma Clinic (SAC), a joint program with the University of California, San Diego Health's divisions of Allergy & Immunology and Pulmonary/Respiratory Medicine. The program aims to enhance the health outcomes of asthmatic patients and minimize healthcare resource utilization.

Past studies from the last 5-10 years have shown that children with Medicaid insurance have higher rates of hospital readmission complications and fewer outpatient visits than children with private medical insurance[15]. Conversely, children with private insurance demonstrate better medication compliance and access to family-centered care than those with Medicaid[15]. Previous studies also indicate that arranging a follow-up visit before leaving the hospital/E.D. – especially with an allergy and asthma specialist – improves treatment outcomes[16-18]. The implementation of a personalized care coordination plan has been shown to enhance E.D. visits, hospitalizations, and symptom management in general[17].

Currently, a comprehensive demographic description like race, sex, and age of the previous and current patients at the Severe Asthma Clinic is lacking. Therefore, this study aims to describe patient demographics and assess the change in E.D. visits, hospitalization, and medication prescriptions post-SAC visit. Additionally, the study seeks to investigate the changes in Asthma Therapy Assessment Questionnaire (ATAQ) scores and pulmonary function tests (PFTs) with each SAC visit.

CHAPTER 2: METHODS AND PROCEDURES

Our team conducted a retrospective study approved by the University of California, San Diego Institutional Review Board (IRB#210174), which also granted a waiver of consent. We retrospectively reviewed the charts of all patients seen at the multidisciplinary Severe Asthma Clinic (SAC) between January 2015 and December 2020. A multidisciplinary team, including allergy/immunology, pulmonology, clinical pharmacy, respiratory therapy, and nurse case managers, saw each patient at the SAC at least once. All patients seen at the SAC clinic were included in the study without any exclusion criteria.

We extracted data from Rady's Epic electronic medical record (EMR), encompassing visits and admissions at Rady Children's Hospital (RCH), Rady Urgent Care Clinics, and Rady Children Hospital/Children's Primary Care Medical Group (CPCMG) outpatient clinics. Due to EMR limitations, we did not collect data from outside the Rady Children's Hospital organization. Sex, age, race, and ethnicity were identified by the family. We collected BMI percentiles using the Centers for Disease Control and Prevention (CDC) clinical growth charts at the time of the first SAC visit, defining obesity as a BMI greater than the 95th percentile, overweight as a BMI between the 85th-95th percentile, and healthy weight as a BMI between the 5th and 85th percentile. Household income was estimated based on the patient's recorded zip code using data from the U.S. Census Bureau. Insurance information was collected based on the primary insurance used at the first SAC visit as listed on the patient's face sheet, categorized into Champus/Tricare, Medicaid/Medi-Cal, or private insurance.

The CDC defines social determinants of health (SDH) as conditions in places where people live, learn, work, and play that affect a wide range of health risks and outcomes[17]. SDH screening has been incorporated into the EMR, covering food insecurity, transportation, housing, mental health, and smoking status. EMR Data for these SDH variables was collected using a spreadsheet without time constraints since some categories were incorporated into the EMR after 2015. Patients were screened during various visits, not exclusively during their SAC visit.

Past medical history data was collected based on the active diagnoses on the problem list in the EMR at the patient's first SAC visit. The number of ER visits, inpatient hospitalizations, and intensive care unit (ICU) admissions were identified based on specific diagnoses, including asthma exacerbation, wheezing associated respiratory illness, acute respiratory distress, and status asthmaticus. Data was collected from three years prior (pre-SAC) and one year after (post-SAC) the first SAC visit. A mean of the data from three years prior to the first SAC clinic was calculated for comparison to account for decreased healthcare utilization during the COVID-19 pandemic. The number of ER visits included patients discharged from the RCH emergency room and patients admitted to the inpatient unit after being seen in the ER. Inpatient admissions included patients seen in the RCH Emergency Room and then admitted to the inpatient unit, along with patients directly admitted to the inpatient unit from an outside hospital. A systemic steroid course was defined based on the type of systemic steroid prescribed. Each oral corticosteroid course was used to treat a distinct episode of asthma exacerbation. Oral corticosteroid prescriptions listed as "PRN" prescriptions

were not included. A review of the EMR was conducted to assess if the PRN prescription was used for an acute asthma exacerbation.

