5-2023

# Inpatient department hospital utilization among pregnant women with spinal cord injury or paralysis in the United States.

Sonali S. Salunkhe
*University of Louisville*

# INPATIENT DEPARTMENT HOSPITAL UTILIZATION AMONG PREGNANT WOMEN WITH SPINAL CORD INJURY OR PARALYSIS IN THE UNITED STATES

By

Sonali S. Salunkhe
M.D., Saratov State Medical University, 2011
M.P.H., University of Louisville, 2019

A Dissertation
Submitted to the Faculty of the
School of Public Health and Information Sciences at the University of Louisville
in Partial Fulfillment of the Requirements
for the Degree of

Doctor of Philosophy in Public Health Sciences

Department of Health Management and Systems Sciences
University of Louisville
Louisville, KY

May 2023

INPATIENT DEPARTMENT HOSPITAL UTILIZATION AMONG PREGNANT WOMEN WITH SPINAL CORD INJURY OR PARALYSIS IN THE UNITED STATES

By

Sonali S. Salunkhe
M.D., Saratov State Medical University, 2011
M.P.H., University of Louisville, 2019

A Dissertation Approved on

April 13, 2023

by the following Dissertation Committee:

_____
Liza M. Creel, PhD, MPH, Dissertation Chair

_____
Christopher E. Johnson, PhD, Dissertation Committee Member

_____
Beatrice Ugiliweneza, PhD, MSPH, Dissertation Committee Member

_____
Robert M. Carini, PhD, Dissertation Committee Member

## DEDICATION

I would like to dedicate this dissertation to researchers whose work focuses on maternal and child health and healthcare disparities. I would also like to dedicate this dissertation to my daughter, whose one smile enlightens my day.

# ACKNOWLEDGMENTS

I would wholeheartedly like to acknowledge my dissertation committee members, Dr. Liza M. Creel, Dr. Beatrice Ugiliweneza, Dr. Christopher E. Johnson, and Dr. Robert M. Carini who have been so supportive throughout the process of my dissertation by providing their valuable feedback right from my first draft to the final dissertation, discussing my thoughts and ideas, and pushing me to accomplish my goals. I would specifically like to extend my gratitude to my dissertation committee members and other professors for the amazing mentoring that I received from them.

I would also like to thank my daughter, husband, family, and friends for always being there for me and supporting me in fulfilling my dreams. I am truly thankful to you all.

This dissertation and research was supported, in part, by the Commonwealth Institute of Kentucky (CIK) in the University of Louisville School of Public Health and Information Sciences and the Child and Adolescent Health Research Design Unit (CAHRDS) in the University of Louisville School of Medicine, Department of Pediatrics. The views expressed are those of the authors and do not necessarily reflect the official position of CIK, CAHRDS, or the University.

ABSTRACT

INPATIENT DEPARTMENT HOSPITAL UTILIZATION AMONG PREGNANT WOMEN WITH SPINAL CORD INJURY OR PARALYSIS IN THE UNITED STATES

Sonali S. Salunkhe

April 13, 2023

BACKGROUND: Spinal cord injury (SCI) results from damage to the spinal cord, leading to a temporary or permanent alteration in its normal function, usually causing a lifelong disability. SCI is one of the major causes of paralysis. Due to a sparsity of available research and to address the existing gaps, it is essential to evaluate the inpatient hospital use of pregnant women with SCI/paralysis.

METHODS: This study operationalizes inpatient hospital use in three ways. We used the National (Nationwide) Inpatient Sample (NIS) from 2006 through 2019. The first analysis used a hurdle model for length of hospital stay and a linear regression for total hospitalization charges to assess non-delivery-related healthcare utilization for pregnant women with SCI/paralysis. The second analysis employed negative binomial regression for length of stay and ordinary least squares regression for total hospitalization charges to examine delivery-related healthcare utilization for pregnant women with SCI/paralysis. The third analysis used propensity-score kernel matching to determine the impact of

SCI/paralysis on the healthcare utilization for inpatient encounters of pregnant women divided into groups - with and without SCI/paralysis.

RESULTS: The average length of hospital stay for pregnant women with SCI/paralysis admitted for non-delivery and delivery-related reasons were 7.85 days (median: 4 days, IQR: 2 - 7 days) and 8.11 days (median: 4 days, IQR: 2 - 8 days), respectively. The average total hospitalization charges for pregnant women with SCI/paralysis admitted for non-delivery and delivery-related reasons were $85,676.47 (median: $29,181.31, IQR: $15,757.56 - $70,767.22, in 2019 dollars) and $79,027.84 (median: $30,043.4, IQR: $16,164.16 - $78,386.09, in 2019 dollars). The pregnant women with SCI/paralysis had, on average, a length of stay of about three days (SE: 0.22) longer and a total hospitalization charge of approximately $30,393.23 (SE: $24,84.01, in 2019 dollars) more than the pregnant women without SCI/paralysis.

CONCLUSION: Pregnant women with SCI/paralysis have greater hospital inpatient service utilization when compared to those without SCI/paralysis. It is essential for a healthcare delivery system to understand the extent of healthcare utilization of pregnant women with SCI/paralysis to be able to develop effective programs and policies to address the needs of this population.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

# INTRODUCTION

The Triple Aim framework - "improving the individual experience of care; improving the health of populations; and reducing per capita costs of care for populations" (Berwick, Nolan, & Whittington, 2008, p. 760), developed by researchers at the Institute for Healthcare Improvement in 2008, describes an approach to improving the health system performance ("The IHI Triple Aim," 2021). It is essential to consider the connection between access to healthcare and health outcomes at the population level. Healthcare utilization, in general, is attributed to the people's usage of different healthcare services for various reasons (Carrasquillo, 2013). Research suggests that healthcare service utilization depends on a number of factors, including gender, geographic, racial, socioeconomic, and cultural barriers, among others, that contribute to patients' access to healthcare services within a healthcare system (Roy et al., 2021).

## Spinal Cord Injury and Paralysis

Spinal cord injury (SCI) results from damage to the spinal cord that leads to a temporary or permanent alteration in the spinal cord's normal sensory, motor, or autonomic function, which usually leads to severe morbidity and lifelong disability in the individual (Ahuja et al., 2017; Bennett, Das, & Emmady, 2022). Major causes of paralysis include stroke (seen in 33.7% of paralysis cases), SCI (seen in 27.3% of paralysis cases), multiple sclerosis (seen in 18.6% of paralysis cases), and cerebral

palsy (seen in 8.3% of all paralysis cases) (Armour, Courtney-Long, Fox, Fredine, & Cahill, 2016). According to the World Health Organization, the international prevalence of SCI is between 250,000 and 500,000 individuals each year ("Spinal cord injury," 2013). In the United States, approximately 17,730 new SCIs occur per year, of which 22% are in women ("National Spinal Cord Injury Statistical Center," 2019). Women with SCI in their childbearing age represent a growing population, and in the United States, each year, approximately more than 2,000 women in their reproductive period suffer from an SCI (Ghidini, Healey, Andreani, & Simonson, 2008).

Studies suggest that individuals with SCI have reported an average of eight to fourteen secondary conditions per year, including but not limited to obesity, pressure sores, depression, and urinary tract infections (Hamilton et al., 2017; Piatt, Nagata, Zahl, Li, & Rosenbluth, 2016; Richardson, Samaranayaka, Sullivan, & Derrett, 2021). The neurological, physical, or physiological secondary conditions caused by SCI can influence pregnancy outcomes (Iezzoni, Chen, & McLain, 2015). Improper management of secondary health conditions accompanying SCI can further worsen the health conditions leading to hospitalizations for decubitus ulcers, pneumonia, or septicemia (Hamilton et al., 2017), which in turn places a heavy burden on the healthcare system.

**Burden of care**

SCI leads to significant individual and societal costs ("Spinal cord injury," 2013). Depending upon the severity of the injury, the average yearly expenses for individuals suffering from traumatic SCI range from $397,544 to $1,218,106 (in 2021 dollars) for the first year of injury, followed by $48,287 to $211,528 (in 2021 dollars) for each subsequent year ("National Spinal Cord Injury Statistical Center," 2022). In 2019, in the

United States, there were 216,981 total treat-and-release emergency room visits for non-maternal care for pregnant women, and it accounted for 113.1 dollars per million ("Emergency Department and Inpatient Utilization," 2021). Also, in 2019, the overall aggregate cost of all delivery hospitalizations and the hospitalizations for maternal care (except for delivery) by the expected primary payer in the United States were 20,385.2 million dollars and 1,821.4 million dollars, respectively ("Emergency Department and Inpatient Utilization," 2021). Since SCI and pregnancy/delivery hospitalizations separately lead to such high healthcare costs, it can cause an increased financial burden for pregnant women with SCI/paralysis. Therefore, it is essential to examine the healthcare utilization and hospitalization charges for pregnant women with SCI or paralysis.

The hospitalization rates for individuals with SCI are 1.7 to 2.4 times higher when compared to the United States general population (Johnson, Gerhart, McCray, Menconi, & Whiteneck, 1998). Moreover, it has been documented that those individuals with an SCI have a median of 22 contact points in total with the healthcare system in the year they were injured compared to three contact points per year for the general masses (Dryden et al., 2004). After discharge from an acute trauma setting, approximately 58% of individuals with SCI had more utilization of healthcare services within the first year itself (Sikka et al., 2019). Studies suggest that the average rehospitalization rates among individuals in the first year of their SCI are higher compared to the rehospitalization rates in the following years (Cardenas, Hoffman, Kirshblum, & McKinley, 2004), indicating higher healthcare utilization and associated costs. For individuals with SCI, healthcare services play an even more crucial role in decreasing an individual's risk of not only

managing but also preventing any secondary complications or chronic conditions (Hamilton et al., 2017). Women with SCI are opting to conceive (Hocaloski et al., 2017). Although research suggests that there is no evidence that SCI affects a woman's ability to conceive (Iezzoni et al., 2015; Jackson & Lindsey, 1998; McLain, Massengill, & Klebine, 2016), this assertion has not been demonstrated empirically (Iezzoni et al., 2015), and so information on healthcare utilization pregnant women with SCI is limited. Due to a sparsity of available research and to address the existing gaps in terms of health services utilization of this population, it is essential to study and evaluate the healthcare utilization of pregnant women with SCI or paralysis.

There are several key measures for inpatient hospital use and quality. Length of hospital stay is used as a quality metric to assess the efficiency of hospital management because the decreased length of hospital stay can improve bed turnover and allow the hospitals to meet the demand for healthcare services (Siddique et al., 2021). When demand for healthcare services exceeds hospital capacity, it leads to emergency room crowding and in-patient admission strain, which are associated with adverse health outcomes in patients, including higher inpatient mortality (Siddique et al., 2021; Sun et al., 2013). Hospitalization charges are an indicator of the potential financial implications of pregnancy with SCI/paralysis. Research suggests that while pregnancy alone leads to an increase in healthcare services utilization and costs, it is frequently compounded by pregnancy-related complications that increase the associated healthcare services utilization and costs even more (Law et al., 2015; Moore, Witt, & Elixhauser, 2014). Therefore, to maximize the opportunities for healthy pregnancies, it is important to study trends in pregnancies among women with SCI, and their healthcare utilization in terms of

length of hospital stay and hospitalization charges, key indicators of healthcare quality in general.

**Overview**

The reasons for inpatient hospitalizations during pregnancy can differ as a pregnant woman can be admitted for delivery-related reasons or non-delivery-related care. The three distinct manuscripts included in this dissertation will assist in addressing the existing research gaps related to hospital-based pregnancy healthcare needs and healthcare utilization (inpatient department hospitalizations) among pregnant women with SCI or paralysis. The healthcare needs and type of healthcare service required by pregnant women for maternal care (except delivery) and for delivery and labor can be very different. Therefore, it is important to assess delivery and non-delivery-related hospitalizations separately. To our knowledge, this topic has not been previously studied. To approach the study, we applied the framework for the study of access and utilization developed by Aday and Andersen in 1974 (Aday & Andersen, 1974) to create the conceptual framework of our research. This framework offers well-grounded guidance for identifying factors known to influence access to healthcare services, including both chronic and acute needs. These are known barriers to accessing healthcare services, especially among pregnant women and those with chronic healthcare needs such as SCI or paralysis. The first paper assesses the healthcare utilization and trends of non-delivery-related healthcare utilization for pregnant women with SCI/paralysis in the United States. The second paper examines the trends and inpatient department healthcare utilization of pregnant women with SCI or paralysis who are admitted to the hospital only for delivery or labor-related causes. Finally, the third paper evaluates the burden of care for pregnant

women with SCI or paralysis compared to pregnant women without SCI or paralysis. This research uses nationally representative hospitalization data, which helps to improve generalizability. The use of a large dataset that is representative of the general population in the United States to study SCI/paralysis in pregnant women is vital because, as discussed above, length of stay and the associated hospitalization charges are some of the important metrics in understanding healthcare utilization. Additionally, this study will look at hospital-based care for pregnant women with SCI or paralysis, providing a lens for estimating prevalence in the United States and for identifying potential gaps or disparities in care. The proposed dissertation will also assess the trends across the past two decades to determine if the healthcare utilization for pregnant women with SCI/paralysis has changed. Finally, we will be able to identify characteristics associated with higher healthcare utilization among those with SCI/paralysis, offering evidence for which women may need more support and services while pregnant. This enables the formulation of recommendations for healthcare policies and practice changes to better serve this population.

