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National Trends of Aspiration Pneumonia Admissions in the Pediatric Patient Population from 2006 – 2016 and the Association of Aerodigestive Programs on those Admission rates in the United States.

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By

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B.S. Arizona State University, 2015

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An abstract of
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National Trends of Aspiration Pneumonia Admissions in the Pediatric Patient Population from 2006 – 2016 and the Association of Aerodigestive Programs on those Admission rates in the United States

By Rhea Shah

Background: Aspiration pneumonia occurs when someone aspirates a large amount of food and particles, leading to harmful bacteria being deposited into their lungs causing a pulmonary infection. It is a cause of serious mortality and morbidity among people of all ages but there is a lack of data on patient characteristics for hospitalizations in the pediatric patient population. This study aims to look at patient characteristics of children hospitalized with a diagnosis of aspiration pneumonia and explore the association between the prevalence of aerodigestive programs, which function as a multidisciplinary center to manage care for patients with aerodigestive disorders and its impact on hospitalizations of children with ASP in hospitals from 2006-2016 within the United States.

Methods and Findings: A secondary data analysis was conducted in SAS utilizing data from the Kids' Inpatient Database. ICD-9 and ICD-10 diagnoses codes for principal diagnosis of aspiration pneumonia were used to identify the study population. There were a total of 25,267 hospitalizations in the United States for aspiration pneumonia during the study period but there was a lower number of admissions in 2016 than 2006. Exploratory analysis and descriptive statistics were used to explore patient and hospital characteristics and associations of categorical variables were tested with Chi square or Fisher's exact tests, as applicable, and continuous variables were compared using the Wilcoxon rank-sum test. Children that were white, male or used public insurance were more likely to be diagnosed ASP (p-value <.0001). Pediatric patients were more likely to be admitted into urban, teaching hospitals and hospitals with larger bed size (p<.0001). Compared to people whose principal diagnoses was not aspiration pneumonia, patients with aspiration pneumonia had a greater number of chronic conditions, a higher length of stay in the hospital as well as higher hospital costs (p<.0001). The number of aerodigestive programs and hospitalizations from aspiration pneumonia within the United States data were also compared in order to assess for an association. We found that aerodigestive programs are thriving, especially since the last 5 years and have proliferated in academic centers, especially in the South and West region of the United States. When we looked at regional distribution of hospital admissions for those admitted at the academic centers only, we found that the number of admissions were lower in the South and West region of the United States in 2016, compared to 2006.

Conclusion: This study showed that the overall rate of hospital admissions for the pediatric patient population in the United States was lower in 2016 than 2006. However, the association between the lower number could be due to due to readmissions because patients were subsequently treated at an aerodigestive program, thereby addressing underlying causes for ASP and preventing further illness, or if a patient was identified prior to developing ASP and referred to an aerodigestive program, thereby never needing admission. However, more research is needed on where these programs operate, utilization of these programs by the pediatric patient population, as well as the integration of all that data in order to be able to evaluate health outcomes for patients diagnosed with aspiration pneumonia.

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TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION

Introduction and Rationale

Pneumonia is a lung infection characterized by an inflammation of the air sacs in one or both lungs ("Pneumonia," 2018) caused by viruses, bacteria or fungi. Common causes of pneumonia in the United Stated are influenza, respiratory syncytial virus or streptococcus pneumoniae (CDC, 2020). It impairs the normal lung function due to the collection of fluid and pus with its severity ranging from mild to severe, depending on the individual. It disproportionately affects people with a weakened immune system, young children and the elderly. In 2016, the annual number of emergency department visits for pneumonia was 1.7 million (*National Hospital Ambulatory Medical Care Survey: 2016 Emergency Department Summary Tables*, 2017). It is the leading cause of infection-related deaths in the United States and for children, it is the number one most common reason for hospitalization (*Top 20 Pneumonia Facts—2018*, 2018). For children with chronic medical conditions, it can be a cause of serious morbidity and mortality. There are several different types of pneumonia including aspiration, hospital-acquired, community-acquired, ventilator-associated, and health care-acquired.

Aspiration pneumonia (ASP) occurs when a person inhales food, saliva or other particles in their airways, leading to accumulation of harmful bacteria in the lungs from the aspirated contents. People are usually able to remove the aspirated material through coughing unless they have impaired coughing ability or swallowing function. In a recent study conducted looking at hospitalization characteristics of patients with aspiration pneumonia, it was found that, compared to those with community acquired pneumonia (CAP), neurologically impaired children hospitalized with aspirational pneumonia have higher complication rates, length of stay and hospital costs (Hirsch, Monuteaux, Fruchtman, Bachur, & Neuman, 2016). Another study found

that among neurologically impaired (NI) patients hospitalized with aspiration pneumonia, rates of complications (34.0% vs 15.2%, 95% CI), length of stay (median 5 vs 3 days, aOR 1.4, 95% CI) and hospitalization costs (median $11,594 vs $5,162, 95% CI) were greater compared to patients with non-aspiration pneumonia (Thomson et al., 2016). Compared to patients with CAP, patients with aspiration pneumonia had a median hospitalization cost that was 2.4 times greater, had a higher chance of mortality (1.6% vs 0.4%, P<.001), and were more likely to be publicly insured (66% vs 59%, P<.001). Aspiration pneumonia disproportionately affects medically complex children more severely and can account for longer and more costly hospitalizations and higher rates of ICU admission and readmission rates (Hirsch et al., 2016). In addition, patients with aspiration pneumonia had a higher chance of readmission within 30 days after hospital discharge. Children with aspiration pneumonia generally tend to be patients with predisposing comorbidities, chronic conditions, or neurological impairment; **therefore, properly coordinated and interdisciplinary care is needed to help manage care for patients with aspiration pneumonia as well as to help prevent ASP in patients who are at-risk due to other underlying, contributing conditions.**

Aerodigestive programs provide comprehensive and coordinated interdisciplinary care for children that have complex airway, respiratory, and gastrointestinal tract disorders. The first program was developed in 1999 at Cincinnati Children's Hospital Medical Center, and since then, numerous programs have been established across the country. A recent study in 2017 evaluated the state of 34 different aerodigestive programs in the country, showed that more than 60% of the programs have been operating for less than five years (Gumer et al., 2019). Since these sites serve as multidisciplinary centers, they can play a major role in coordinating care for their medically complex patients with more than one health concern, i.e. neurologic dysfunction, esophageal

motility disorders, enteral tube feeding, dysphagia, chronic conditions, respiratory difficulty, etc. Studies have shown that these programs have improved clinical effectiveness by combining clinic encounters with operative procedures due to coordination of multiple specialties, decreased cost, reductions in anesthetic episodes, and resource use (Collaco et al., 2015), as well as reduction in unnecessary testing, risks of anesthesia, and time to diagnosis (Wootten, Belcher, Francom, & Prager, 2019).

Complications due to multiple chronic conditions or for children with special healthcare needs can affect a patient's quality of life and health outcomes (Leyenaar, Lagu, Shieh, Pekow, & Lindenauer, 2014). They contribute towards a population that has unmet needs and increased mortality and morbidity as well as fragmentation of care leading to patient and caregiver dissatisfaction (Kuo, Cohen, Agrawal, Berry, & Casey, 2011; Silver & Stein, 2001). Patients with aspiration pneumonia are more likely to have a variety of medical conditions that necessitates the need more for multiple specialists with particular knowledge in addition to that of a primary care physician. Coordinated and interdisciplinary care can help patients with aspiration pneumonia receive effective treatment and prevent the recurrence of the condition, thereby reducing hospitalizations and readmissions. Therefore, multidisciplinary centers such as aerodigestive programs may provide an opportunity to enhance health outcomes for certain conditions that require care from multiple specialties to prevent these conditions, such as aspiration pneumonia.