Corticosteroid potency scores were calculated using the medications and doses as listed in the NIH Asthma Guidelines 2007 and the 2020 AAP Update on Pediatric Treatment[18,19]. The Asthma Therapy Assessment Questionnaire (ATAQ) score, a validated assessment of asthma control, is calculated at each SAC visit and recorded in the EMR. We analyzed the change in the ATAQ score with each SAC visit. Pulmonary function tests (PFTs) were collected at each SAC visit, excluding patients under five years of age or those unable to perform the tests correctly.

Due to the COVID-19 pandemic, there was a significant decrease in asthma admissions due to new mask requirements and school closures. We used March 11, 2020, as the starting date of the pandemic in our study to identify patients whose data could be affected. We divided the patients into a pre-COVID pandemic group and a COVID pandemic group, comparing all variables collected for the study between these two groups.

We reported results as means, comparing measures from three years prior and one year after the first SAC visit using paired Wilcoxon Signed-Rank tests. A linear mixed-effects model with random intercept structure was used to analyze change over time for ATAQ scores and PFT results. We set statistical significance at a p-value < 0.05.

CHAPTER 3: RESULTS

The Severe Asthma Clinic (SAC) at Rady Children's Hospital saw 153 patients between January 2015 and December 2020. Approximately 50% of these patients were white, 6.6% were Hispanic, and 17.1% were black. The median age for children with asthma at the time of their first SAC visit was 9.85 years, with an interquartile range of 6.57-13.80 years. Most patients fell below the 85th percentile for BMI; however, about 22% were classified as obese. Additionally, 43.8% of the patients had a diagnosis of allergic rhinitis (Table 3.1).

Table 3.1: Patient Demographics. A total of 153 patients were included. Only 152 patients reported race, zip code (household income) and BMI data. All data was collected from the first severe asthma clinic (SAC) visit. Data was represented with median (Q1-Q3) format or count (%). Estimated household income (HHI) was calculated based on zip code. BMI percentile was categorized using the CDC percentile categories. Past medical history was identified based on patient problem list ICD 9/10 codes at the first SAC visit. Smoking history was collected by screening assessments in the inpatient or ambulatory setting 1 year prior to the first SAC visit.

Characteristic	**Value**
Age, median, (Q1-Q3)	9.85 (6.57 - 13.80)
Race, no, (%)	
Black or African-American	26 (17.1%)
Hispanic/Latino/Latinx	10 (6.6%)
Other	40 (26.3%)
White	76 (50.0%)
Household Income (HHI), median (1k), (Q1-Q3)	64.94 (48.44 - 80.80)
Insurance Type, no, (%)	
Champus/Tricare	5 (3.3%)
Medicaid/Medi-cal	103 (67.3%)

Table 3.1, continued: Patient Demographics.

Preferred Provider Organization (Private)	45 (29.4%)
BMI Percentile, no, (%)	
Healthy Weight (5th to 85th Percentile)	93 (61.2%)
Overweight (85th to 95th Percentile)	26 (17.1%)
Obese (> 95th Percentile)	33 (21.7%)
Past Medical History, no, (%)	
Asthma	151 (98.7%)
Influenza	1 (0.7%)
COVID-19 Infection	0 (0.0%)
Allergic Rhinitis	67 (43.8%)
Upper Respiratory Infection	15 (9.8%)
Pneumonia	19 (12.4%)
Smoking History, no (%)	
Current Everyday Smoker	1 (0.7%)
Passive Smoke Exposure- Never Smoker	11 (7.2%)

A portion of the population was screened for social determinants of health, but this was limited by constraints in our EMR and consistency of screening (Table 3.2).

Table 3.2: Social Determinants of Health. This table depicts the social determinants of health for our patient population. Median household income is based on patient zip code using the U.S. Census of Bureau. Transportation, housing, food insecurity, and PHQ2 scores were limited due to EMR. This data came from the PHQ2-Patient Health Questionnaire-2.