The first manuscript aims to assess the healthcare utilization and trends of non-delivery related healthcare utilization for pregnant women with SCI/paralysis in the United States, in terms of length of hospital stay and hospitalization charges. By using the conceptual framework for the study of access and utilization developed by Aday and Andersen in 1974, it employs a hurdle model to examine the length of stay and a linear regression to assess the hospitalization charges for inpatient department admissions of non-delivery-related pregnant women with SCI/paralysis. The findings are beneficial in identifying characteristics associated with higher healthcare utilization among those with

SCI/paralysis, offering evidence for which women may need more support and services while pregnant.

The second manuscript aims to examine the inpatient department healthcare utilization and the associated trends in the healthcare utilization of pregnant women with SCI or paralysis who are admitted to the hospital for delivery or labor-related care. It uses a negative binomial regression model for the length of hospital stay and the ordinary least squares regression with a natural log transformation for total hospitalization charges. The results enable us to make the necessary recommendations for healthcare policies to better serve pregnant women with SCI/paralysis who are admitted to the hospital for labor, delivery, and childbirth.

Finally, the third manuscript aims to evaluate the impact of SCI/paralysis on the inpatient department healthcare utilization of pregnant women. It employs propensity-score kernel matching to compare the differences between both the pregnant women groups (with SCI/paralysis and without SCI/paralysis).

To make recommendations for addressing the healthcare needs of pregnant women with SCI or paralysis, researchers require complete information about the pregnancy prevalence, socio-demographic factors, hospitalization outcomes, healthcare utilization, and costs of the services associated with perinatal care for pregnant women with SCI or paralysis.

# CHAPTER 1: ASSESSMENT OF THE NON-DELIVERY RELATED HEALTHCARE UTILIZATION FOR PREGNANT WOMEN WITH SPINAL CORD INJURY OR PARALYSIS IN THE UNITED STATES

## OVERVIEW

We used the NIS from 2006 through 2019 to assess healthcare utilization for pregnant women with SCI/paralysis in the United States. Outcome variables were length of hospital stay and total hospitalization charges. Independent variables included patient demographics, socioeconomic status, and hospital characteristics. A hurdle model was used for length of hospital stay and a linear regression was used for total hospitalization charges. The average length of hospital stays for pregnant women aged 19 years or younger with SCI/paralysis was 50.3% higher than the average length of stay for those aged 25 to 29 years. The average length of hospital stay and total hospitalization charges for pregnant women with SCI/paralysis were 7.85 days (median: 4 days, SD: +/-14.85, IQR: 2 - 7 days) and $85,676.47 (median: $29,181.31, SD: +/-188,288.8, IQR: $15,757.56 - $70,767.22, in 2019 dollars), respectively. This research study highlights the need for improved surveillance of pregnant women with disabilities.

Keywords: Pregnancy; spinal cord injury; paralysis; length of stay; hospitalization charges

# INTRODUCTION

SCI occurs due to an insult to the spinal cord which causes a temporary or permanent change in the sensory, motor, or autonomic function in the individual (Dawood, Altanis, Ribes-Pastor, & Ashworth, 2014). Women with SCI with a lesion at any spinal cord level can be pregnant and deliver a baby (McLain et al., 2016). SCI by itself leads to a drastic change in the pathophysiology of an individual, which is further compounded by the pathophysiological changes occurring due to pregnancy (Hambly & Martin, 1998). Moreover, pregnancies in women with SCI are regarded as high-risk in nature due to their associated medical complications and challenges (Robertson, Dawood, & Ashworth, 2020), such as anemia, urinary tract infections, autonomic dysreflexia, and pressure ulcers, among others (Dawood et al., 2014; Robertson et al., 2020). The Triple Aim framework, which targets to improve population health and their experience of care while decreasing the costs of care (Berwick et al., 2008), illustrates a path to enhancing the health system performance ("The IHI Triple Aim," 2021). Therefore, it is important to understand the healthcare utilization of pregnant women with SCI/paralysis to improve the health of this population and also recognize the associated financial burden incurred by it and improve the overall health system performance.

The reasons for inpatient hospitalizations during the course of pregnancy can differ, as it can be for delivery and labor-related care or non-delivery-related care. The purpose of this research study was to assess non-delivery related healthcare utilization for pregnant women with SCI or paralysis in the United States, in terms of length of hospital stay and total hospitalization charges.

## CONCEPTUAL FRAMEWORK

The conceptual framework used for this research study was based upon the framework for the study of access and utilization developed by Aday and Andersen in 1974 (Aday & Andersen, 1974). This framework was employed to identify the variables for the characteristics of the health delivery system and the characteristics of the population at risk to understand the healthcare utilization for pregnant women with SCI/paralysis (Appendix A).

Characteristic of health delivery system: The health delivery system in the framework refers to the organizations and availability of resources in the healthcare delivery system for the people's use and how healthcare services usage in the healthcare system changes over time (Andersen, 1995).

Characteristic of population at risk: The characteristics of population at risk discusses how healthcare utilization is dependent on predisposing characteristics of the population, enabling resources, and the need for healthcare services (Andersen, 1995).

## STUDY HYPOTHESES

The following are the hypotheses for this research study:

*Hypothesis 1a*. Predisposing factors (age and race/ethnicity) of pregnant women with SCI/paralysis will show an association with the length of hospital stay. White pregnant women with SCI/paralysis will show a shorter length of hospital stay as compared non-White women.

*Hypothesis 1b.* Enabling factors (patient's location, estimated median household income, and health insurance) for pregnant women with SCI/paralysis will have an association with the length of hospital stay.

*Hypothesis 1c*. Pregnant women with SCI/paralysis with an emergent type of hospital admission will show a longer length of hospital stay compared to the elective type.

*Hypothesis 1d*. Pregnant women with SCI/paralysis with other comorbidities will show a longer length of hospital stay compared to those without any other comorbidities.

*Hypothesis 1e*. Characteristics of the hospital (bed size, location, region, and urban/rural character of the hospital) will show an association with the length of hospital stay for pregnant women with SCI/paralysis.

## METHODS

### Data source and sample population

The data were obtained from the NIS developed by and made available through the Healthcare Cost and Utilization Project (HCUP). HCUP produces several healthcare databases through a Federal-State-Industry partnership and are sponsored by the Agency for Healthcare Research and Quality ("HCUP Overview," 2022). The NIS is a hospital sample drawn from the State Inpatient Databases that provides inpatient data to HCUP. The NIS is a stratified sample of all inpatient hospital discharges from the community hospitals of the U.S. depending on the characteristics of the hospital, and within each of the stratum, clusters or hospitals are chosen from the sample. However, in 2012, HCUP redesigned the sampling approach to sample hospital discharges from submitting hospitals at the rate of approximately 20% ("NIS OVERVIEW," 2022). Therefore, for years 2011 and before, NIS was a sample of U.S. hospitals, whereas for years 2012 and later, NIS is a sample of hospital discharges ("NIS OVERVIEW," 2022). The sample for this study comprised of inpatient encounters of pregnant women admitted to the hospital for non-delivery-related reasons from 2006 through 2019.

**Inclusion and Exclusion criteria**

Since our population of interest was non-delivery related inpatient department hospitalization encounters of pregnant women, the International Classification of Diseases (ICD), ICD-9 and ICD-10 codes were used to extract this sample population from 2006 through 2019. Hospital discharge data for the year 2015 comprises a mix of ICD-9 and ICD-10 data because ICD-9 was used for the first three quarters of 2015 and ICD-10 for the last quarter of 2015 ("NIS OVERVIEW," 2022). The ICD-9 and ICD-10 codes used to extract the inpatient encounters of non-delivery-related pregnant women are in Appendices B and C, respectively. And ICD-9 and ICD-10 codes used to extract SCI/paralysis encounters are in Appendices D and E, respectively.

**Measures**

As discussed earlier, the Aday and Andersen model was used as a guide to include the following variables in the study.

*Dependent Variables:* The unit of analysis was the patient encounter. The two outcome variables were the length of hospital stay and the total hospitalization charges. The NIS data includes a variable for length of stay, measured in days. The outcome variable total hospitalization charges for the encounter were reported in U.S. dollars. Also, the total hospitalization charges were adjusted to 2019 dollars using the medical component of the Consumer Price Index ("U.S. Bureau of Labor Statistics," n.d.).

*Independent Variables:* The population predictor variables for this research study included patient age (<= 19 years old, 20-24 years old, 25-29 years old, 30-34 years old, 35-39 years old, >= 40 years old), race/ethnicity (White, Black, Hispanic, Other, Unknown), estimated median household income (Quartile 1, Quartile 2, Quartile 3, and

Quartile 4), location (metropolitan area >= 1 million residents, a metropolitan area < 1 million residents, a micropolitan area, neither metro/micropolitan area), primary payer (Medicare, Medicaid, private, self-pay, other), and type of admission (non-elective, elective). In addition to these independent variables of the population of risk, a modified Elixhauser comorbidity index was calculated to control for patient comorbidities (Elixhauser, Steiner, Harris, & Coffey, 1998), which are known to increase the probability of higher utilization and costs (Owens, Liang, Barrett, & Fingar, 2022). The modified Elixhauser comorbidity index comprised of 30 comorbidities instead of 31 (Sharma, Schwendimann, Endrich, Ausserhofer, & Simon, 2021), as the comorbidity of paralysis was excluded (since the sample population has SCI/paralysis). The modified Elixhauser comorbidity index was then divided into four categories - equal to zero, equal to one, equal to two, and equal to three or more. The independent variables for characteristics of the health delivery system included hospital bed size (small, medium, large), hospital location and teaching status (rural hospital, urban nonteaching hospital, urban teaching hospital, and regional location of hospital (northeast, Midwest, south, west). These variables for hospital characteristics are already provided in the NIS data.

**Statistical Analysis:** All statistical analyses were conducted using STATA SE 17.0 (StataCorp, College Station, TX) statistical software. Due to the change in the sampling design, to plot trends across years, the analyses were conducted by incorporating a weighting variable - "TRENDWT" for encounters from 2006 to 2011 and "DISCWT" for encounters from 2012 to 2019. A Stata program by Stagg (2015) was used to calculate the Elixhauser comorbidity index. The survey-specific data analysis tools with "svyset" command from Stata were used for statistical analyses where YEAR and

NIS_STRATUM were used as the stratum identifier, HOSP_NIS and HOSPID were used as cluster identifiers, and TRENDWT and DISCWT as pweights, following guidance from HCUP on study design. Since the survey design already incorporated the YEAR variable in the strata, the model did not control for the year of inpatient encounters separately.

*Length of hospital stay:* A multicollinearity check was done using all the predictor variables, since collinearity is checked with the independent variables and not the statistical model. The variance inflation factors and tolerance statistics did not reveal any strong collinearity issues. A total of 49 inpatient encounters had a length of hospital stay of zero. The length of stay was calculated as the difference in the admission and discharge dates and was available in the NIS dataset. So, a value of zero could be because the patient was admitted and discharged from the hospital within one day. Next, since zero inflation was affecting the results for outcome variable length of hospital stay, a hurdle model was employed. To enable a hurdle model, a binary logistic regression model with length of stay as a binary variable (0 days and >=1 days), and a negative binomial regression model with length of stay >=1 days (excluded 0 days of hospital stay) was conducted. In order to check for any dependent variable issues with the binary logistic regression model, the model was run with output in log odds format and checked for standard errors being less than two. The count model for length of stay was examined for over- and under-dispersion to make a choice between Poisson and negative binomial regression model. The p-value for the over- and under-dispersion model revealed a p-value < .05, suggesting that Poisson regression would create a dispersion problem. Therefore, a negative binomial regression model was chosen. The output from the binary

logistic regression model were reported in odds ratio format and the output from negative binomial regression model were reported in the count ratio or incidence rate ratio format.