Problem Statement

As the number of aerodigestive programs continue to increase, there is a need for data on the number of centers, where they are based, patient volume, providers, and clinical outcomes. While there are a lot of data available on children with pneumonia, community acquired

pneumonia and aspiration pneumonia in the elderly, there is a lack of data on incidence, patient demographics, and hospitalization characteristics of children diagnosed with aspiration pneumonia. **In addition to there being a paucity of data on the prevalence and trends in aspiration pneumonia in children within the United States, there is also minimal research to show whether aerodigestive programs have had an effect in admission rates for pediatric aspiration pneumonia in the regions where they operate.**

Purpose Statement

This study aims to look at patient characteristics of children hospitalized with a diagnosis of aspiration pneumonia and explore the association between the prevalence of aerodigestive programs in the United States and its impact on hospitalizations of children with ASP in hospitals from 2006-2016.

Research Question/Objectives/Hypothesis

This analysis will use the pediatric hospitalization data from the Kids' Inpatient database (KID) from 2000-2016 to describe the characteristics of pediatric patients diagnosed with aspiration pneumonia and explore variables such as admission rates, demographic characteristics, length of stay, hospital characteristics, and insurance status. We will evaluate trends in rates of admission for aspiration pneumonia and determine whether or not there has been a change in these rates over time. In addition, we will examine the association of the increasing presence of aerodigestive programs in various regions (northeast, northwest, southeast and southwest) around the United States on rates of hospital admissions for aspiration pneumonia.

Significance Statement

There is a gap in the literature on incidence rates of aspiration pneumonia in children as well as on the impact of aerodigestive programs on clinical outcomes. This study will provide data

on patient characteristics for children hospitalized with ASP in the United States from 2006-2016 and whether there is as association between those rates and prevalence of aerodigestive programs on better patient clinical outcomes or rates within the United States.

Definition of Terms

aOR: Adjusted Odd's Ratio

ASP: Aspiration pneumonia

CAP: Community Acquired Pneumonia

CCC: Complex Chronic Conditions

CI: Confidence Interval

LOS: Length of Stay

KID: Kids' Inpatient Database

NI: Neurologically Impaired

CHAPTER 2: LITERATURE REVIEW

Pneumonia causes about one million hospital admissions each year, making it the most common infectious cause of hospitalization in the United States (Lindenauer et al., 2018). Worldwide, it is the number one infectious cause of death in children, killing 808,694 children under the age of 5 in 2017, accounting for 15% of all deaths of children under five years old (WHO, 2019). It is also a frequent cause of hospitalization in children with approximately 40% of children with pneumonia requiring hospitalization (Vaughan & Katkin, 2002).

Aspiration pneumonia (ASP), a subset of pneumonia associated with heightened morbidity and mortality, is a pulmonary infection that occurs after large volumes of oropharyngeal or upper gastrointestinal contents are aspirated causing inflammation of the lungs (Son, Shin, & Ryu, 2017). Data are lacking, especially in pediatric patients, on the incidence, prevalence and patient characteristics of individuals with aspiration pneumonia. Quantifying aspiration pneumonia is particularly difficult because there is currently no specific marker for this condition and the frequency of overlap with other types of pneumonia (Lanspa et al., 2015). In some cases, United States Centers for Medicare and Medicaid Services' (CMS) hospital mortality and readmission measures do not include aspiration pneumonia, thus providing inaccurate and biased measures about patient characteristics (Bratzler et al., 2011; Lindenauer et al., 2018). In addition, the lack of uniformity in coding and diagnosing pneumonia between hospitals and providers contribute to the difficulty of evaluating national trends (Lindenauer et al., 2018).

Distribution of Aspiration Pneumonia:

Although data are sparse, existing studies have shown that about 5%-15% of the pneumonias cases in the hospitalized patient population are aspiration pneumonia cases (DiBardino & Wunderink, 2015; Marik, 2001; Moine, Vercken, Chevret, Chastang, & Gajdos,

1994). It is the second most common diagnosis in Medicare patients who are hospitalized, making it common to nursing home residents (DiBardino & Wunderink, 2015). Among the United States hospital admissions for aspiration pneumonia in acute care settings, the rates of aspiration pneumonia hospitalizations as well as in-hospital mortality has decreased from 2002 to 2012 (Wu, Chen, Wang, & Pinelis, 2017); however, this overall decrease was driven by decreasing incidence among the elderly population. This study separated the age groups into patients younger than 65 years (20.7%) and patients aged 65 years or older (79.3%). For both groups, it was found that the hospital costs were higher through the years, males were more likely to be diagnosed with ASP , and the median length of stay was lower by one day. In addition, the southern region of the United States had the greatest number of diagnosis for both the age groups, with aspiration pneumonia comprising almost 38% of the patients admitted with aspiration pneumonia (Wu et al., 2017).

Patient Demographics of Adults

Aspiration pneumonia is the most common cause of death in patients with dysphagia meaning swallowing difficulties and is also common among the elderly and residents of nursing homes, people with altered mental ability and a risk factor for people who practice poor dental and oral hygiene (Marik, 2001; Son et al., 2017). A 2015 study aiming to describe the trends of incidence and mortality over 32 years in patients with Parkinson's disease hospitalized with aspiration pneumonia, found a 10-fold increase in aspiration pneumonia cases for patients with Parkinson's disease compared to non-Parkinson's Disease patients (Akbar et al., 2015). This study was performed using data from 1979-2010 and also showed decreased mortality overtime and a higher likelihood of aspiration pneumonia diagnoses in males. Another study looking at aspiration pneumonia in nursing home residents found that in patients with a previous history of pneumonia,

aspiration pneumonia was the most serious complication of gastronomy tube feedings (Cogen & Weinryb, 1989). A retrospective observational study conducted in Spain from 2003 to 2013 looking at temporal trends in hospitalized patients with aspiration pneumonia aged 75 or older, and associated outcomes concluded that patients with aspiration pneumonia are older, male and have more comorbidities than those without a diagnosis of aspiration pneumonia (Palacios-Cena et al., 2017).

Hospitalizations, Readmissions and Health Outcomes

Patients hospitalized for aspiration pneumonia generally have longer and more expensive hospitalizations, higher rates of ICU admission and higher 30-day readmission rates compared to those admitted for other types of pneumonia. A study looking at adult patients aged 18 years or older diagnosed with community acquired pneumonia (CAP) and presence of aspiration pneumonia from 71 hospitals in 16 countries found that patients with ASP were older, had greater disease severity and more comorbidities than patients with nonaspiration pneumonia (Lanspa et al., 2015). In addition, they were more likely to be cared for in the ICU (19% vs 13%, p=.002) and have longer lengths of hospital stay (unadjusted 8 vs 4 days, p<.0001). A study limited to surgical patients with a discharge diagnosis of ASP in 52 Maryland hospitals from January 1, 1999 to December 31, 2000 reported similar outcomes of increased risk of admission to the ICU, in-hospital mortality, longer hospital length of stay and increased total hospital charges (Kozlow, Berenholtz, Garrett, Dorman, & Pronovost, 2003). Similarly, another study done to investigate the proportion of ASP cases among patients with CAP in a university-affiliated tertiary hospital in Korea in 2016, reported that patients with ASP were more likely to be older and male. In addition, they depicted that those with higher confusion, uremia, respiratory rate, blood pressure, were more

likely to be admitted into the ICU (p<.0001) with longer hospital stays (p<.0001) (Jeon et al., 2019).

Patient Demographics of Children

Among children under 20, ASP is a serious cause of mortality and morbidity, yet there is a paucity of data on patient characteristics and demographics. A study conducted in 2016 assessed these characteristics for patients diagnosed with aspiration pneumonia and compared it to those diagnosed with CAP. Over the six-year study period, which included 133,586 pediatric admissions, approximately 10% of patients were diagnosed with aspiration pneumonia. Even though there were less patients diagnosed with aspiration pneumonia compared to CAP, they were observed to be slightly younger, had longer hospitalizations and higher rates of ICU admission (Hirsch et al., 2016). Among children with ASP, mortality was more likely (1.6% vs 0.4%, p<.0001), and they were more likely to have a complex chronic condition (CCC) (87% vs 36%, p<.0001) or a neurologic comorbidity compared to children with CAP (Hirsch et al., 2016). One thing to note about this study population is that a patient was considered to have aspiration pneumonia if the *International Classification of Diseases, Ninth Revision* (ICD-9) diagnosis codes were 507.0 (aspiration pneumonia), 507.1 (pneumonitis due to inhalation of oils and essences), and 507.8 (pneumonitis due to other solids and liquids). This is important because most studies use only code 507.0 to classify a patient as being diagnosed with aspiration pneumonia.