Social Determinants of Health	**Value**
Medicaid/Medical Insurance (n=153, %)	67.3
Median Household Income (n= 153,$)	64,940
Transportation (n = 15, %)	7

Table 3.2, continued: Social Determinants of Health.

Housing (n= 15,%)	20
Food Insecurity (n= 48,%)	
Positive Screen	8.3
Refused to answer	6.3
Positive PHQ2 Screen (n= 49,%)	18.4

Depression and food insecurity were screened in approximately 32% of the population, with 18.4% and 8.3% testing positive on the PHQ2 screen for depression and food insecurity, respectively. Only 10% of the patients were screened for housing and transportation concerns; of these, 20% and 7% screened positive and negative, respectively. The median household income, determined based on zip code, was $64,940, and 67.3% of patients were covered by Medicaid/Medi-Cal insurance. Results can be categorized into two groups: health care utilization and treatment outcomes.

Health Care Utilization

When comparing health care utilization pre-SAC to post-SAC, statistically significant decreases were observed in the number of ER encounters ($p< 0.001$), hospital encounters ($p<0.001$), and ICU encounters ($p<0.001$). Patients in the pre-SAC group spent an average of 30.93 hours (SD +/- 41.12) admitted in the hospital, whereas post-SAC patients spent an average of 14.29 hours (SD +/- 49.68), a statistically significant reduction ($p<0.001$) (Figure 3.1).

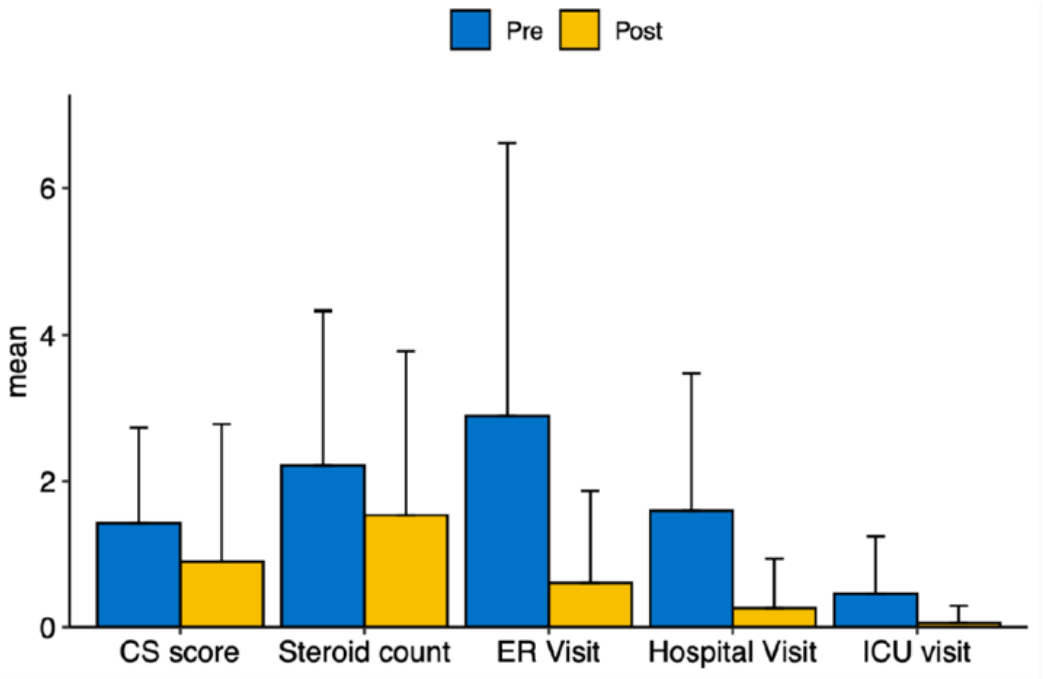

Figure 3.1: Bar Graph Demonstrating Change in Treatment and Hospital-Related Outcomes from Pre-SAC to Post-SAC. This graph visualizes the data from Table 2 with a visual representation of standard deviation for each category. All findings had statistically significant results.