*Total hospitalization charges:* Since total hospitalization charges was a continuous variable, an ordinary least squares linear regression with a natural log transformation of total hospitalization charges was used to assess the effects of healthcare utilization. For the purpose of interpretation of the log values, the values were converted into percentages by (exp(coefficient)-1) *100.

*Trends:* Both the mean and median values for length of hospital stay and total hospitalization charges by year were used to plot the trends in the length of stay and total hospitalization charges among inpatient encounters of pregnant women with SCI/paralysis since the variables had a skewed distribution.

*Prediction models:* Prediction modeling with mean-centered control variables was done to predict the future outcomes with respect to the length of hospital stay for pregnant women with SCI/paralysis. In the prediction equation, the focal variable was the independent variable that was predicted, and other independent variables acted as control variables. All the independent variables in the regression were mean-centered except for the focal variable, which was not.

## RESULTS

**Description of inpatient encounters:** A total of 3,166 and 3,117 inpatient hospital discharges for pregnant women with SCI/paralysis were identified for the binary dependent variable and count variable models, respectively (see Table 1). A sample of 3,166 inpatient encounters were queried for the OLS model with the outcome variable of total hospitalization charges (see Table 2). The average length of hospital stay and total

hospitalization charges for pregnant women with SCI/paralysis admitted for non-delivery-related reasons were 7.85 days (median: 4 days, SD: +/-14.85, IQR: 2 - 7 days) and $85,676.47 (median: $29,181.31, SD: +/-188,288.8, IQR: $15,757.56 - $70,767.22, in 2019 dollars) respectively. The inpatient encounters of pregnant women with SCI/paralysis for non-delivery related reasons were most likely in the 25 to 29 years age group, White, in the first quartile of estimated median household income by zip code, and from a metropolitan area with one million residents or more. Pregnant women with SCI/paralysis were more likely to have Medicaid coverage and be admitted non-electively to the hospital. A majority of the sample population had a modified Elixhauser comorbidity index of one or more, suggesting the presence of other comorbidities in addition to SCI/paralysis. Pregnant women with SCI/paralysis were mainly admitted into a hospital located in the southern U.S., an urban teaching hospital, and a hospital with a large bed size.

**Length of hospital stay:** Table 3 shows the output for the hurdle model. The sample population for the binary logistic regression model comprised of 3,166 inpatient encounters, and for the negative binomial regression model comprised of 3,117 inpatient encounters (all non-zero lengths of stay).

*a. Characteristics of population at risk:* The average length of hospital stays for pregnant women with SCI/ paralysis aged 19 years or younger was 50.3% higher, and aged 40 years or above was 30.7% higher than the average length of stay for pregnant women with SCI/paralysis aged 25 to 29 years. The odds of one or more days of hospital stay in pregnant women with SCI/paralysis with an estimated median household income in the second quartile was 3.617 times the odds for those with an estimated median household

income in the first quartile, i.e., the odds increased by 261.7%. Having a modified Elixhauser comorbidity index of one increased the average length of hospital stay by 36.3% for pregnant women with SCI/paralysis when compared with a modified Elixhauser comorbidity index of zero. Drawing on these results, the prediction model for the average length of hospital stays among pregnant women with SCI/paralysis by modified Elixhauser comorbidity index predicted that those with an Elixhauser Index of one, two, and three or more would have approximately six, ten, and 12 days of hospital stay (respectively) compared to four days of stay by those with an Elixhauser Index of zero (see Figure 1). The odds of one or more days of hospital stay in pregnant women with SCI/paralysis with self-pay as a primary payer was 0.182 times the odds for those on private insurance, i.e., the odds decreased by 81.8%. The predicted average length of hospital stays among inpatient encounters of non-delivery-related pregnant women with SCI or paralysis by primary payer showed that the predicted average length of stay for pregnant women with other payer would have on average six days of stay as compared to four or five days of stay by other primary payers (see Figure 2).

*b. Characteristics of health delivery system:* The average length of stay for pregnant women with SCI/paralysis admitted in a hospital with medium and large bed sizes was 19.0% and 47.6% higher (respectively) than the average length of stay for pregnant women with SCI/paralysis admitted in a hospital with small bed size. The odds of having one or more days of hospital stay in hospitals with large bed size was 2.908 times the odds for small bed size hospitals. In other words, the odds increased by 190.8%. With respect to the location and teaching status of the hospital, the admission of pregnant women with SCI/paralysis resulted in an urban non-teaching hospital and an urban

teaching hospital resulted in an average length of hospital stay of 37.6% and 88.9% higher than the rural hospital. These results were consistent with the prediction modeling of these variables too (see Figures 3 and 4). Finally, the southern and western regions of the United States had, on an average 30.2% and 20.3% higher admission of pregnant women with SCI/paralysis compared to the hospitals in the northeast region of the U.S.

**Total hospitalization charges:** Table 4 shows the results for the ordinary least squares regression model predicting the natural log of total hospitalization charges among inpatient encounters of non-delivery-related pregnant women with SCI/paralysis.

*a. Characteristics of population at risk:* Compared to pregnant women with SCI/paralysis in the age group of 25 to 29 years, for those who were 19 years or younger and 40 years or older, the average total hospitalization charges increased by 38.4% and 28.78%, respectively. Compared to White pregnant women with SCI/paralysis, for Black and Hispanic pregnant women with SCI/paralysis, the average total hospitalization charge increased by 23.89% and 21. 81%, respectively. The average total hospitalization charges for pregnant women with SCI/paralysis on Medicare and Medicaid decreased by 32. 39% and 13.35%, respectively, when compared to pregnant women on private insurance. Furthermore, the average total hospitalization charge for pregnant women with a modified Elixhauser comorbidity index of one, two, and three or more increased by 35.88%, 106.63%, and & 232.75%, respectively, when compared to a modified Elixhauser comorbidity index of zero.

*b. Characteristics of health delivery system:* The average total hospitalization charge for pregnant women with SCI/paralysis admitted in an urban non-teaching and urban teaching hospital increased by 59.29% and 102.31% when compared to the total

hospitalization charge for those admitted in a rural hospital. Compared to admission in a small bed size hospital, the average total hospitalization charge for those admitted in medium and large bed size hospitals increased by 23% and 48.39%, respectively. Finally, the average total hospitalization charge for pregnant women with SCI/paralysis admitted in a hospital in the western region of the U.S. increased by 28.63% when compared to hospital admission in the northeast region of the U.S.

**Trends:** The trends for hospital length of stay and total hospitalization charges can be seen in Figures 5 and 6. The trends in the mean length of hospital stay for pregnant women with SCI/paralysis from 2006 through 2019 fluctuated between six and ten days, with no specific upward or downward trend. On the other hand, the median length of hospital stay for the sample population for the same period was approximately constant between three to four days. With the total hospitalization charges (both mean and median), there was a clear upward trend from 2006 through 2019; however, the trend showed a much steeper increase from 2009 onwards.

## DISCUSSION

In this research study, we used a national inpatient hospitalization database to assess non-delivery related healthcare utilization for pregnant women with SCI/paralysis in the United States, in terms of length of hospital stay and total hospitalization charges. The findings showed that the average length of hospital stay and total hospitalization charges for pregnant women with SCI/paralysis admitted for non-delivery-related reasons were 7.85 days (median: 4 days, SD: +/-14.85, IQR: 2 - 7 days) and $85,676.47 (median: $29,181.31, SD: +/-188,288.8, IQR: $15,757.56 - $70,767.22, in 2019 dollars) respectively. Overall, it was seen that the sample population was mainly White, aged 25

to 29 years, on Medicaid, and in the lowest quartile for estimated median household income. The sample population were more likely to have other comorbidities in addition to SCI/paralysis and were more likely to have a non-elective admission into the hospital.

The characteristics of health delivery system that had more inpatient encounters of pregnant women with SCI/paralysis were predominantly large bed size hospitals, urban teaching hospitals, and hospitals located in the southern U.S. A qualitative research study to understand the healthcare practitioner's perspectives regarding the provision of maternal care to pregnant women with disabilities found that practitioners lacked education and training in providing specific maternal care to such a population and there existed an insufficiency of coordination between the team of practitioners (Mitra et al., 2017). The same study also reported various clinical practice barriers encountered by healthcare providers, such as lack of access to healthcare systems and required equipment for women with disabilities (Mitra et al., 2017). This could explain why a majority of inpatient encounters of pregnant women with SCI/paralysis were in large bed size and urban teaching hospitals and not small bed size or rural hospitals. When the hospital capacity cannot meet the demand for healthcare services, it causes emergency room crowding and increased inpatient admissions, which in turn are associated with poor or adverse health outcomes in admitted patients, including higher mortality (Siddique et al., 2021; Sun et al., 2013).

Hospitalization charges are an indicator of the potential financial implications of pregnancy with disabilities like SCI/paralysis. The results from this study revealed that pregnant women with SCI/paralysis admitted to the hospital for non-delivery-related purposes encountered an average total hospitalization charge of $85,676.47 (in 2019 U.S.

dollars). It has been cited that women with disabilities have numerous challenges related to the affordability of healthcare services due to various factors, including their poor socio-economic status, unemployment, monetary dependence, increased transportation and commuting costs, single status, and no insurance coverage (Matin et al., 2021).

A systematic review of qualitative studies to assess the barriers to healthcare access among women with disabilities reported that research studies have emphasized a lack of knowledge regarding maternal care for women with disabilities (Matin et al., 2021). It has been reported that SCI caregivers prefer medical professionals to provide them with the required health information regarding their patients and also access to other support services (Coffey et al., 2017). The results from this study revealed the subpopulations that show a longer length of hospital stay and total hospitalization charges. These findings can be used by healthcare providers in providing healthcare utilization information to pregnant women with SCI/paralysis.

*Limitations:* It is important to note certain limitations in this research study. Firstly, the identification of the sample population was based completely on ICD codes. The version of ICD codes changed from the fourth quarter of 2015, and so the study employed both ICD-9 and ICD-10 codes to identify inpatient encounters of pregnant women with SCI/paralysis. Therefore, in addition to the possibility of a coding error, the change in the ICD code version can also lead to missing a few inpatient encounters in the sample population leading to misclassification bias. Secondly, since the observation represents an inpatient encounter and not a unique patient identification, there is a possibility that one patient could be recorded for many encounters. Next, another limitation of the study is that the severity of SCI or paralysis is missing. Finally, NIS is representative of the

inpatient hospitalizations only, so information on any follow-up visits post-discharge is lacking.

## CONCLUSIONS

By employing a nationally representative inpatient hospitalization database, the research study reported the characteristics of the population at risk for non-delivery-related inpatient hospitalizations of pregnant women with SCI/paralysis. This research study highlights the necessity for improved surveillance of pregnant women with disabilities because this research study did not fill in all the gaps within the literature. The results can inform healthcare organizations regarding the longer length of hospital stay and higher total hospitalization charges of pregnant women with disabilities like SCI/paralysis so that the healthcare systems can alleviate hurdles such as fewer admissions in rural and small bed size hospitals encountered by this population. Most importantly, it will provide healthcare providers with the epidemiology of pregnant women with SCI/paralysis who are admitted for non-delivery-related reasons to the hospital, thus allowing data-informed responses to serving them. Future research should focus on examining these healthcare utilization outcomes if prenatal care visits of pregnant women with SCI/paralysis are increased.