Aspiration pneumonia and Complex Chronic Conditions

Aspiration pneumonia disproportionately affects those children and adults with multiple chronic medical conditions. Common comorbidities include oropharyngeal dysfunction, neurologic dysfunction, esophageal motility disorders, and enteral tube feeding (Hirsch et al., 2016). A study looking at management and outcomes of pneumonia among children with complex

chronic conditions found that children with CCC are older, twice as likely to experience pneumonia complications, more likely to have public insurance, have higher hospital charges and have a four-fold increased likelihood of 30-day readmission. They are also more likely to receive diagnostic testing and three to nine times more likely to go through intensive therapies indicating higher resource utilization (Leyenaar et al., 2014). However, it is to be noted that this study encompasses patients diagnosed with admissions for any type of pneumonia and is not specific to patients with ASP.

Another study that was limited to children with neurological impairment, comparing those diagnosed with aspiration pneumonia to those without, showed that the former experienced more complications, had a longer length of stay (median 5 vs 3 days, 95% CI 1.2-1.3), 40% greater odds of ICU transfers (95% CI 1.1-1.9), greater hospitalization costs and 20% greater odds of hospital readmissions within 30 days (CI 1.1-1.4) (Thomson et al., 2016). In addition, it showed that children diagnosed with aspiration pneumonia are more likely to be publicly insured, be older in age, and have a higher prevalence of CCC (Thomson et al., 2016), as validated by previously mentioned studies.

Readmissions, Health Outcomes and Hospital Charges

Pneumonia, in addition to being a leading cause of hospitalization in children, is also a major cause of readmissions (Neuman et al., 2014). Readmissions are increasingly becoming an indicator of quality of care, especially early hospital readmissions which contribute to higher hospital costs and economic, physical and emotional burden on the patient and family. A retrospective cohort study looked at children previously hospitalized with pneumonia and studied rates, factors and costs associated with readmission. The 30-day readmission rates were 7.7.%, and pneumonia-specific readmission rates were 3.1%. Out of all the readmissions, pneumonia was

the most common diagnosis for readmission, representing 22.6% (Neuman et al., 2014). However, another study showed that for pediatric patients hospitalized with pneumonia, recurrent pneumonia occurs in only one tenth of the studied population with the most common predisposing factor being oropharyngeal dysphagia with aspiration syndrome (Owayed, Campbell, & Wang, 2000).

Readmissions were also associated with substantial costs, accounting for 16.3% of the total costs for all pneumonia hospitalizations due to costs being higher than index admission ($11,344 vs $4,495, P<.001) (Neuman et al., 2014). These findings are crucial when looking at the economic burden of this condition, because they can lead to detrimental consequences due to increasing hospital costs. For example, the cost of hospitalization for aspiration pneumonia has almost doubled between 2002 and 2012 (Wu et al., 2017). Patients with more than one CCC are more likely to be readmitted, as well as patients that have public insurance compared to private (Berry et al., 2011; Neuman et al., 2014). However, the findings from these studies cannot be generalizable to nonchildren's hospitals because they were conducted at free standing pediatric hospitals where there are a higher number of children with comorbidities.

Hospital Characteristics

Existing literature shows that patients that were treated in teaching hospitals compared to non-teaching hospitals had lower likelihoods of in-hospital mortality (AOR, 0.91; 95% CI, 0.89–0.93; $P < 0.0001$) (Wu et al., 2017). In addition, it also showed that patients treated at hospitals with larger bed size had lower likelihoods of in person mortality. This study examining national trends in admission for aspiration pneumonia in the US from 2002-2012 showed that out of the 406,798 patients admitted, information on hospital size was available for 405,343 patients (99.6%). Of those, almost 59% of the patients were admitted to large hospital bed size. However,

out of 372,051 (missing information for 34,747) patients, approximately 64% of patients were admitted to nonteaching hospitals (Wu et al., 2017).

One study exploring readmission rates and factors for children diagnosed with pneumonia showed that care provided in hospitals with lower volumes of admissions for pneumonia was associated with an increased risk of readmission. In those hospitals, about 1/3 of the readmissions occurred within one week after discharge and hospitals with higher volumes of pneumonia hospitalizations had lower readmission rates (Neuman et al., 2014).

Another study found that children with CCC were more likely to be admitted to larger hospitals compared to children without CCC (60.4% vs 41.0%, $p < .001$). In addition, only 1/3 of the children without CCC were admitted to teaching hospitals or centers compared to more than half of the children with CCC ($p < .001$) (Leyenaar et al., 2014).

Treatment and Prevention

ASP is a significant factor in mortality and morbidity in these patients and care is generally costly, complex, and reliant on multiple procedures, necessitating guidance from different specialties and frequent hospitalizations Since it disproportionally affects those with multiple chronic conditions and critically ill patients, it is imperative that care for them should be also be coordinated along with it being consistent, effective, cost-efficient, outcomes-driven and patient centered..

Coordinated Care

Due to the complexity of ASP patients with multiple chronic conditions, coordinated care is needed to better manage their outcomes and reduce the incidence. Pediatric multidisciplinary care programs have been increasing and gaining popularity in the recent years. They have continuously been endorsed by the American Academy of Pediatrics and the American Academy

of Family Practice (Wootten et al., 2019). In addition, medical homes for children with complex health care needs have been supported due to their ability to provide improved, quality care at lower costs (Wootten et al., 2019). This could be due to coordinated visits which can help minimize lost revenue, opportunity cost, travel costs and time off work for guardians of pediatric patients diagnosed with an aerodigestive disorder (Wootten et al., 2019). A study looking at a hospital-based multidisciplinary clinic for medically complex children and its effect on healthcare costs and burden observed that there was a significant decrease in Medicaid costs due to lower inpatient costs, number of hospitalizations and length of stay to provide care (Collaco et al., 2015). Similarly, another study conducted in Arkansas looking at hospital-based comprehensive care clinic costs for Medicaid-insured medically complex children found that there was an increase in the number of outpatient claims and a decrease in the number of emergency department visits (Casey et al., 2011). The increase in outpatient claims was due to children moving from inpatient to outpatient settings. Other studies of multidisciplinary clinics for medically complex children have observed improved parent satisfaction and decreased caregiver strain (Boesch et al., 2018; Farmer, Clark, Sherman, Marien, & Selva, 2005).

Aerodigestive Programs

Aerodigestive programs are coordinated clinics that provide multiple services and care to children with complex conditions that affect their breathing, swallowing, and other upper digestive tract functions and can therefore provide opportunities towards increasing the value of care for these patients. Examples of conditions include structural or functional airway disease, lung injury from aspiration or infection, lung disease, and behavioral feeding problems (Piccione & Boesch, 2018). They are conducted as an Integrated Practice Unit (IPU), where care is organized around

the patient. The multidisciplinary team works together for the full care cycle of the condition and is responsible for the patient outcome.

A study conducted in 2017 evaluated the state of the pediatric aerodigestive programs by surveying their size, composition, prevalence and the number of patients they serve. It showed that the number of patients that were cared for by each program depended on the size and the age of the program. Most programs were based in academic settings and approximately 64.7% of the programs were started between 2012 and 2017 (Gumer et al., 2019). This has possible been the only study that has looked at the size and prevalence of aerodigestive programs and therefore, has provided essential information into their characteristics. The limitation of this study was that the data was based on the number of aerodigestive programs that had responded to their survey thereby likely underestimating the number of active programs.

There have been a few studies aiming to determine the effects of interdisciplinary care coordination on patient outcomes. Enrollment in aerodigestive programs reduced unnecessary testing, decreased length of stay in the hospital, and reduced costs, anesthetic exposures and procedural changes (Collaco et al., 2015; Ruiz et al., 2020; Skinner et al., 2016; Wootten et al., 2019). These findings are relevant as ASP is a complication of general anesthesia accounting for 10% to 30% of all deaths associated with anesthesia (Marik, 2001).