Statistically significant improvements were also noted in treatment outcomes between these groups, including the corticosteroid potency score ($p<0.001$) and the number of oral corticosteroid courses ($p< 0.001$) (Table 3.3, Figure 3.1). Although the Sars-CoV-2 pandemic overlapped with the data for 48 of the 153 patients, no statistically significant differences were observed in post-SAC outcomes between the pre-COVID and post-COVID groups.

Table 3.3: Change in Treatment and Hospital Related Outcomes form Pre-SAC to Post-SAC. Note: ER: Emergency Room; ICU: Intensive Care Unit; ICS: inhaled corticosteroid. Table 3.3 shows data analysis using the paired T-test to compare a mean of the 3 years prior and 1 year post first SAC visit. Data was reported in a mean (SD) format. ER visits included patients who were discharged from the ER and those admitted to the hospital. Inpatient hospital hours included entire period of inpatient admission including intensive care unit (ICU). Each ICS prescription was given a potency score of mild, medium, or high (1, 2, 3) based on the 2007 NIH Asthma guidelines.[1] Combination ICS/long acting beta-agonist were also given a potency score mild, medium, or high (1,2,3) based on the 2020 AAP Asthma Guidelines Update[2]. Systemic steroid courses included the number of either inpatient or outpatient prescribed steroid courses, days varied, for an asthma exacerbation.

	Pre- SAC n = 153 (SD)	**Post- SAC n = 153 (SD)**	**p-value**
ICS Score	1.42 (1.31)	0.90 (1.89)	< 0.001
Steroid count	2.21 (2.11)	1.54 (2.24)	< 0.001
ER Visit	2.90 (3.72)	0.61 (1.26)	< 0.001
Hospital Visit	1.59 (1.88)	0.26 (0.68)	< 0.001
ICU Visit	0.46 (0.79)	0.06 (0.24)	< 0.001
Hospital Hours	30.93 (41.12)	14.29 (49.68)	< 0.001

Treatment Outcomes

The ATAQ score, a measure of asthma control, was collected at each SAC visit. The data shows a statistically significant decrease ($p< 0.001$) in the ATAQ score, at a rate of -0.050 per month after the first SAC visit. Pulmonary function tests (PFTs) were also conducted at each SAC visit to assess lung function. Figure 2 illustrates a statistically significant increase in forced vital capacity (FVC, +0.020 per month) and forced expiratory volume in one second (FEV1, +0.015 per month) after starting treatment at SAC. However, the change in the FEV1/FVC ratio was not statistically significant ($p=0.634$).