Table 1: Descriptive Statistics[1]

| | ***Binary Logistic Model*** | | ***Negative Binomial Model*** | |
|---|---|---|---|---|
| ***Variables*** | *Central Tendency Measure* | *Variability Measure* | *Central Tendency Measure* | *Variability Measure* |
| **Dependent Variables** | | | | |
| Length of hospital stay [a] | | | | |
| 0 days [2] | | 1.52% | | |
| >=1 day(s) | | 98.48% | | |
| Length of hospital stay [b] | | | 7.85 (mean); 4 (median) | 14.85 (std. dev.); 2 - 7 (IQR) |
| | | | | |
| **Independent Variables** | | | | |
| Age-group | | | | |
| 19 years or less | | 5.93% | | 5.88% |
| 20 to 24 years | | 20.68% | | 20.74% |
| 25 to 29 years [2] | | 26.16% | | 26.12% |
| 30 to 34 years | | 25.88% | | 25.83% |
| 35 to 39 years | | 16.73% | | 16.76% |
| 40 years or more | | 4.62% | | 4.66% |
| Race/Ethnicity | | | | |
| White [2] | | 45.30% | | 45.40% |
| Black | | 19.98% | | 20.00% |
| Hispanic | | 16.64% | | 16.42% |
| Other | | 7.05% | | 7.08% |
| Unknown | | 11.03% | | 11.10% |
| Median Household Income | | | | |
| Quartile 1 [2] | | 34.28% | | 33.95% |
| Quartile 2 | | 25.94% | | 26.16% |
| Quartile 3 | | 22.24% | | 22.28% |
| Quartile 4 | | 17.54% | | 17.62% |
| Residential location | | | | |
| Metropolitan >= 1 million [2] | | 55.00% | | 55.09% |
| Metropolitan < 1 million | | 29.04% | | 29.00% |
| Micropolitan | | 9.53% | | 9.58% |
| Not metro/micropolitan | | 6.43% | | 6.34% |
| Primary Payer | | | | |
| Medicare | | 12.02% | | 11.96% |
| Medicaid | | 45.63% | | 45.67% |
| Private [2] | | 36.33% | | 36.52% |
| Self-pay | | 2.81% | | 2.64% |

| | | | | |
|---|---|---|---|---|
| Other | | 3.20% | | 3.21% |
| Type of Admission | | | | |
| Non-elective [2] | | 67.38% | | 67.35% |
| Elective | | 32.62% | | 32.65% |
| Modified Elixhauser Index | | | | |
| Equals zero [2] | | 43.30% | | 43.43% |
| Equals one | | 27.08% | | 26.92% |
| Equals two | | 16.80% | | 16.82% |
| Equals three or more | | 12.82% | | 12.83% |
| Hospital Bed size | | | | |
| Small [2] | | 8.77% | | 8.62% |
| Medium | | 20.74% | | 20.71% |
| Large | | 70.49% | | 70.67% |
| Hospital Location/Teaching | | | | |
| Rural [2] | | 6.40% | | 6.34% |
| Urban nonteaching | | 21.09% | | 20.99% |
| Urban teaching | | 72.51% | | 72.67% |
| Hospital Region | | | | |
| Northeast [2] | | 12.74% | | 12.68% |
| Midwest | | 22.27% | | 22.29% |
| South | | 41.77% | | 41.82% |
| West | | 23.23% | | 23.21% |

[1] Due to sampling design a weighting variable (TRENDWT for 2006 to 2011 and DISCWT for 2012 to 2019) was used for the calculation of all statistics
[2] Reference group for the regression analysis
[a] For binary dependent variable, length of hospital stay, n=3166
[b] For count variable, length of stay, n=3117
IQR, Inter-quartile range

Table 2: Descriptive statistics ($n$ = 3166) [1]

| ***Variables*** | ***Central Tendency Measure*** | ***Variability Measure*** |
|---|---|---|
| **Dependent Variable** | | |
| Total hospitalization charges (in 2019 dollars) [2] | 85676.47 (mean); 29181.31 (median) | 188288.8 (Std. Dev.); 15757.56 - 70767.22 (IQR) |
| | | |
| **Independent Variables** | | |
| Age-group | | |
| 19 years or less | | 5.94% |
| 20 to 24 years | | 20.68% |
| 25 to 29 years [3] | | 26.16% |
| 30 to 34 years | | 25.88% |
| 35 to 39 years | | 16.73% |
| 40 years or more | | 4.62% |
| Race/Ethnicity | | |
| White [3] | | 45.30% |
| Black | | 19.98% |
| Hispanic | | 16.64% |
| Other | | 7.05% |
| Unknown | | 11.03% |
| Median Household Income | | |
| Quartile 1 [3] | | 32.28% |
| Quartile 2 | | 25.94% |
| Quartile 3 | | 22.24% |
| Quartile 4 | | 17.54% |
| Residential location | | |
| Metropolitan >= 1 million [3] | | 55.00% |
| Metropolitan < 1 million | | 29.04% |
| Micropolitan | | 9.53% |
| Not metropolitan or micropolitan | | 6.43% |
| Primary Payer | | |
| Medicare | | 12.02% |
| Medicaid | | 45.63% |
| Private [3] | | 36.33% |
| Self-pay | | 2.81% |
| Other | | 3.20% |
| Type of Admission | | |
| Non-elective [3] | | 67.38% |
| Elective | | 32.62% |

| | | |
|---|---|---|
| Modified Elixhauser Index | | |
| Equals zero [3] | | 43.30% |
| Equals one | | 27.08% |
| Equals two | | 16.80% |
| Equals three or more | | 12.82% |
| Hospital Bed size | | |
| Small [3] | | 8.77% |
| Medium | | 20.74% |
| Large | | 70.49% |
| Hospital Location/Teaching | | |
| Rural [3] | | 6.40% |
| Urban nonteaching | | 21.09% |
| Urban teaching | | 72.51% |
| Hospital Region | | |
| Northeast [3] | | 12.74% |
| Midwest | | 22.27% |
| South | | 41.77% |
| West | | 23.23% |

[1] n=3166 inpatient encounters; due to sampling design a weighting variable (TRENDWT for 2006 to 2011 and DISCWT for 2012 to 2019) was used for the calculation of all statistics
[2] Ln-transformed in the regression to correct for skewness; ln-transformation rendered the distribution approximately normal
[3] Reference group for the regression analysis
IQR, Inter-quartile range

Table 3: Hurdle regression results (binary logistic regression model predicting the odds of having 1 or more days of non-delivery related hospital stay for pregnant women with SCI or paralysis and negative binomial regression predicting length of non-delivery related hospital stay for pregnant women with SCI or paralysis with at least one day) [1]

| | ***Binary Logistic Regression*** [2] | | ***Negative Binomial Regression*** [3] | |
|---|---|---|---|---|
| ***Variables*** | *Odds Ratio* | *95% Confidence Interval* | *Count Ratio* | *95% Confidence Interval* |
| Constant | 13.135** | 2.354, 73.293 | 1.758* | 1.224, 2.524 |
| Age-group | | | | |
| 25 to 29 years (reference) | | | | |
| 19 years or less | 0.695 | 0.233, 2.075 | 1.503** | 1.173, 1.925 |
| 20 to 24 years | 1.404 | 0.574, 3.434 | 1.097 | 0.915, 1.315 |
| 30 to 34 years | 0.867 | 0.393, 1.914 | 1.034 | 0.899, 1.191 |
| 35 to 39 years | 1.198 | 0.498, 2.879 | 1.120 | 0.951, 1.318 |
| 40 years or more | 2.506 | 0.314, 20.027 | 1.307* | 1.020, 1.674 |
| Race/Ethnicity | | | | |
| White (reference) | | | | |
| Black | 0.901 | 0.370, 2.192 | 1.022 | 0.881, 1.187 |
| Hispanic | 0.431* | 0.201, 0.925 | 1.091 | 0.914, 1.303 |
| Other | 1.020 | 0.294, 3.532 | 1.058 | 0.898, 1.246 |
| Unknown | 1.464 | 0.392, 5.466 | 1.111 | 0.908, 1.358 |
| Median Household Income | | | | |
| Quartile 1 (reference) | | | | |
| Quartile 2 | 3.617** | 1.458, 8.975 | 0.942 | 0.810, 1.094 |
| Quartile 3 | 1.719 | 0.743, 3.975 | 0.916 | 0.789, 1.064 |
| Quartile 4 | 1.972 | 0.760, 5.114 | 0.887 | 0.759, 1.036 |
| Residential location | | | | |
| Metropolitan >= 1 mil (reference) | | | | |
| Metropolitan < 1 mil | 0.738 | 0.374, 1.459 | 1.063 | 0.926, 1.220 |
| Micropolitan | 1.390 | 0.365, 5.289 | 0.975 | 0.782, 1.215 |
| Not metro/micropolitan | 0.589 | 0.173, 1.999 | 1.002 | 0.824, 1.218 |
| Primary Payer | | | | |
| Private (reference) | | | | |
| Medicare | 0.554 | 0.206, 1.489 | 0.850 | 0.701, 1.030 |
| Medicaid | 0.925 | 0.411, 2.084 | 0.937 | 0.822, 1.060 |
| Self-pay | 0.182** | 0.067, 0.495 | 0.966 | 0.733, 1.273 |
| Other | 1.182 | 0.141, 9.916 | 1.105 | 0.759, 1.608 |
| Type of Admission | | | | |
| Non-elective (reference) | | | | |
| Elective | 0.986 | 0.534, 1.822 | 0.946 | 0.844, 1.061 |
| Modified Elixhauser Index | | | | |
| Equals zero (reference) | | | | |
| Equals one | 0.542 | 0.274, 1.071 | 1.363*** | 1.189, 1.562 |
| Equals two | 0.708 | 0.272, 1.845 | 2.203 | 1.853, 2.619 |

| | | | | |
|---|---|---|---|---|
| Equals three or more | 0.640 | 0.218, 1.876 | 2.693 | 2.264, 3.203 |
| Hospital Bed size | | | | |
| Small (reference) | | | | |
| Medium | 2.029 | 0.771, 5.339 | 1.190* | 0.988, 1.434 |
| Large | 2.908* | 1.283, 6.587 | 1.476*** | 1.240, 1.758 |
| Hospital Location/Teaching | | | | |
| Rural (reference) | | | | |
| Urban nonteaching | 1.303 | 0.388, 4.374 | 1.376* | 1.075, 1.762 |
| Urban teaching | 2.502 | 0.725, 8.627 | 1.889*** | 1.502, 2.375 |
| Hospital Region | | | | |
| Northeast (reference) | | | | |
| Midwest | 1.288 | 0.443, 3.748 | 1.094 | 0.905, 1.323 |
| South | 1.836 | 0.788, 4.275 | 1.302*** | 1.126, 1.504 |
| West | 1.470 | 0.598, 3.613 | 1.203* | 1.025, 1.412 |

[1] Hurdle model used to control for the effects of zero-inflation; due to sampling design a weighting variable (TRENDWT for 2006 to 2011 and DISCWT for 2012 to 2019) was used for the calculation of all statistics
[2] Based on *n* = 3166 inpatient encounters; model analyzes the odds of pregnant women having 1or more days of non-delivery related hospital stay instead of 0 days
[3] Based on *n* = 3117 inpatient encounters; model analyzes the length of hospital stay for pregnant women who have at least one day of non-delivery related inpatient hospitalization

Table 4: Ordinary least squares regression model predicting natural log of total hospitalization charges among inpatient encounters of non-delivery related pregnant women with SCI or paralysis[1]

| ***Variables*** | ***Coefficient*** | ***95% Confidence Interval*** | ***p-value*** |
|---|---|---|---|
| Constant | 9.220 | 8.958, 9.483 | <.001 |
| Age-group | | | |
| 25 to 29 years (reference) | | | |
| 19 years or less | 0.325 | 0.154, 0.496 | <.001 |
| 20 to 24 years | -0.017 | -0.122, 0.089 | .756 |
| 30 to 34 years | -0.005 | -0.108, 0.097 | .919 |
| 35 to 39 years | 0.110 | -0.001, 0.222 | .052 |
| 40 years or more | 0.253 | 0.060, 0.445 | .010 |
| Race/Ethnicity | | | |
| White (reference) | | | |
| Black | 0.088 | -0.023, 0.198 | .119 |
| Hispanic | 0.214 | 0.096, 0.331 | <.001 |
| Other | 0.192 | 0.045, 0.339 | .011 |
| Unknown | -0.034 | -0.154, -0.086 | .579 |
| Median Household Income | | | |
| Quartile 1 (reference) | | | |
| Quartile 2 | 0.082 | -0.017, 0.181 | .103 |
| Quartile 3 | 0.041 | -0.067, 0.148 | .461 |
| Quartile 4 | 0.070 | -0.053, 0.192 | .264 |
| Residential location | | | |
| Metropolitan >= 1 million [2] | | | |
| Metropolitan < 1 million | -0.058 | -0.151, 0.035 | .222 |
| Micropolitan | 0.087 | -0.067, 0.241 | .267 |
| Not metropolitan or micropolitan | 0.014 | -0.148, 0.177 | .864 |
| Residential location | | | |
| Private (reference) | | | |
| Medicare | -0.391 | -0.508, -0.275 | <.001 |
| Medicaid | -0.143 | -0.234, -0.053 | .002 |
| Self-pay | -0.026 | -0.240, 0.188 | .811 |
| Other | -0.138 | -0.392, 0.115 | .285 |
| Type of Admission | | | |
| Non-elective (reference) | | | |
| Elective | -0.292 | -0.372, -0.213 | <.001 |
| Modified Elixhauser Index | | | |
| Equals zero (reference) | | | |
| Equals one | 0.307 | 0.222, 0.391 | <.001 |
| Equals two | 0.726 | 0.612, 0.840 | <.001 |
| Equals three or more | 1.202 | 1.066, 1.339 | <.001 |

| | | | |
|---|---|---|---|
| Hospital Bed size | | | |
| Small (reference) | | | |
| Medium | 0.207 | 0.072, 0.342 | .003 |
| Large | 0.395 | 0.274, 0.516 | <.001 |
| Hospital Location/Teaching | | | |
| Rural (reference) | | | |
| Urban nonteaching | 0.466 | 0.289, 0.642 | <.001 |
| Urban teaching | 0.705 | 0.544, 0.865 | <.001 |
| Hospital Region | | | |
| Northeast (reference) | | | |
| Midwest | -0.025 | -0.165, 0.115 | .724 |
| South | 0.006 | -0.122, 0.135 | .923 |
| West | 0.252 | 0.111, 0.393 | <.001 |