A study conducted at the Pediatric Aerodigestive Center for aerodigestive disorders showed a $182 average cost savings per family per PAC visit, a 41% reduction in anesthetic episodes and a $1985 per episode reduction in anesthesia and related care costs (Collaco et al., 2015). The related care costs could include charges for operative encounters such as operating clinician’s fees, anesthesiologist’s fees, facility fee including preoperative care, operating room costs and postoperative observation.

A 2016 study investigating the activities before and after enrollment in a Multidisciplinary Pediatric Aerodigestive Care Team (MPACT) observed a significant shift from inpatient to outpatient area as well as an overall 20% reduction in patient charges (Skinner et al., 2016). Similarly, a 2017 study looking at 113 patients with aerodigestive disorders and special healthcare needs enrolled in a pediatric multidisciplinary clinic showed a 70% decrease in technical direct care cost and length of stay in the hospital by an estimated one week per year (Appachi et al., 2017).

A 2018 study evaluating the impact of an interdisciplinary care model for pediatric aerodigestive patients observed a reduction of 144 days in time to diagnosis, fewer specialist consultations (5 vs 11), fewer radiation exposures (2. Vs 4) as well as reductions in anesthetic episodes (1 vs 2) and total cost (median of $10,374 to $6055) (Collaco et al., 2015).

Contradicting Studies on overall reduction in charges

There are however, studies that have also shown that the cost savings for aerodigestive programs is not generalizable to all clinicians and hospitals, and establishment of these programs may not be financially feasible in all settings and to all stakeholders (Melzer, Richards, & Covington, 2004; Wootten et al., 2019). For example, in a study conducted in a pediatric endocrinology clinic in 2004, it was observed that the clinical revenues allocated by such methods do cover physician expenses for a single specialty for endo and diabetes but do not cover non-physician and facility practice expenses while delivering multidisciplinary care to children with diabetes (Melzer et al., 2004). Similarly, a 2005 study looking at medically complex children being treated in a Special Primary Care Clinic that provided interdisciplinary care showed a reduction in length of stay for non-intensive care hospital admissions but an increase in the use of surgical services (Berman et al., 2005). The findings from these studies are helpful because most

of the children who suffer from aspiration pneumonia have more than one chronic condition and therefore, need services from different specialties, increasing overall hospital costs for these patients.

Conclusion

Since aspiration pneumonia cause inflammation of the airways and lungs and disproportionately affects critically ill patients, aerodigestive programs could provide an opportunity to improve health outcomes in this population by improving the efficiency and quality care provided. Research is lacking on additional benefits, if there are any, of aerodigestive programs and observable health outcomes for subtypes of disease, such as aspiration pneumonia. Furthermore, additional data are needed on hospital admission rates, readmission rates, patient characteristics and hospital characteristics for the pediatric patient population diagnosed with ASP. Herein, we propose an analysis to explore these characteristics for the pediatric patient population (patients aged 21 and younger) and look at the association of aerodigestive programs characteristics to see any changes in the trends of hospital admissions over a 10-year period, from 2006 to 2016. This valuable information will be imperative to understand and develop management strategies in the future, which could help reduce the incidence and improve prevention efforts in this particular population. Recommended preventive measures include identifying high-risk patients and implementing evidence based practices to prevent occurrences (Echevarria & Schwoebel, 2012). Additionally, it may provide valuable information on the role of aerodigestive programs in preventing the onset of the condition or enhancing outcomes for pediatric patients diagnosed with ASP.

CHAPTER 3: METHODS

Introduction:

The purpose of this study is to explore patient characteristics of children hospitalized due to aspiration pneumonia (ASP) in the U.S from 2006-2016 and explore the association between the prevalence of aerodigestive programs in the United States and its impact on hospital admissions of children with ASP. A cross sectional study was conducted using secondary data from the Kids' Inpatient Database (KID) developed for the Healthcare Cost and Utilization Project and a survey created and distributed by The North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition Aerodigestive Special Interest Group.

Population and Sample:

We used the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) to select our population for the study for datasets 2006, 2009 and 2012. We identified patients who were admitted with a primary diagnosis of aspiration pneumonia (code 507.0). We used the International Classification of Diseases, 10th Revision, Clinical Modification (ICD-10-CM) code J690 to identify patients who were admitted with a primary diagnosis of aspiration pneumonia for the 2016 dataset. All other primary diagnoses were used as the comparative group and labeled as patients without aspiration pneumonia. We only used primary diagnosis for aspiration pneumonia as an inclusion criterion because we did not want to include patients that developed aspiration pneumonia during their hospital stay. For data regarding aerodigestive programs, only programs within the United States were included in the analysis.

Instruments:

Data was used from the Kids' Inpatient Database (KID), a large, publicly-available, cross-sectional dataset of pediatric, in-patient care developed for the Healthcare Cost and

Utilization Project, sponsored by the Agency for Healthcare Research and Quality. The KID produces national estimates of pediatric hospital inpatient stays for patients aged 21 years and younger. Unweighted, it contains information from approximately 3 million pediatric discharges each year, whereas weighted, it contains data from roughly 6 million hospitalizations. For this study, weighted estimates were used for all analyses. Data are collected every 3 years, with the exception of 2015 due to the transition to ICD-10-CM/PCS coding on October 1, 2015. Therefore, the 2016 dataset was also used in this study. The data includes discharges from January to December of each calendar year.

Aerodigestive program data were obtained from The North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition Aerodigestive Special Interest Group. This data was collected by creating an 11-question Red Cap survey and submitting it several times to the pediatric gastroenterology (PEDS-GI) listserv over a 10-week period (Gumer et al., 2019).

Procedures:

We used the ICD-9 and ICD-10 diagnoses to identify our study population (CMS). Then, the discharge-level weight (variable DISCWT) was used to provide the national and regional estimates of hospitalizations for aspiration pneumonia between 2006-2016 in the United States. Then, exploratory analysis and descriptive statistics were used to explore baseline patient demographics and hospital characteristics. Baseline sociodemographic characteristics included primary expected payer, sex, race, elective vs non-elective admission and patient location. Hospital characteristics included hospital bed size (small, medium or large), location and teaching status (rural, urban nonteaching, urban teaching) and hospital control/ownership. Other characteristics such as the median length of stay (LOS), number of chronic conditions, and total cost of hospitalization were also explored, stratified by years and compared between patients with

aspiration pneumonia and patients without. In order to determine actual costs of hospitalizations and not what hospitals billed for services, a cost to charge ratio specific to each year was used to translate charges into actual costs ((HCUP), 2019). All costs were then converted using inflation rates of each year to 2016 to rule out inflation as a cause of cost changes. Associations of categorical variables were tested with Chi square or Fisher's exact tests, as applicable, and continuous variables were compared using the Wilcoxon rank-sum test. Statistical significance was tested using a p-value of .05. Linear regression was attempted to model the relationship between a diagnosis of ASP and variables such as length of stay and total cost of hospitalizations. Since LOS is a highly skewed variable, logarithmic transformation was used to transform it into a more normalized dataset. In addition, regression was used to model the relationship between race, payer and sex and LOS and hospital cost. In order to be included into the regression model, categorical variables such as payer and race were recoded and each level of the variable were compared to a reference level that was predetermined.

We excluded aerodigestive programs that were not within the United States. The included programs were stratified by region of the United States (Northeast, Midwest, South, West) and years of existence based on survey data (2006, 2009, 2012, 2016 and post 2016). The regions and years were identical to the ones used by the KID dataset. Descriptive statistics about the programs such as years active, regional distribution and program type were explored.

The number of aerodigestive programs and hospitalizations from aspiration pneumonia within the United States data were then compared in order to assess for an association. The change in number of aerodigestive programs was then assessed and compared to hospitalizations of aspiration pneumonia in teaching facilities, by region and year. All analysis was done using SAS version 9.4 software (SAS Institute Inc., Cary, NC).