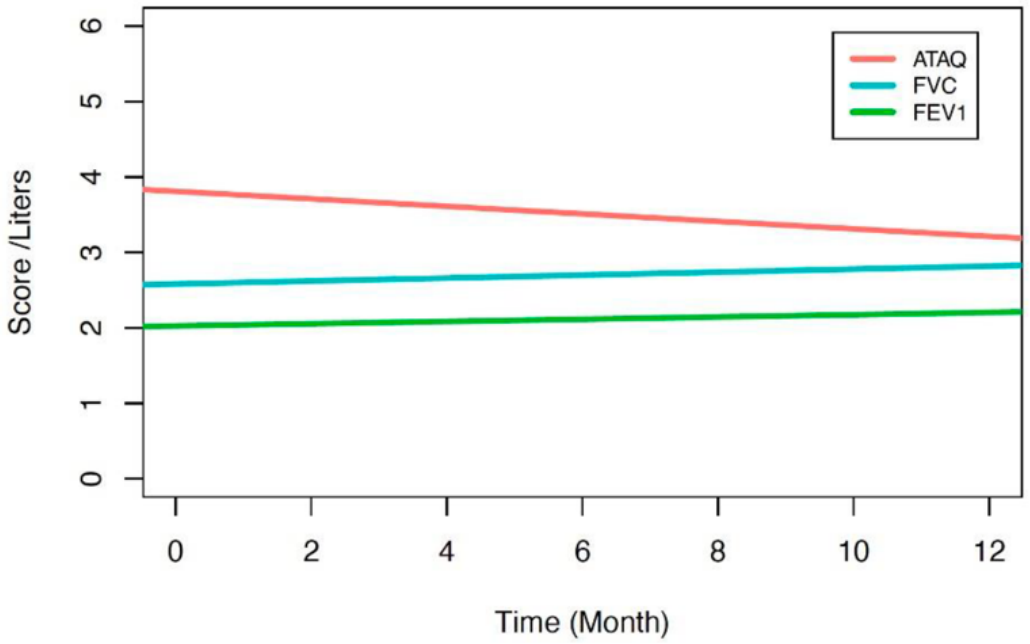

Figure 3.2: Change in ATAQ score and PFTs over time. This figure depicts the change in ATAQ score and PFTs over time. The Y-axis represents the ATAQ score or the pulmonary function test value in liters. The X-axis represents the number of months from the first SAC visit. The ATAQ (Asthma Therapy Assessment Questionnaire) score ranges from 0-4. FVC (forced vital capacity) and FEVI (forced expiratory volume in the first second) are both recorded in volume (Liters), both with a statistically significant increase from the first SAC.

CHAPTER 4: DISCUSSION

This study's findings, including reduced asthma-related ED visits, hospitalizations, and ICU admissions, indicate that health care utilization significantly decreased after enrollment in the SAC follow-up program. Our results align with existing research suggesting that multidisciplinary clinics and home visiting programs improve health care utilization[10]. One study demonstrated that a single follow-up clinic visit focusing on asthma self-monitoring and management, environmental modification and trigger control, and linkages to ongoing care, resulted in a substantial reduction in ED visits[21]. Another meta-analysis indicated that community-based interventions for childhood asthma reduced the asthma-related ED visits and hospitalizations[22]. Our study suggests that a precise diagnosis, evaluation of comorbidities, and optimization of medication adherence are likely pivotal factors in decreasing healthcare utilization[19,20].

In addition to a reduction in healthcare utilization, the post-SAC group exhibited objective and measurable improvement in asthma-related symptoms and control through decreased corticosteroid potency score, lower ATAQ scores, and improvement in pulmonary function tests (PFTs)[11,23]. Better asthma control with decreased corticosteroid potency may lead to fewer side effects, such as oral thrush and loss of adult height[23]. Higher ATAQ scores have been associated with higher rates of asthma-related hospitalizations, ER visits, and those scores may be helpful in identifying patients requiring intensive asthma management such as SAC[11,24]. Improved asthma control, as demonstrated by improved ATAQ scores, could lead to an enhanced quality of life and fewer school absences[24]. We found a stepwise improvement in FEV1 in the

post-SAC group, which is a significant finding, considering the challenge of demonstrating improvements in PFTs in pediatric asthma studies[11].

The presence of an outpatient care system in our study reduced the length of stay[25]. This could be attributed to the fact that exacerbations may have been milder, and caregivers may feel better educated and less anxious about discharge, leading to a relatively lower risk for readmission[25]. Further steps are underway to increase harmonization between hospitalized asthma patients and our SAC, which has been proven successful at other institutions[26.]

The screening of social determinants of health (SDH) in SAC, as demonstrated by Leibel et al., helps decrease health care utilization and provides insight regarding health care equity and resource allocation[10]. Factors like race/ethnicity, insurance type, BMI, and other demographic data can guide further analysis and studies[10,12]. Housing conditions and barriers to care can directly contribute to asthma exacerbations and under-treatment[17,29]. Not addressing the social needs of our patients through clinical-community partnerships and culturally appropriate education, improving health outcomes in our most vulnerable population might be challenging[29].

Our study is limited by a relatively small sample size from a single institution; the data used was taken from the electronic medical records, which did not account for other health system admissions or ER visits without hospitalizations. As the only pediatric tertiary care center in the region and our close location to the Mexican border, our study population may not represent other hospital settings. The social determinants of health findings were limited due to the inconsistency in screening patients. This should improve as SDH screening is further adopted throughout the organization.

Conclusion

Multidisciplinary clinic follow-up post-hospital discharge can enhance patient outcomes and decrease resource utilization in asthma patients. Future studies should focus on a randomized clinical trial, comparing patients with severe asthma who were seen at SAC and those who were not, to establish key elements in reducing readmission rate and improving the quality of life in children with severe asthma.

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