[1] Based on *n* = 3166 inpatient encounters; due to sampling design a weighting variable (TRENDWT for 2006 to 2011 and DISCWT for 2012 to 2019) was used for the calculation of all statistics; dependent variable ln-transformed to correct for skewness

Table 5: Interpretation percentage values of independent variables used for ordinary least squares regression model predicting natural log of total hospitalization charges among inpatient encounters of non-delivery related pregnant women with SCI or paralysis[1]

| ***Variables*** | ***Interpretation values*** | ***p-value*** |
|---|---|---|
| Constant | 1010093.23 | <.001 |
| Age-group | | |
| 25 to 29 years (reference) | | |
| 19 years or less | 38.399 | <.001 |
| 20 to 24 years | -1.663 | .756 |
| 30 to 34 years | -0.531 | .919 |
| 35 to 39 years | 11.681 | .052 |
| 40 years or more | 28.778 | .010 |
| Race/Ethnicity | | |
| White (reference) | | |
| Black | 9.177 | .119 |
| Hispanic | 23.890 | <.001 |
| Other | 21.177 | .011 |
| Unknown | -3.340 | .579 |
| Median Household Income | | |
| Quartile 1 (reference) | | |
| Quartile 2 | 8.570 | .103 |
| Quartile 3 | 4.137 | .461 |
| Quartile 4 | 7.213 | .264 |
| Residential location | | |
| Metropolitan >= 1 million [2] | | |
| Metropolitan < 1 million | -5.630 | .222 |
| Micropolitan | 9.083 | .267 |
| Not metropolitan or micropolitan | 1.434 | .864 |
| Primary Payer | | |
| Private (reference) | | |
| Medicare | -32.389 | <.001 |
| Medicaid | -13.352 | .002 |
| Self-pay | -2.578 | .811 |
| Other | -12.907 | .285 |
| Type of Admission | | |
| Non-elective (reference) | | |
| Elective | -25.335 | <.001 |
| Modified Elixhauser Index | | |
| Equals zero (reference) | | |
| Equals one | 35.878 | <.001 |
| Equals two | 106.632 | <.001 |
| Equals three or more | 232.747 | <.001 |
| Hospital Bed size | | |

| | | |
|---|---|---|
| Small (reference) | | |
| Medium | 23.002 | .003 |
| Large | 48.387 | <.001 |
| Hospital Location/Teaching | | |
| Rural (reference) | | |
| Urban nonteaching | 59.287 | <.001 |
| Urban teaching | 102.306 | <.001 |
| Hospital Region | | |
| Northeast (reference) | | |
| Midwest | -2.492 | .724 |
| South | 0.635 | .923 |
| West | 28.634 | <.001 |

[1] Based on *n* = 3166 inpatient encounters; due to sampling design a weighting variable (TRENDWT for 2006 to 2011 and DISCWT for 2012 to 2019) was used for the calculation of all statistics; dependent variable ln-transformed to correct for skewness
Interpretation values (in percentages) calculated by (exp(coefficient)-1) *100

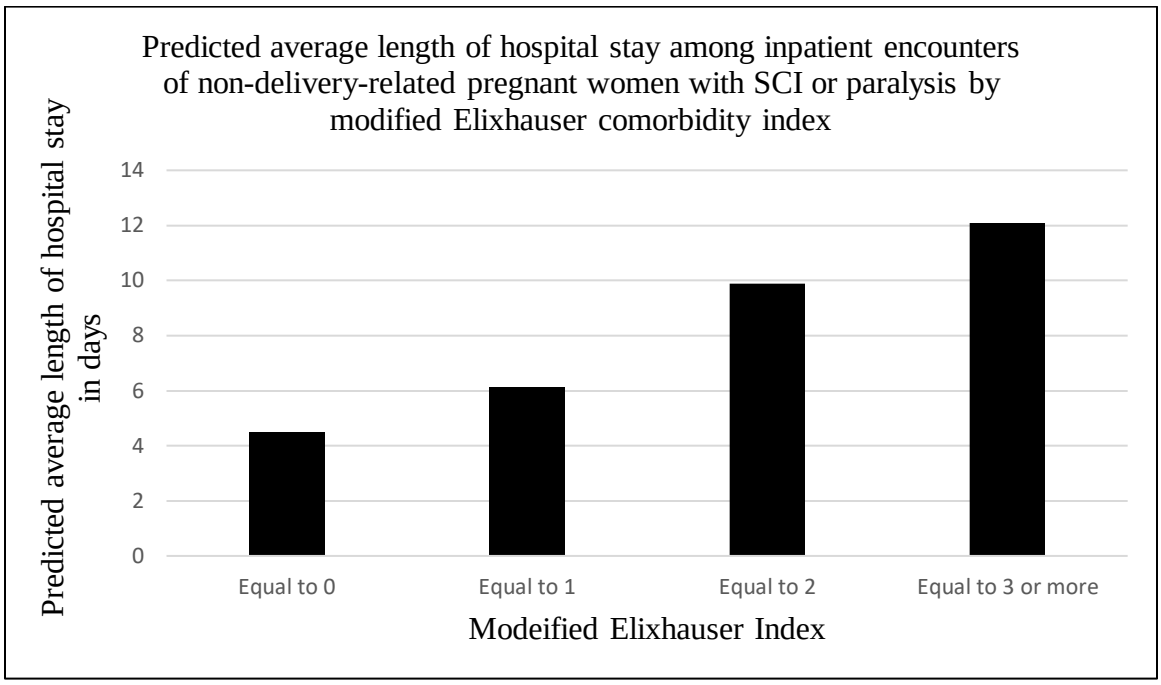



Figure 1: Predicted average length of hospital stay among inpatient encounters of non-delivery-related pregnant women with SCI/paralysis by modified Elixhauser comorbidity index

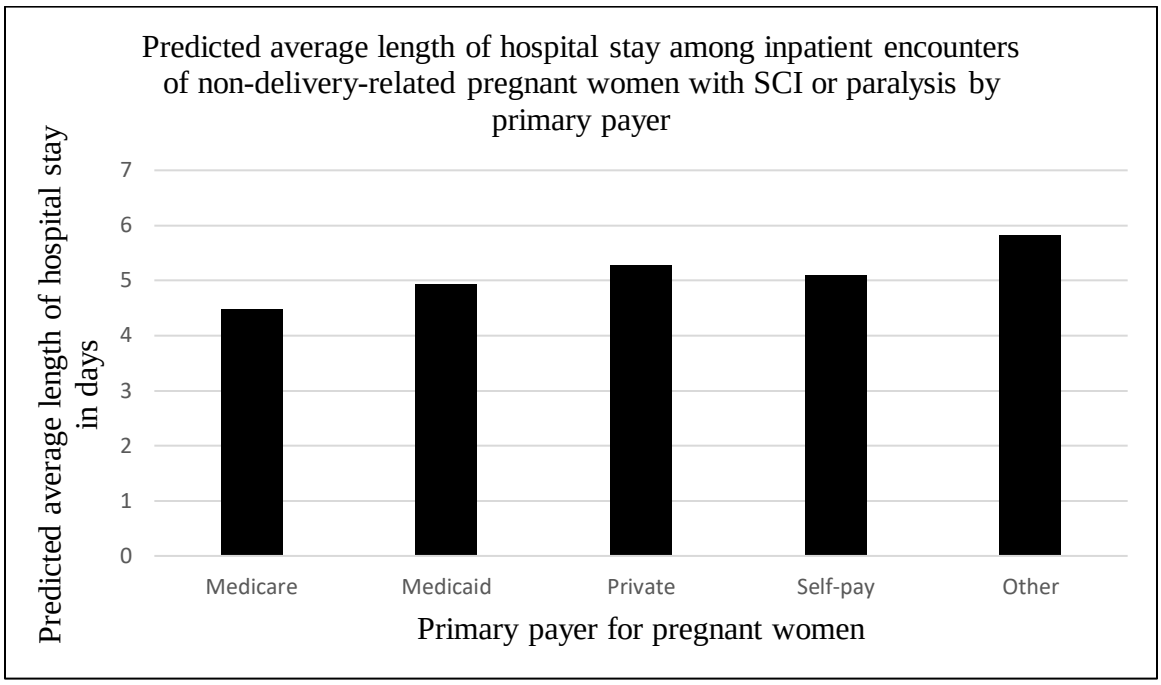



Figure 2: Predicted average length of hospital stay among inpatient encounters of non-delivery-related pregnant women with SCI/paralysis by primary payer

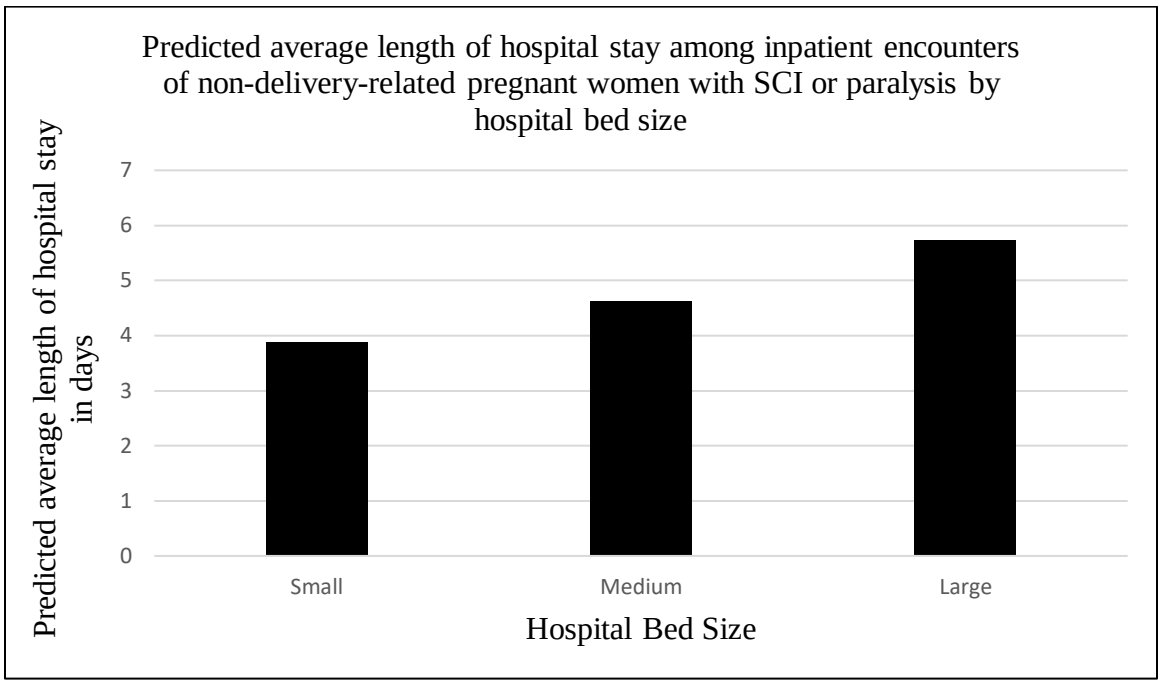



Figure 3: Predicted average length of hospital stay among inpatient encounters of non-delivery-related pregnant women with SCI/paralysis by hospital bed size