Ethical Considerations

No IRB approval was needed in this study because no human subjects were involved. All patient information was deidentified and therefore, the study was exempt from IRB approval. However, an HCUP Data Use Agreement Training Tool was completed and the Data Use Agreement was read and signed in order to use the database. The data were purchased by a single investigator and stored at the Emory Children's Center for divisional use.

Limitations and delimitations

Because the KID is a cross-sectional, encounter-based database, it does not contain longitudinal data, and there could be multiple hospital admissions due to aspiration pneumonia for the same patient. Therefore, we are assuming that some hospital admissions are readmissions for the same patient and not all new patients. However, since the goal of our study was to address the overall population level trends and not look at individual healthcare burden, the KID was appropriate to address the question. In addition, data are provided for inpatient encounters only; therefore, patients treated as outpatients are not included. Another limitation was that the aerodigestive program data were self-reported and could therefore introduce bias into data collection. In addition, the number of programs may be underestimated because of lack of response or programs whose leadership is not included in the list-serv which was used to collect the data.

CHAPTER 4: RESULTS

TABLE 1:National and regional estimates of patients diagnosed with aspiration pneumonia from 2006-2016.

Variable	Level	Overall	2006	2009	2012	2016
National Estimates		25,267	6,722	6,757	6,021	5,767
Regional Estimate	Northeast	4,882 (19.3%)	1,204 (17.9%)	1,351 (20.0%)	1,265 (21.0%)	1,061 (18.4%)
	Midwest	5,872 (23.2%)	1,521 (22.6%)	1,594 (23.6%)	1,447 (24.0%)	1,309 (22.7%)
	South	8,403 (33.3%)	2,236 (33.3%)	2,077 (30.7%)	2,036 (33.8%)	2,053 (35.6%)
	West	6,110 (24.2%)	1,761 (26.2%)	1,735 (25.7%)	1,271 (21.1%)	1,342 (23.3%)

*National and regional estimates were calculated using weighted data because it was a discharge level estimate.

FIGURE 1: National estimates of hospital admissions of patients diagnosed with aspiration pneumonia (ASP) from 2006-2016.

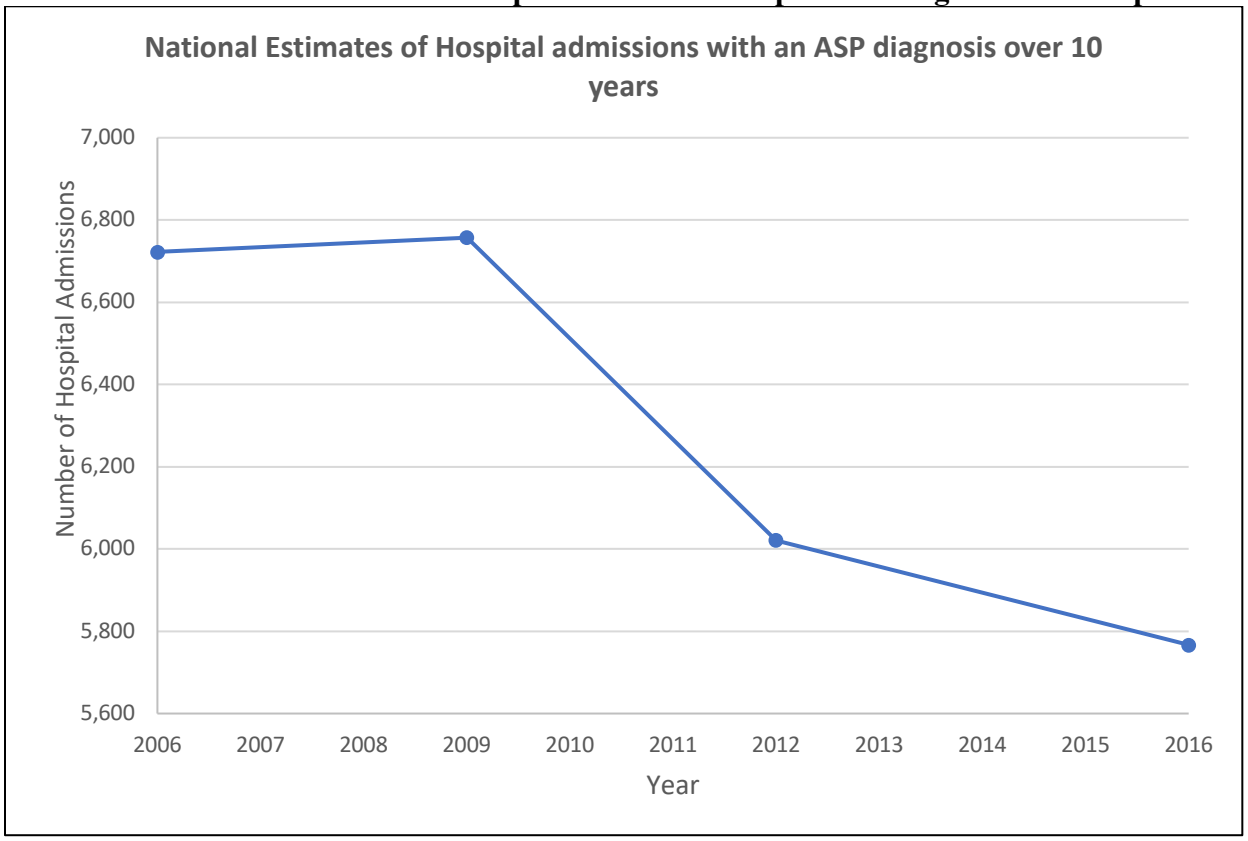

FIGURE 2: Regional estimates of hospital admissions of patients diagnosed with aspiration pneumonia (ASP) from 2006-2016.

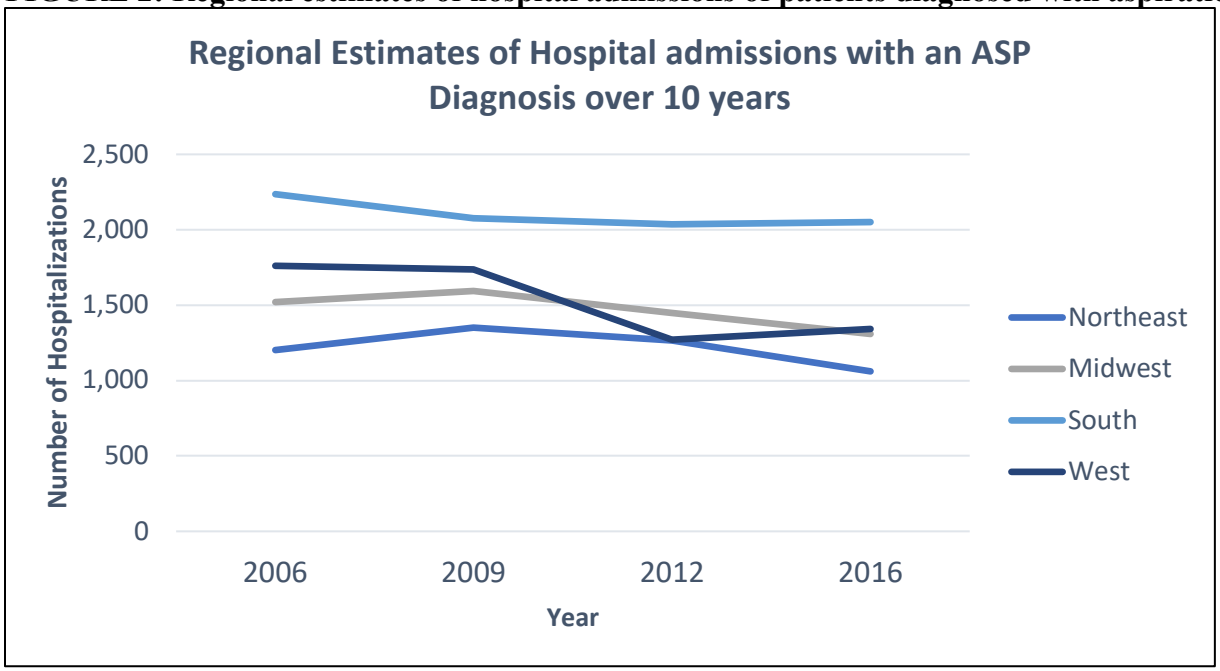

TABLE 2: Demographic data of patients diagnosed with aspiration pneumonia between 2006-2016.

Variable	Level	Overall	Patients with ASP	Patients without ASP	P-Value
Total Patients		27,870,522	25,267 (.09%)	27,845,256 (99.9%)	
Sex	Female	14,502,932 (52.0%)	10,732 (42.5%)	14,492,200 (52.0%)	**<.0001**
	Male	13,237,948 (47.5%)	14,514 (57.4%)	13,223,434 (47.5%)	
	Missing	129,643 (0.5%)	21 (0.1%)	129,622 (0.5%)	

Variable	Level	Overall	Patients with ASP	Patients without ASP	P-Value
Race	White	12,031,704 (43.2%)	10,703 (42.4%)	12,021,001 (43.2%)	**<.0001**
	Black	3,751,665 (13.5%)	3,238 (12.8%)	3,748,427 (13.5%)	
	Hispanic	5,278,883 (18.9%)	5,271 (20.9%)	5,273,612 (18.9%)	
	Asian or Pacific Islander	945,334 (3.4%)	701 (2.8%)	944,632 (3.4%)	
	Native American	203,280 (0.7%)	288 (1.1%)	202,993 (0.7%)	
	Other	1,363,101 (4.9%)	1,263 (5.0%)	1,361,838 (4.9%)	
	Missing	4,316,601 (15.4%)	3,803 (15.1%)	4,312,798 (15.5%)	
Primary Expected Payer	Medicare	90,101 (0.3%)	164 (0.6%)	89,937 (0.3%)	**<.0001**
	Medicaid	13,355,716 (48.0%)	15,344 (60.7%)	13,340,372 (47.9%)	
	Private Insurance	12,163,778 (43.7%)	8,141 (32.2%)	12,155,637 (43.7%)	
	Self-Pay	1,230,029 (4.4%)	434 (1.7%)	1,229,595 (4.4%)	
	No Charge	52,785 (0.2%)	18 (0.1%)	52,766 (0.2%)	
	Other	926,466 (3.3%)	1,147 (4.5%)	925,318 (3.3%)	
	Missing	51,649 (0.2%)	19 (.1%)	51,630 (0.2%)	

Variable	Level	Overall	Patients with ASP	Patients without ASP	P-Value
Elective vs Non-elective Admission	Elective	2,848,284 (10.2%)	1,660 (6.6%)	2,846,624 (10.2%)	**<.0001**
	Non-elective	24,952,478 (93.4%)	23,516 (93.1%)	24,928,962 (89.5%)	
	Missing	76,497 (0.3%)	91 (0.3%)	76,406 (0.3%)	
Patient Location NCHS Urban-Rural Code	"Central" counties of metro areas of >=1 million population	9,100,342 (32.7%)	8,106 (32.1%)	9,092,236 (32.7%)	**.0035**
	"Fringe" counties of metro areas of >=1 million population	6,254,114 (22.4%)	5,566 (22.0%)	6,248,548 (22.4%)	
	Counties in metro areas of 250,000-999,999 population	5,475,387 (19.6%)	4,942 (19.6%)	5,470,444 (19.6%)	
	Counties in metro areas of 50,000-249,999 population	2,433,968 (8.7%)	2,201 (8.7%)	2,431,768 (8.7%)	
	Micropolitan counties	2,711,318 (9.7%)	2,424 (9.6%)	2,708,893 (9.7%)	
	Not metropolitan or micropolitan counties	1,665,652 (6.0%)	1,653 (6.5%)	1,663,999 (6.1%)	
	Missing	229,741 (0.8%)	375 (1.5%)	229,366 (0.8%)	

TABLE 3: Hospital demographics for patients diagnosed with aspiration pneumonia between 2006-2016 stratified by years.

Variable	Level	Overall	2006	2009	2012	2016	P-Value
Total Patients		25,267	6,722	6,757	6,021	5,767	
Hospital Bed size	Small	2,744 (10.9%)	976 (14.5%)	729 (10.8%)	516 (8.6%)	524 (9.1%)	**<.0001**
	Medium	6,021(23.8%)	1,745 (26.0%)	1,454 (21.5%)	1,357 (22.5%)	1,465 (25.4%)	
	Large	15,648 (61.9%)	3,814 (56.7%)	3,908 (57.8%)	4,148 (68.9%)	3,778 (65.5%)	
	Missing	854 (3.4%)	187 (2.8%)	666 (9.9%)	-	-	

Location and Teaching Status	Rural	1,512 (6.0%)	520 (7.7%)	451 (6.7%)	344 (5.7%)	197 (3.4%)	**<.0001**
	Urban Nonteaching	3,556 (14.1%)	1,175 (17.5%)	1,144 (16.9%)	818 (13.6%)	419 (7.3%)	
	Urban Teaching	19,346 (76.6%)	4,840 (72.0%)	4,497 (66.6%)	4,859 (80.7%)	5,150 (89.3%)	
	Missing	853 (3.4%)	187 (2.8%)	665 (9.8%)	-	1(0%)	

TABLE 4: Comparison of hospital data for patients diagnosed with aspiration pneumonia to patients without aspiration pneumonia.

Variable	Diagnosis	2006 Median (IQR)	2009 Median (IQR)	2012 Median (IQR)	2016 Median (IQR)	P-Value
Length of Stay	Patients with Aspiration Pneumonia	5 Days (3-10 Days)	5 Days (2-9 Days)	4 Days (2-9 Days)	4 Days (2-8 Days)	**<.0001**
	Patients without Aspiration Pneumonia	2 days (2-3 Days)	2 days (2-3 Days)	2 days (2-3 Days)	2 days (2-3 Days)	
Total cost of hospitalization	Patients with ASP	$7,886 ($3,649-$18,335)	$8,216 ($3,914-$19,154)	$8,752 ($4,175-$19,337)	$10,349 ($5,152-$23,585)	**<.0001**
	Cost (2016)	$9,384 ($4,342-$21,819)	$9,202 ($4,384-$21,452)	$9,190 ($4,384-$20,304)	$10,349 ($5,152-$23,585)	
	Patients without ASP	$1,401 ($683-$3,616)	$1,572 ($761-$4,128)	$1,827 ($885-$4,877)	$1,892 ($959-$5,198)	
	Cost (2016)	$1,667 ($813-$4,303)	$1,761 ($852-$4,623)	$1,918 ($929-$5,121)	$1,892 ($959-$5,198)	

*IQR: Interquartile Range, middle 50% of the data.
*Length of Stay: Days are calculated by subtracting the admission date from the discharge date. Same-day stays are therefore coded as 0.
*Total cost of hospitalization utilizes cost to charge ratios of each year to convert hospital charges into actual costs.
*Cost (2016) reflects what the cost would be in 2016 for each year in order to rule out inflation.

TABLE 5: Information on aerodigestive programs in the United States stratified by region.

Variable	Level	Total (N=31)	Northeast (N=4)	Midwest (N=6)	South (N=11)	West (N=10)
Year	2006	3 (9.68%)	1	1	1	0
	2009	4 (12.9%)	1	1	2	0
	2012	9 (29.0%)	1	3	4	1
	2016	25 (80.6%)	3	5	10	7
	Post 2016	31 (100%)	4	6	11	10
Years programs have been active	Less than 5 years	20 (64.52%)	3	3	6	8
	Between 5 to 10 years	8 (25.81%)	0	2	4	2
	More than 10 years	3 (9.68%)	1	1	1	0

TABLE 6: Information on aerodigestive programs in the United States stratified by year, region and program type.

Aerodigestive Program Type	Level	Total (N=31)	Northeast (N=4)	Midwest (N=6)	South (N=11)	West (N=10)
Academic Centers	2006	2	1	1	-	-
	2009	1	-	-	1	-
	2012	4	-	2	1	1
	2016	12	2	2	3	5
	Post 2016	3	-	-	1	2
Hybrid	2006	1	-	-	1	-
	2009	0	-	-	-	-
	2012	1	-	-	1	-
	2016	4	-	-	3	1
	Post 2016	3	1	1	-	1

*Hybrid programs are a combination of private and academic style.