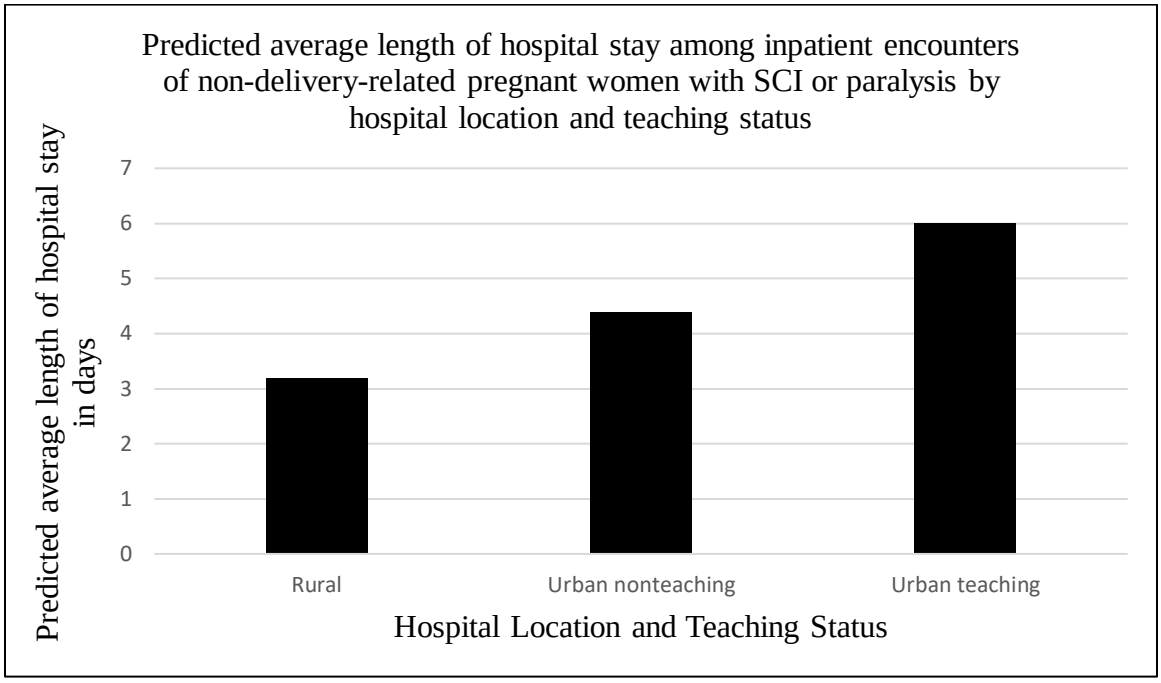



Figure 4: Predicted average length of hospital stay for inpatient encounters of non-delivery-related pregnant women with SCI/paralysis by hospital location/teaching status

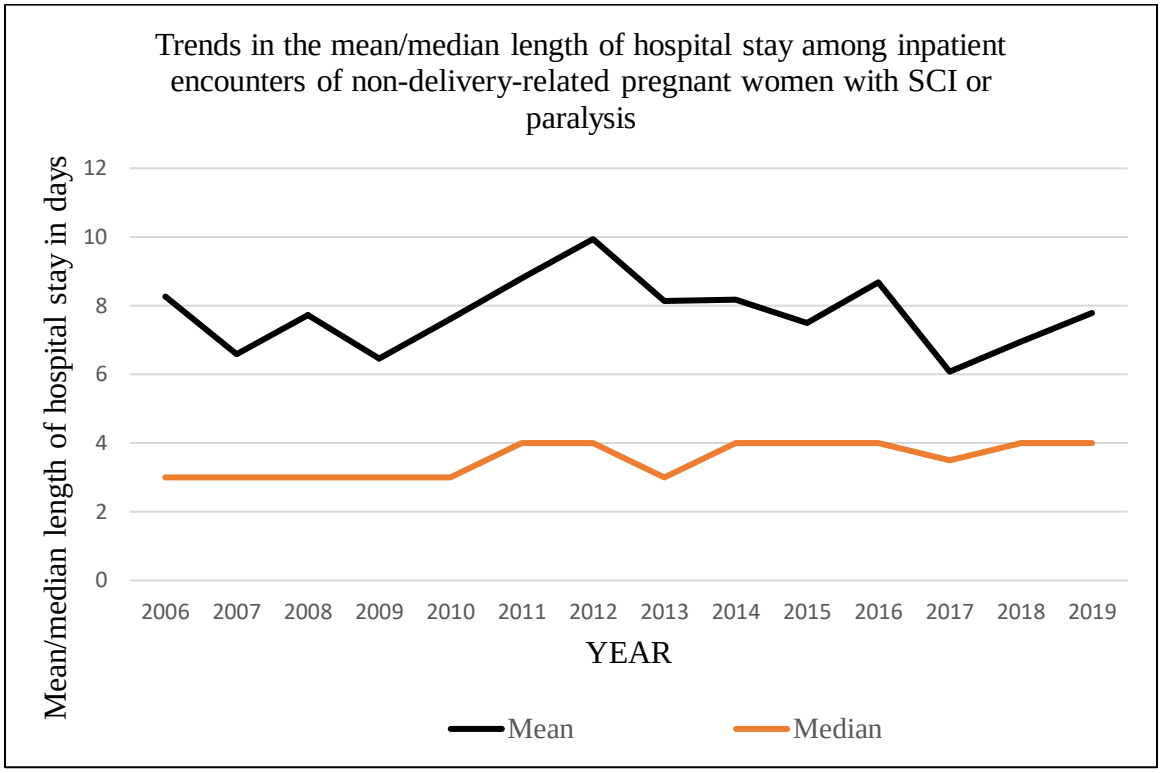



Figure 5: Trends in the mean/median length of hospital stay among inpatient encounters of non-delivery-related pregnant women with SCI/paralysis

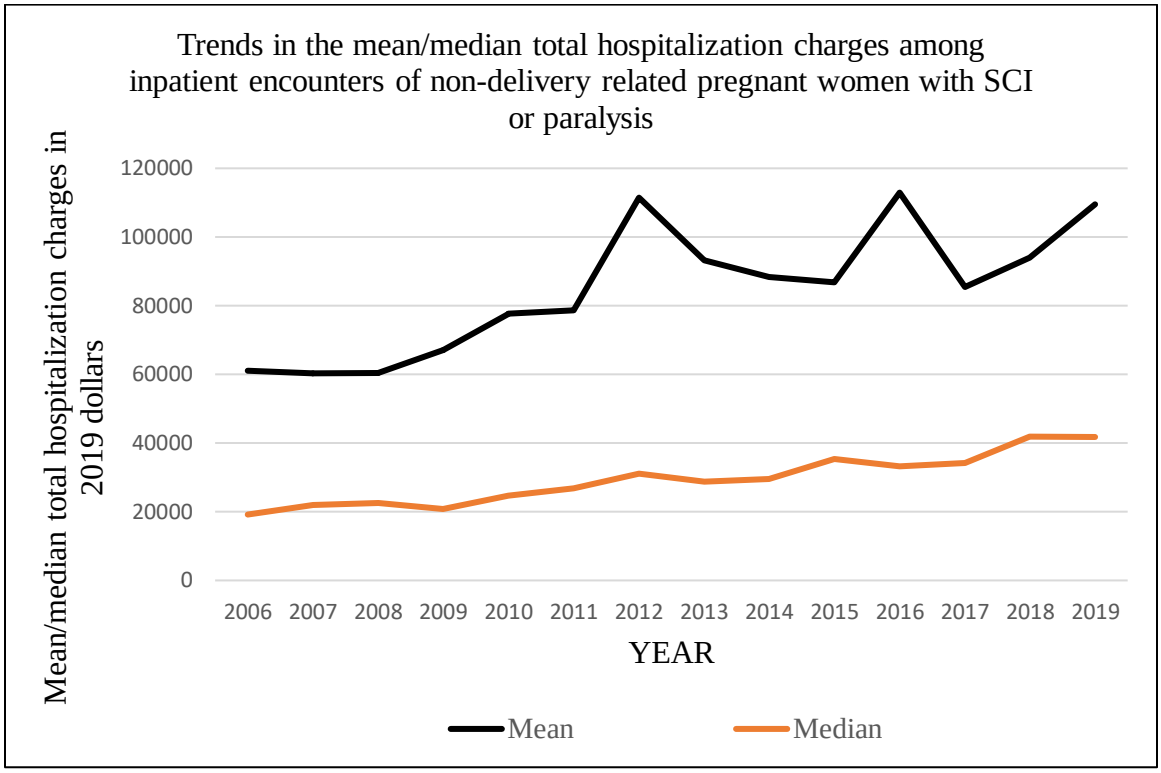



Figure 6: Trends in the mean/median total hospitalization charges among inpatient encounters of non-delivery related pregnant women with SCI/paralysis

# CHAPTER 2: DELIVERY-RELATED HEALTHCARE UTILIZATION OF PREGNANT WOMEN WITH SPINAL CORD INJURY OR PARALYSIS IN THE UNITED STATES

## OVERVIEW

We used the NIS data from the years 2006 through 2019 to examine delivery-related healthcare services utilization among pregnant women with SCI or paralysis in the United States. The length of stay was examined using the negative binomial regression model and total hospitalization charges were assessed by using the ordinary least squares regression with natural log transformation. The sample population for this research study was 2,241 inpatient encounters. The average length of hospital stay in this population was 8.11 days (median: 4 days, SD: +/-15.27, IQR: 2 - 8 days) and the average total hospitalization charges were $79,027.84 (median: $30,043.4, SD: +/-186,048.9, IQR: $16,164.16 - $78,386.09, in 2019 dollars). The findings from this research study equips healthcare providers with healthcare services utilization estimates for delivery and labor-related inpatient hospitalization of pregnant women with disabilities.

Keywords: spinal cord injury; paralysis; delivery; length of stay; charges

## INTRODUCTION

SCI has been identified as one of the different conditions that, when present in a pregnant woman, the pregnancy is rendered as a high-risk pregnancy (Robertson et al., 2020). SCI and paralysis in pregnancies are comparatively rarely seen when compared to other conditions (Robertson et al., 2020); however, physicians must be aware of the associated obstetric complications that compound the already physiological changes occurring during pregnancy in pregnant women with SCI (Crosby, St-Jean, Reid, & Elliott, 1992). Pregnant women with SCI/paralysis have higher chances of associated labor or obstetric complications such as anemia, autonomic dysreflexia, decreased blood pressure, urinary tract infections, preterm labor, and Cesarean section (Hambly & Martin, 1998). In order to prevent the complication of autonomic dysreflexia, it has been recommended that pregnant women with SCI in the higher lesions receive epidural anesthesia very early in the first stage of labor (Hughes, Short, Usherwood, & Tebbutt, 1991). As research shows that there are several complications associated with delivery and labor for pregnant women with SCI, it is even more important to understand the health services utilization of this population in order for the healthcare system to be responsive to medical needs and acknowledge the financial implications associated with the necessary healthcare rendered to this population.

Health services utilization during inpatient hospitalization for non-delivery-related reasons by pregnant women with SCI or paralysis is different than delivery-related hospitalization for the pregnant women with SCI or paralysis. The healthcare utilization for non-delivery-related inpatient hospitalization of pregnant women with SCI/paralysis has been quantified (Chapter #1). The objective of this research study was

to examine delivery-related healthcare services utilization among pregnant women with SCI or paralysis in the United States.

## CONCEPTUAL FRAMEWORK

The conceptual framework used for this research study was adapted from the framework for the study of healthcare access and utilization developed by Aday and Andersen in 1974 (Aday & Andersen, 1974). This framework was used to categorize the variables into the characteristics of the health delivery system and the characteristics of the population at risk in order to understand its influence on the healthcare utilization for pregnant women with SCI/paralysis (Appendix A).

## METHODS

**Study design and data source:** The research study was conducted retrospectively by using the data from NIS, the largest inpatient department hospitalization database in the U.S. The NIS data is created by using the State Inpatient databases and it represents an approximately 20% stratified sample of all inpatient discharges in the country ("NIS OVERVIEW," 2022). A cross-sectional analysis of the data with a study period from 2006 through 2019 was performed. Each observation in the NIS data corresponds to a unique inpatient encounter.

**Study population:** The ICD-9 and ICD-10 codes used to extract the delivery-related inpatient encounters of pregnant women from 2006 through 2019 are in Appendices D and E. The ICD codes used to extract SCI/paralysis inpatient encounters from NIS are outlined in Appendices F and G.

**Outcome variables:** The two primary outcomes for this research study were the length of hospital stay and total hospitalization charges. The length of hospital stay (in days)

was already available in the dataset and was calculated by taking the difference of the admission date and discharge date. The total hospitalization charges variable was continuous in nature and available in dollars. It was adjusted to 2019 U.S. dollars by using the medical component of the Consumer Price Index ("U.S. Bureau of Labor Statistics," n.d.).

**Predictor variables:** Drawing from the framework for the study of healthcare access and utilization developed by Aday and Andersen in 1974, predictor variables for population characteristics at risk and characteristics of the health delivery system were identified from the data.

*Characteristics of the population at risk:* Characteristics of the at-risk population are used to understand how the healthcare services utilization depends upon the predisposing characteristics of the population, the presence/absence of enabling resources, and their need for healthcare services (Andersen, 1995).

*Predisposing variables*

Age: The age variable was an integer and it identified the pregnant women's age which was re-coded by stratifying into the following age groups: <= 19 years old, 20-24 years old, 25-29 years old (reference group), 30-34 years old, 35 to 39 years old, and >= 40 years old.

Race/ethnicity: The race/ethnicity variable was categorical in nature with the following categories- White (reference group); Black; Hispanic; Other (Asian or Pacific Islander, Native American, and Other); and Unknown.