Results

National and Regional Estimates

Over the 10-year study period, there were 25,267 patients who were hospitalized with a primary diagnosis of aspiration pneumonia (ASP). Overall, the number of hospitalizations due to ASP decreased from 6,722 in 2006 to 5,767 in 2016. From the 25,267 patients diagnosed with ASP, 33.3% of the hospitalizations were in the south, 24.2% were in the west, 23.2% were in the Midwest and 19.3% were in the northeast. Every region showed an overall decrease in the number of hospitalizations due to aspiration pneumonia. A chi-square test was conducted, looking at the association between hospital region and yearly hospitalizations, controlling for ASP diagnosis, giving a p-value of <.0001. Additional data on yearly rates are available in Table 1.

Patient Demographics

Of the 25,267 patients diagnosed with aspiration pneumonia, information on primary expected payer was available for 25,248 patients (99.9%). People with ASP were more likely to be on Medicaid (60.7%) than other insurances (p-value <.0001). Information on sex was available for 25,246 patients (99.9%). Males were more likely to be diagnosed with ASP (relative risk= 1.23, p-value <.0001) than females. Information on race was available for 21,464 (84.9%). Children admitted with ASP were more likely to be white (42.4%), followed by Hispanics (20.9%) and then Blacks (12.8%) (p-value <.0001). Information on whether a patient's admission to the hospital was elective or non-elective was available for 16,943 patients (99.6%). Children diagnosed with ASP were more likely to have a non-elective admission compared to an elective admission (p-value <.0001). Patient location information was available for 24,892 patients (98.5%). Children diagnosed with ASP were more likely to be from metro areas of >=1 million population (p-value .0035). These demographic characteristics of hospital admissions were consistent with patients not

diagnosed with ASP. More details on patient demographic characteristics, stratified by patients with and without a diagnosis of aspiration pneumonia is shown in Table 2.

Hospital Demographics

Hospital data on bed size, hospital location, and teaching status were available for 96.6% of the patients. Children diagnosed with ASP were more likely to be admitted at large hospitals (64.1%) compared to medium (24.7%) or smaller bed size (11.2%) hospitals (p-value <.0001). Through the years, there was an increase in pediatric patients with aspiration pneumonia being admitted to larger bed size hospitals and a decrease in patients being admitted to smaller bed size hospitals. In addition, patients diagnosed with ASP were more likely to be admitted to urban, teaching hospitals (79.2%) rather than urban, nonteaching hospitals (14.6%) or rural hospitals (6.2%) (p-value <.0001). Through the years, there was an increase in patients with aspiration pneumonia being admitted to urban, teaching hospitals and a decrease in patients being admitted to rural or urban, nonteaching facilities. More details on hospital demographic characteristics, stratified by years is shown in Table 3.

Length of Stay and Total Cost of Hospitalization

The median length of stay and total cost of hospitalization was studied for patients with ASP and compared to those without an ASP diagnosis. The median days length of stay for patients with aspiration pneumonia was lower by one day over the years while it stayed the same for patients without. The median length of stay was 4 days for patients with ASP compared to 2 days for patients without. The median cost of hospitalization over the 10 years for patients with aspiration pneumonia was higher from $7,886 in 2006 to $10,349 in 2016 compared to $1,401 to $1,892 for patients without an ASP diagnosis. Ruling out inflation as a cause of the higher cost, the inflation rate compared to 2016 was used to estimate costs for each year. Cost of admission for

ASP was indeed higher from $9,384 in 2006 to $10,349 in 2016 for patients with ASP and $1,667 to $1,892 for patients without ASP. Hospital charges for patients diagnosed with ASP were at least 5 times higher than patients with an ASP diagnosis throughout the years.

Linear regression was conducted for each year of the dataset to see if there was an association between a diagnosis of aspiration pneumonia and variables such as length of stay, total charge of hospitalization. The p-values of all variables were < .0001. Based on a significance level of .05, all variables were significant, indicating that a diagnosis of aspiration pneumonia is associated with a difference in length of stay and total cost of hospitalization. More detail on hospital demographic characteristics, stratified by years is shown in Table 4.

Other

Number of chronic conditions

The number of chronic conditions on each record was only available for datasets in the year 2009 and 2012. The median number of chronic conditions was 4 for patients diagnosed with aspiration pneumonia with an IQR of 4-6 and 0 for patients that were not diagnosed with aspiration pneumonia with an IQR 0-1. The median number of chronic conditions were identical in both datasets. This implies that an ASP diagnosis was significantly associated with a higher number of chronic conditions for patients (p-value <.0001).

Hospital Control/Ownership

For the 2006 dataset, information about hospital control/leadership for patients diagnosed with aspiration pneumonia was available for 6,535 patients (97.2%). Of those records, 79.86% of the hospitals were owned by government or private (collapsed category), 10.1% were private, not-for-profit hospitals, 3.9% were private, investor owned hospitals, 3.5% were government, public hospitals and 2.7% were private hospitals. Beginning 2009, a new variable was introduced

for hospital ownership and control. It was divided into three categories, government (nonfederal), private (not-for-profit) and private (investor owned). Data was available for 17,879 patients (96.4%). Of those, 81.5% were admitted at a private (not-for-profit) hospital, 11.1% were at a government (nonfederal) hospital and 7.4% were at a private (investor owned) hospital. . This implies that an ASP diagnosis was significantly associated with admission to a government or a private (not-for-profit) hospital (p-value <.0001).

Aerodigestive Programs

There are 31 aerodigestive programs within the United States, based on the survey data used. Out of the 31 programs, 11 (35.5%) are in the south, 10 (32.3%) are in the west, 6 in the Midwest (19.4%), and 4 in the northeast (12.9%). About 64.52% of the programs have been active less than 5 years, 25.8% between 5 to 10 years and 9.68% for more than 10 years. 22 (71%) of the programs are based at academic centers whereas 9 (29%) of the programs are based at hybrid centers. More detail on aerodigestive programs' characteristics are shown in Tables 5 and 6.

CHAPTER 5: DISCUSSION AND RECOMMENDATIONS

Discussion:

In this study of pediatric hospitalizations with ASP from 2006-2016, we found that the national and regional hospital admission rates were lower in 2016 compared to 2006. Furthermore, people that were White, male or had public insurance are more likely to be diagnosed with ASP compared to other races, females or insurance type. Hospital admissions costs were higher for all patients, but consistently higher for patients with ASP compared to those without ASP. LOS was lower in 2016 for both groups but still higher for patients with ASP compared to those without. Patients were more likely to be hospitalized in urban, teaching facilities and hospitals with larger bed sizes in 2016 compared to 2006. Lastly, aerodigestive programs have proliferated from 2006-2016 in the United States, especially in the southern and western regions of the United States. However, the west and the south account for more than 50% of hospital admissions for ASP.

From 2006-2016, there were a total of 25,267 pediatric admissions for aspiration pneumonia, with 33.3% occurring in the southern region of the United States, while 24.2% were in the west, 23.2% were in the Midwest and 19.3% were in the northeast. Comparing prevalence rates over the 10-year period survey data has been collected, the admissions for ASP decreased by 14.2% with the largest decrease noticed in the western region where rates dropped by 23.8%. To our knowledge, this is the first study to look at trends for ASP specific pediatric hospital admissions, especially regional patterns of ASP among children. These regional variations could be due to the differences of populations that reside in the communities, the severity of illnesses of those patients, their access to services, physician abilities in accurately diagnosing conditions as

well as the quality of care received, which may affect readmissions (Tape, Heckerling, Ornato, & Wigton, 1991).

Approximately 93.9% of the total hospitalizations were non-elective, 57.5% were male patients and 60.8% of the hospitalizations were patients that used Medicaid. most 50% of the patients were White, 24.6% Hispanic and 15.1% were Black. Other studies have also shown that patients diagnosed with aspiration pneumonia usually tend to be male and publicly insured (Hirsch et al., 2016; Thomson et al., 2016). There are studies that have reported that there is not a significant difference in risk of dysphagia, which is a common cause of ASP, between males and females (Byeon, 2016; Cho et al., 2015). Therefore, there is limited research on why males are more susceptible to ASP. A possible reason could be due to the difference in immune response to the aspirates, attributed to estrogens and progestins present in females (Jeon et al., 2019). Studies have also shown that patients using public insurance face a higher likelihood of preventable admissions due to barriers to access, environmental or social factors or even the lack of quality care, which could be the case for ASP as well (Basu, Friedman, & Burstin, 2004; Weissman, Gatsonis, & Epstein, 1992).

A comparison of length of stay and total costs associated with each hospitalization was explored between patients whose principal diagnosis was aspiration pneumonia compared to patients with all other diagnosis. The length of stay was lower by one day for patients with ASP (5 days to 4 days, p-value < .0001) but remained consistently less for patients without ASP (2 days). Median hospital costs were higher for both groups through the years, but median costs were 5 times more compared to patients without ASP showing a significant association between a diagnosis of ASP and higher hospital costs ($p<.0001$). In order to rule out inflation as a cause of higher costs, all the costs were converted using inflation rates to what they would be in 2016. Cost

for patients with ASP were higher in 2016 compared to 2006 ($10,349 vs $9,384) as well as for patients without ASP ($1,892 vs $1,667). These findings complement findings of another study that looked at national trends of hospitalizations for aspiration pneumonia in all age groups that found that the cost of hospitalizations almost doubled and LOS decreased by 1 day for patients with aspiration pneumonia (Wu et al., 2017). The median number of diagnosis on patients with ASP was 9 compared to 3 (p-value <.0001) for patients without ASP. In addition, the number of chronic conditions on each record was available for 2009 and 2012 dataset. It showed that patients with ASP had a median number of 4 chronic conditions on each record whereas patients with other diagnoses had 0 (p-value <.0001). This is consistent with other studies that show that patients with ASP have more comorbidities and ASP disproportionately affects those with more than one chronic condition (Lanspa, Jones, Brown, & Dean, 2013; Lanspa et al., 2015). In addition, since it affects children with higher medical complexity, it accounts for longer and costlier hospitalizations (Hirsch et al., 2016).

Patients were more likely to be admitted to larger bed size hospitals and urban, teaching facilities. Through the years, there were 8.8% more hospitalizations in large bed size hospitals and 17% more admissions to urban, teaching facilities. This could be due to teaching hospitals' reputation of providing high-quality for treatment of rare and complex diseases, specialized services, advanced technology and innovations in clinical care (Ayanian & Weissman, 2002). However, there are still gaps in literature showing evidence of improved quality of care in teaching facilities compared to non-teaching facilities. Further research comparing the facilities in terms of disease-specific outcomes, measures of high-quality care and reasons as to why teaching hospitals are perceived to have better quality of care is needed so that doctors, health policy makers and patients can make better, more informed decisions.

From 2006-2016, the number of aerodigestive programs have increased from 3 to 28, and the number of hospitalizations of ASP overall was 14.2% lower, from 6,772 to 5,767. Most of the aerodigestive programs are established in academic centers and based on the number of hospitalizations, more patients with ASP are being admitted in urban, teaching facilities as well. For example, a higher number of patients were hospitalized in 2016 at urban, teaching facilities compared to 2006 (89.3% vs 74.1%), showing a significant association between an ASP diagnosis and admissions at academic centers (p-value <.0001). When we looked at regional distribution of hospital admissions for those admitted at the academic centers only, we found that the number of admissions were lower in the South and West region of the United States in 2016, compared to 2006. Therefore, since the proliferation of aerodigestive programs has mostly been in the south and west, one plausible explanation for the decrease of hospitalizations due to ASP in the academic centers at those regions could be due to a decrease in readmissions. This is assuming that the decrease was due to readmissions because patients were subsequently treated at an aerodigestive program, thereby addressing underlying causes for ASP and preventing further illness, or if a patient was identified prior to developing ASP and referred to an aerodigestive program, thereby never needing admission. However, more research is needed on this particular topic on whether hospital admissions were lower in facilities with actively running aerodigestive programs or whether any of the children hospitalized have previously participated or were able to participate in an aerodigestive program within that specific facility. Therefore, supplementary research and data are needed on where these programs operate, utilization of these programs by the pediatric patient population, as well as the integration of all that data in order to be able to evaluate health outcomes for each patient. To our knowledge, since there is scarce data on aerodigestive programs and their impact on rates of disease-specific outcomes, we are unable to compare our

results with other literature out there. However, a study looking at association of enrollment in aerodigestive clinic with reduced hospital stay for children with special health care needs found that there was no significant difference in number of admissions per year with enrollment (Appachi et al., 2017). This study did not specifically evaluate number of admissions related to ASP. However, it did find a decrease in LOS over the study period.

Recommendations

Previous studies have only reported on ASP for a specific subgroup of patients, mainly elderly and those with multiple chronic conditions. There is still a lack of data targeting pediatric patients admitted for ASP. More research is needed on population-level data, especially in children on predisposing factors, appropriate management and preventive strategies of ASP to improve outcomes. In addition, due to inconsistencies in diagnoses and coding practices across different facilities, a standardized process for diagnosing and coding ASP is essential (Lindenauer et al., 2018).

Additional research is also needed on the prevalence and characteristics of aerodigestive programs and their effect on disease-specific outcomes, including ASP. Since aerodigestive programs combine multiple specialties, it leads to improved communication between the disciplines and innovation in health care delivery, contributing towards enhanced quality of care (Wootten et al., 2019). Care coordination efforts, such as aerodigestive programs are shown to reduce hospital stay and readmissions leading to lower hospital charges for both patients and providers (Appachi et al., 2017). Therefore, more research on their cost effectiveness, validation of aerodigestive approach while not compromising patients' health outcomes and impact on caregivers and patients is needed especially as health delivery method is moving towards value-based care.

Strengths and Limitations

According to our knowledge, this study is the first large, population-based study looking at pediatric hospitalizations with ASP. The Kids' Inpatient Database, which is the largest publicly available all-payer inpatient care database comprising information from 4,200 United States hospitals, was used. This provided us with a large and diverse sample size, representing the different regions from across the country. Therefore, findings from this study could be used to generalize prevalence of pediatric ASP hospitalizations and patient characteristics within the United States.

A limitation of this study is that due to its cross-sectional nature, assessing readmissions of patients for ASP is beyond the scope of this study. Additionally, the study population differed at every point that data was collected (2006, 2009, 2012 and 2016), which provides prevalence of ASP and not incident cases. Therefore, this study can only report on associations and not on the causality between pediatric ASP admissions and variables of interest. This in turn, could also skew data that has been received on estimations of admission rates and descriptive statistics about patient characteristics and demographic characteristics and the generalizability of the results. Population selection was done using ICD-9 diagnosis and thus, misdiagnosis of patients is a possibility. The data available for patient characteristics were strictly inpatient; therefore, information regarding characteristics of those patients treated at outpatient settings is not included. In addition, the aerodigestive program data that was used was self-reported and therefore, could have introduced bias into the study. Because data regarding prevalence and information on aerodigestive programs is scarce, the associations made in this study between the prevalence of programs and rates of hospitalization are based on the available data.

Conclusion

In conclusion, we looked at patient characteristics of children under 21 admitted to a hospital in the United States between 2006-2016 with a principal diagnosis of ASP and compared it to the prevalence of aerodigestive programs within the United States to explore an association between the programs and rates of hospital admissions. We found that the overall number of admissions for aspiration pneumonia had decreased in 10 years, with the most significant decrease noticed in the west region. Patients with ASP were more likely to use Medicaid, were male, and admitted to larger, teaching facilities. In addition, they experienced longer hospital stays and higher costs, and had a greater number of chronic conditions and diagnoses compared to those without ASP. Aerodigestive programs are thriving, especially in academic centers with over 64% of them based in the south and west. Consequently, there are fewer admissions due to aspiration pneumonia in those regions and therefore, we believe it might be due to fewer readmissions after being treated at aerodigestive centers. More research on this association is needed especially connecting aerodigestive programs and their impact on disease-specific outcomes.

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