*Enabling factors*

Median household income: The estimated median household income variable was available in the dataset and was estimated using the patient's zip code and was categorized into Quartile 1 (reference group), Quartile 2, Quartile 3, and Quartile 4.

Patient location: The variable for the patient location was also categorical in nature with four categories - a metropolitan area with more than or equal to one million residents (reference group), a metropolitan area with less than one million residents, a micropolitan area, and neither metropolitan nor micropolitan area.

Primary payer: The primary payer variable was a categorical variable grouped into five categories - private (reference group), Medicare, Medicaid, self-pay, and other (no charge and other).

*Need variables*

Type of admission: The variable for the type of admission was binary in nature and classified as non-elective (reference group) and elective.

Modified Elixhauser comorbidity index: In order to account for accompanying comorbidities of patients during admission, a modified Elixhauser comorbidity index was calculated (Elixhauser et al., 1998) and used as a predictor variable in the model. There are a total of 31 comorbidities that are taken into consideration while computing the index (Sharma et al., 2021); however, since paralysis was already included in our sample population, paralysis was excluded from the index, making it a total of 30 comorbidities instead. A Stata program by Stagg (2015) was used to calculate the Elixhauser comorbidity index. The calculated modified Elixhauser comorbidity index ranged from 0 to 13. In the regression model, the index was divided into four categories - equal to 0 (reference group), equal to one, equal to two, and equal to three or more.

*Characteristics of the health delivery system:* The characteristics of the health delivery system comprises of the organizations and availability of resources in the healthcare system for the population (Andersen, 1995).

Hospital bed size: The hospital bed size variable was categorized into small (reference group), medium, and large. The categorization of bed size was dependent upon the hospital characteristics (region, urban-rural character and teaching status) ("HCUP NIS Description of Data Elements," 2008a).

Hospital location/teaching status: The hospital location/teaching status variable comprised of three categories - rural hospital (reference group), urban nonteaching hospital, and urban teaching hospital.

Hospital region: The hospital region variable referred to the U.S. region in which the hospital was located and was categorized into the northeast region (reference group), Midwest region, southern region, and western region. It followed the U.S. Census Bureau's classification as to which states fell within each of these regions ("HCUP NIS Description of Data Elements," 2008b).

**Statistical analysis:** We used descriptive statistical analysis to assess the patient characteristics and hospital characteristics of pregnant women with SCI/paralysis who were admitted to the hospital for delivery-related reasons. The outcome variables were expressed as means and medians with standard deviations and interquartile range, and categorical variables were expressed as percentages. The NIS sampling design changed in 2012, and therefore, the following weighting variables were incorporated in the analyses - "TRENDWT" for encounters from 2006 to 2011 and "DISCWT" for encounters from 2012 to 2019. For the survey-specific statistical analysis, both YEAR and

NIS_STRATUM were grouped together and used as the stratum identifier, HOSP_NIS and HOSPID were used as cluster identifier, and TRENDWT and DISCWT as weighting variables. The model did not control for the YEAR variable separately in the model because the stratum identifier already took the year of inpatient encounters into account. A multivariable regression model was used to conduct the statistical analysis. The delivery-related length of stay of pregnant women with SCI/paralysis was examined using the negative binomial regression model and total hospitalization charges were assessed by using the ordinary least squares regression with a natural log transformation. The multicollinearity check of all the predictor variables did not reveal any strong collinearity issues because the tolerance values were greater than 0.2 and variance inflation factors (VIF) were less than five. The urban nonteaching hospitals and urban teaching hospitals had a tolerance value and VIF close to the cut-off (urban nonteaching hospital: tolerance value = 0.2075 and VIF = 4.8192; urban teaching hospital: tolerance value = 0.2016 and VIF = 4.9609). The log values were converted into percentages by doing the following calculation (exp(coefficient)-1) *100. All the statistical analyses were conducted using the STATA SE 17.0 (StataCorp, College Station, TX) statistical software by taking into consideration the sampling design of the data. A p-value of <.05 was considered as statistically significant.

*Trends:* The trends in both the length of hospital stay and total hospitalization charges by year among delivery-related inpatient encounters of pregnant women with SCI/paralysis were plotted by taking into account the mean and median values as the dependent variables were skewed.

*Prediction models:* Prediction modeling was employed to predict the length of hospital stay for delivery-related inpatient encounters of pregnant women with SCI/paralysis depending on the characteristics of the population and health delivery system. In the prediction regression, the focal variable was the predictor variable that was predicted, and the other predictor variables were the control variables. All the predictor variables except for the focal variable were mean-centered in the regression.

## RESULTS

**Inpatient hospitalizations:** A total of 2,241 delivery-related inpatient hospitalizations of pregnant women were identified, which represented a weighted sample of 10,954 inpatient hospitalizations for the study period. A detailed descriptive statistic of the sample population can be seen in Table 6. The average length of hospital stay in this population was 8.11 days (median: 4 days, SD: +/- 15.27, IQR: 2 - 8 days) and the average total hospitalization charges were $79,027.84 (median: $30,043.4, SD: +/- 186,048.9, IQR: $16,164.16 - $78,386.09, in 2019 dollars). A majority of the inpatient encounters were in pregnant women aged 30 to 34 years (25.81%) followed by 25 to 29 years (24.57%). The age group of pregnant women with SCI/paralysis with the least proportion of the total sample size was 19 years and younger, which made up 4.55% of the total sample. The sample population was predominantly White (45.19%) and in the first quartile of estimated median household income (32.89%). Most of the inpatient hospitalizations had Medicaid (44.73%) as their primary payer, and pregnant women on Medicare made up 11.56%. A majority of the admissions were non-elective (63.78%) and with a modified Elixhauser comorbidity index of one or more (54.51%). The hospitals where the pregnant women with SCI/paralysis were admitted demonstrated very distinct

characteristics, such as most of the hospitals were large bed size (70.35%), urban teaching (71.03%), and located in the southern region (42.20%) of the United States.

**Length of hospital stay:** Table 7 shows the output for the negative binomial regression model predicting the length of hospital stay for delivery-related inpatient encounters of pregnant women with SCI/paralysis. None of the predisposing or enabling variables demonstrated any significant results. An inpatient encounter where the pregnant women with SCI/paralysis had a modified Elixhauser comorbidity index of one, two, and three or more increased the average length of hospital stay by 40.7% (95% CI, 1.205-1.643; p <.001), 115.0% (95% CI, 1.754-2.637; p <.001), and 199.1% (95% CI, 2.464-3.630; p <.001) respectively when compared with a modified Elixhauser comorbidity index of zero. Drawing on these findings, the prediction model showed that the predicted average length of stay among inpatient encounters of delivery-related pregnant women with SCI/paralysis by modified Elixhauser comorbidity index was approximately four, six, nine, and 13 days for an index of zero, one, two, and three or more respectively (see Figure 7). The average length of stay for pregnant women with SCI/paralysis for delivery-related purposes in a medium and large bed size was 32.1% (95% CI, 1.091-1.599; p =.004) and 76.5% (95% CI, 1.469-2.122; p<.001) higher (respectively) than the average length of stay for pregnant women with SCI/paralysis admitted in a small bed size hospital. Moreover, urban teaching hospitals resulted in an average length of hospital stay of 79% higher than the rural hospital among pregnant women with SCI/paralysis. The prediction model revealed that the predicted average length of stay among inpatient encounters of delivery-related pregnant women with SCI/paralysis by hospital location/teaching status was approximately three days for rural hospitals as opposed to

six days for urban teaching hospitals (see Figure 8). Finally, the average length of hospital stays for inpatient encounters in the Midwest, southern, and western regions of the United States were not significantly different from the average length of hospital stay for inpatient encounters of pregnant women with SCI/paralysis in the northeast region.

**Total hospitalization charges:** Compared to delivery-related inpatient encounters of White pregnant women with SCI/paralysis, for Hispanic and other pregnant women with SCI/paralysis, the average total hospitalization charge increased by 18.64% (p=.013) and 21.29% (p=.024) respectively (see Table 8). For the inpatient encounters of pregnant women with SCI/paralysis who were on Medicare as their primary payer, the average total hospitalization charges decreased by 22.66% (p<.001) when compared to the pregnant women with SCI/paralysis on private insurance. Also, the average total hospitalization charge decreased by 25.69% (p<.001) for pregnant women with SCI/paralysis admitted electively to the hospital as compared to those admitted on a non-elective basis. There was no statistically significant difference between the different quartiles of median household income and residential location of the pregnant women. However, the average total hospitalization charge for pregnant women with SCI/paralysis with a modified Elixhauser comorbidity index of one, two, and three or more increased by 48.88%, 123.89%, and 319.54% (p<.001), respectively, when compared to those with a modified Elixhauser comorbidity index of zero. The hospital bed size and location/teaching status of the hospital made a significant difference in the average total hospitalization charges of the sample population. The average total hospitalization charge for pregnant women with SCI/paralysis admitted in medium and large-bed-size hospitals for delivery-related reasons increased by 27.76% (p=.001) and 61.28% (p<.001),

respectively, when compared to those admitted in small-bed-size hospitals. Also, the average charges increased when the admission was in urban nonteaching (57.62%, $p<.001$) and urban teaching (87.20%, $p<.001$) hospitals compared to rural hospitals. The R-squared was 0.3046, which suggested that 30.46% of the variance in total hospitalization charges could be predicted from the independent variables.

**Trends:** The trends in the mean/median length of hospital stay and total hospitalization charges were plotted from 2006 through 2019 (see Figures 9 and 10). No specific trend was noticed in the mean or median length of hospital stay among delivery-related encounters of pregnant women with SCI/paralysis. The mean total hospitalization charges for the sample population increased from approximately $60,000 in 2006 to $140,000 in 2019. With respect to the median hospitalization charges, it was seen that the charges almost doubled from $20,000 in 2006 to $40,000 in the year 2019. So, overall, the trends in the mean and median hospitalization charges from 2006 through 2019 were fairly consistent; however, the mean changes were a bit greater.

## DISCUSSION

Findings from this research study suggest that pregnant women with SCI/paralysis admitted for delivery-related reasons in the hospital were predominantly White, in the age group of 30 to 34 years, in the first quartile of estimated median household income, and mainly used Medicaid as their primary payer. A majority of the sample population were from a metropolitan area with more than a million residents. This is a bit of a contrast to a separate study, which found that pregnant women with multiple sclerosis had a mean age of 31.5 years at the time of their delivery, were more likely to be White, and in the fourth quartile of estimated median household income (MacDonald, McElrath,

& Hernández-Díaz, 2019). Elgendy and colleagues (2020) found that pregnant women with acute stroke were more likely to be older in age than pregnant women who did not have an acute stroke. It has been reported that pregnant women with multiple sclerosis used private insurance as their primary payer for delivery-related hospitalizations (MacDonald et al., 2019), which is a contrast to the results from our research study, which showed that pregnant women with SCI/paralysis were majorly on Medicaid. Also, a study of pregnant women with spina bifida found that these women were more likely to be White and had a private insurance (Shepard, Yan, Hollingsworth, & Kraft, 2018). It is important to note that one of the eligibility criteria for Medicare is that it provides insurance to people with disabilities like SCI, which could be why more than a tenth of the sample population used Medicare as their primary payer. Also, the data revealed that most of the sample population had a modified Elixhauser comorbidity index of one or more (53.51%). Research suggests that pregnant women with spina bifida were more likely to have a higher mean number of comorbidities when compared to pregnant women without such disabilities (Shepard et al., 2018). One of the possible explanations for pregnant women with SCI/paralysis being admitted predominantly in larger bed size and urban teaching hospitals could be because they were referred from rural hospitals or small bed size hospitals. Also, it could be because urban teaching hospitals are more equipped to handle such patients.

This cross-sectional study assessing quality metrics across fourteen years (2006 to 2019) showed that the average length of hospital stay for delivery-related inpatient encounters of pregnant women with SCI/paralysis was 8.11 days (median: 4 days, SD: +/- 15.27, IQR: 2 - 8 days) and the average total hospitalization charges were $79,027.84

(median: $30,043, SD: +/- $186,048.9, IQR: $16,164.16 - $78,386.09, in 2019 dollars). In 1997, the average length of stay in a hospital for childbirth by a pregnant woman was 2.4 days and caesarean delivery led to a stay of four days in the hospital ("Longer Hospital Stays For Childbirth," 2015). Researchers assessed the association between type of maternal disability and hospital length of stay by using hospital discharge data and vital records data of California from 2000 through 2012 and found that prolonged length of stay among disabled women was higher in those with vision disability followed by those with intellectual and developmental disabilities followed by those with physical disabilities (Horner-Johnson, Darney, Biel, & Caughey, 2020). The overall median length of hospital stay for pregnant women with physical disabilities was three days (Horner-Johnson et al., 2020).

Having a modified Elixhauser comorbidity index of one or more among pregnant women with SCI/paralysis admitted for delivery-related reasons in the hospital showed a significantly longer length of hospital stay and higher total hospitalization charges when compared to those with a modified Elixhauser comorbidity index of zero. Pregnant women with disabilities have higher percentages of other comorbidities, such as chronic diabetes, chronic hypertension, and mental health diagnosis, when compared to pregnant women without any disabilities (Horner-Johnson et al., 2020). Additionally, even pregnancy complications like gestational diabetes, preeclampsia, gestational hypertension, and preterm birth are also predominantly noticed among pregnant women with disabilities when compared to those without any disabilities (Horner-Johnson et al., 2020). Delivery-related inpatient hospitalizations of pregnant women with SCI/paralysis in medium and large bed size hospitals demonstrated a longer length of hospital stay and

increased total hospitalization charges when compared to the ones admitted in small bed size hospitals. In a research study focused on comprehending the different barriers encountered by women with disabilities in participating in mammography, researchers found that physical access to the healthcare facility in terms of transportation, navigating the healthcare facility, and use of equipment was one of two most common barriers (Barr, Giannotti, Van Hoof, Mongoven, & Curry, 2008).

Many research studies have focused on maternal morbidity and mortality; however, there is very limited research on the healthcare services utilization of pregnant women. Moreover, research on pregnant women with disabilities is even more sparse. While early discharge from the hospital helps prevent opportunistic infections that can be contracted during the hospital stay (Baek et al., 2018), postpartum care should be rendered to these women to avoid any health-related complications.

There are some limitations to this research study. The unit of analysis was an inpatient encounter and not a unique patient. Therefore, there exists a possibility of two or more encounters for the same patient. Also, since it was not panel data, a unique patient could not be tracked over time to examine their healthcare utilization over the years after their delivery encounter. Next, since the sample was extracted using ICD codes (ICD-9 and ICD-10), there could be potential coding errors and misclassification bias. Also, information on the severity of SCI and paralysis was not available in the data. NIS is a national representative of inpatient hospitalizations, and hence it lacks information on any follow-up visits after the patient is discharged from the hospital.

# CONCLUSIONS

When pregnancy is further compounded by disabilities like SCI or paralysis, it increases their healthcare utilization even more. The findings from this study inform healthcare providers about the need for delivery and labor-related inpatient hospitalization of pregnant women with disabilities such as SCI/paralysis, which can be leveraged when determining the frequency and number of prenatal care visits for this population. Furthermore, the results can also be beneficial in mentally or emotionally preparing pregnant women with disabilities well in advance regarding the higher probability of an extended length of hospital stay. Specifically, it provides a rationale for designing targeted interventions and healthcare policies to improve healthcare services utilization for pregnant women with SCI/paralysis while also considering its financial implications. The subpopulations on whom the interventions could especially focus on Hispanics, other race, and pregnant women with other comorbidities in addition to SCI/paralysis. Future research studies should focus on quantifying the out-of-pocket costs of maternity care and delivery-related inpatient hospitalization for pregnant women with disabilities like SCI/paralysis.

Table 6: Descriptive statistics ($n$ = 2241) [1]

| *Variables* | *Central Tendency Measure* | *Variability Measure* |
|---|---|---|
| **Dependent Variable** | | |
| Length of hospital stay (in days) | 8.11 (mean); 4 (median) | 15.27 (Std. Dev.); 2 - 8 (IQR) |
| Total hospitalization charges (in 2019 dollars) | 79027.84 (mean); 30043.48 (median) | 186048.9 (Std. Dev.); 16164.16 - 78386.09 (IQR) |
| **Independent Variables** | | |
| Age-group | | |
| 19 years or less | | 4.55% |
| 20 to 24 years | | 19.57% |
| 25 to 29 years [2] | | 24.57% |
| 30 to 34 years | | 25.81% |
| 35 to 39 years | | 19.85% |
| 40 years or more | | 5.65% |
| Race/Ethnicity | | |
| White [2] | | 45.19% |
| Black | | 19.29% |
| Hispanic | | 16.60% |
| Other | | 7.64% |
| Unknown | | 11.27% |
| Median Household Income | | |
| Quartile 1 [2] | | 32.89% |
| Quartile 2 | | 25.71% |
| Quartile 3 | | 22.04% |
| Quartile 4 | | 19.37% |
| Residential location | | |
| Metropolitan >= 1 million [2] | | 55.81% |
| Metropolitan < 1 million | | 28.23% |
| Micropolitan | | 9.72% |
| Not metro/micropolitan | | 6.23% |
| Primary Payer | | |
| Medicare | | 11.56% |
| Medicaid | | 44.73% |
| Private [2] | | 38.44% |
| Self-pay | | 2.46% |
| Other | | 2.81% |
| Type of Admission | | |
| Non-elective [2] | | 63.78% |
| Elective | | 36.22% |
| Modified Elixhauser Index | | |

| | | |
|---|---|---|
| Equals zero [2] | | 45.49% |
| Equals one | | 24.97% |
| Equals two | | 15.79% |
| Equals three or more | | 13.74% |
| Hospital Bed size | | |
| Small [2] | | 9.45% |
| Medium | | 20.19% |
| Large | | 70.35% |
| Hospital Location/Teaching | | |
| Rural [2] | | 7.20% |
| Urban nonteaching | | 21.78% |
| Urban teaching | | 71.03% |
| Hospital Region | | |
| Northeast [2] | | 12.18% |
| Midwest | | 21.46% |
| South | | 42.20% |
| West | | 24.16% |

[1] n=2241, due to sampling design a weighting variable (TRENDWT for 2006 to 2011 and DISCWT for 2012 to 2019) was used for the calculation of all statistics
[2] Reference group for the regression analysis
IQR, Inter-quartile range

Table 7: Negative binomial regression model predicting length of hospital stay among inpatient encounters of delivery-related pregnant women with SCI or paralysis[1]

| ***Variables*** | ***Count Ratio*** | ***95% Confidence Interval*** | ***p-value*** |
|---|---|---|---|
| Constant | 1.855 | 1.221, 2.817 | 0.004 |
| Age-group | | | |
| 25 to 29 years (reference) | | | |
| 19 years or less | 1.135 | 0.862, 1.495 | 0.366 |
| 20 to 24 years | 1.013 | 0.821, 1.250 | 0.904 |
| 30 to 34 years | 1.007 | 0.845, 1.200 | 0.936 |
| 35 to 39 years | 1.014 | 0.848, 1.212 | 0.881 |
| 40 years or more | 1.132 | 0.900, 1.425 | 0.29 |
| Race/Ethnicity | | | |
| White (reference) | | | |
| Black | 0.924 | 0.782, 1.092 | 0.353 |
| Hispanic | 0.979 | 0.799, 1.200 | 0.836 |
| Other | 1.088 | 0.907, 1.304 | 0.364 |
| Unknown | 1.039 | 0.833, 1.295 | 0.736 |
| Median Household Income | | | |
| Quartile 1 (reference) | | | |
| Quartile 2 | 1.028 | 0.861, 1.229 | 0.759 |
| Quartile 3 | 0.966 | 0.811, 1.152 | 0.703 |
| Quartile 4 | 1.017 | 0.851, 1.214 | 0.855 |
| Residential location | | | |
| Metropolitan >= 1 million [2] | | | |
| Metropolitan < 1 million | 1.004 | 0.857, 1.176 | 0.962 |
| Micropolitan | 1.026 | 0.792, 1.329 | 0.848 |
| Not metro/micropolitan | 0.928 | 0.748, 1.150 | 0.494 |
| Residential location | | | |
| Private (reference) | | | |
| Medicare | 0.956 | 0.766, 1.192 | 0.687 |
| Medicaid | 1.003 | 0.877, 1.146 | 0.969 |
| Self-pay | 0.953 | 0.677, 1.343 | 0.784 |
| Other | 1.209 | 0.751, 1.945 | 0.434 |
| Type of Admission | | | |
| Non-elective (reference) | | | |
| Elective | 0.937 | 0.821, 1.070 | 0.339 |
| Modified Elixhauser Index | | | |
| Equals zero (reference) | | | |
| Equals one | 1.407 | 1.205, 1.643 | <.001 |
| Equals two | 2.150 | 1.754, 2.637 | <.001 |
| Equals three or more | 2.991 | 2.464, 3.630 | <.001 |
| Hospital Bed size | | | |
| Small (reference) | | | |

| | | | |
|---|---|---|---|
| Medium | 1.321 | 1.091, 1.599 | 0.004 |
| Large | 1.765 | 1.469, 2.122 | <.001 |
| Hospital Location/Teaching | | | |
| Rural (reference) | | | |
| Urban nonteaching | 1.320 | 0.992, 1.758 | 0.057 |
| Urban teaching | 1.790 | 1.367, 2.345 | <.001 |
| Hospital Region | | | |
| Northeast (reference) | | | |
| Midwest | 0.972 | 0.776, 1.216 | 0.801 |
| South | 1.107 | 0.936, 1.308 | 0.236 |
| West | 1.095 | 0.910, 1.317 | 0.335 |

[1] Based on *n* = 2241 inpatient encounters; due to sampling design a weighting variable (TRENDWT for 2006 to 2011 and DISCWT for 2012 to 2019) was used for the calculation of all statistics

Table 8: Ordinary least squares regression model predicting natural log of total hospitalization charges among inpatient encounters of delivery-related pregnant women with SCI or paralysis[1]

| ***Variables*** | ***Coefficient*** | ***95% Confidence Interval*** | ***p-value*** |
|---|---|---|---|
| Constant | 9.305 | 9.004, 9.607 | <.001 |
| Age-group | | | |
| 25 to 29 years (reference) | | | |
| 19 years or less | 0.117 | -0.082, 0.317 | 0.248 |
| 20 to 24 years | 0.003 | -0.123, 0.129 | 0.962 |
| 30 to 34 years | 0.015 | -0.106, 0.136 | 0.805 |
| 35 to 39 years | 0.064 | -0.063, 0.191 | 0.321 |
| 40 years or more | 0.125 | -0.075, 0.325 | 0.221 |
| Race/Ethnicity | | | |
| White (reference) | | | |
| Black | 0.043 | -0.089, 0.174 | 0.523 |
| Hispanic | 0.171 | 0.037, 0.306 | 0.013 |
| Other | 0.193 | 0.026, 0.360 | 0.024 |
| Unknown | -0.050 | -0.193, 0.092 | 0.488 |
| Median Household Income | | | |
| Quartile 1 (reference) | | | |
| Quartile 2 | 0.082 | -0.031, 0.195 | 0.156 |
| Quartile 3 | 0.045 | -0.080, 0.170 | 0.478 |
| Quartile 4 | 0.109 | -0.032, 0.251 | 0.13 |
| Residential location | | | |
| Metropolitan >= 1 million [2] | | | |
| Metropolitan < 1 million | -0.056 | -0.166, 0.054 | 0.32 |
| Micropolitan | 0.068 | -0.101, 0.238 | 0.43 |
| Not metro/micropolitan | -0.047 | -0.241, 0.147 | 0.636 |
| Residential location | | | |
| Private (reference) | | | |
| Medicare | -0.257 | -0.396, -0.118 | <.001 |
| Medicaid | -0.087 | -0.187, -0.014 | 0.092 |
| Self-pay | -0.044 | -0.316, 0.228 | 0.752 |
| Other | -0.056 | -0.334, 0.223 | 0.696 |
| Type of Admission | | | |
| Non-elective (reference) | | | |
| Elective | -0.297 | -0.385, -0.209 | <.001 |
| Modified Elixhauser Index | | | |
| Equals zero (reference) | | | |
| Equals one | 0.398 | 0.296, 0.500 | <.001 |
| Equals two | 0.806 | 0.672, 0.940 | <.001 |
| Equals three or more | 1.434 | 1.281, 1.587 | <.001 |
| Hospital Bed size | | | |

| | | | |
|---|---|---|---|
| Small (reference) | | | |
| Medium | 0.245 | 0.096, 0.394 | 0.001 |
| Large | 0.478 | 0.351, 0.606 | <.001 |
| Hospital Location/Teaching | | | |
| Rural (reference) | | | |
| Urban nonteaching | 0.455 | 0.254, 0.655 | <.001 |
| Urban teaching | 0.627 | 0.443, 0.812 | <.001 |
| Hospital Region | | | |
| Northeast (reference) | | | |
| Midwest | -0.100 | -0.260, 0.060 | 0.221 |
| South | -0.119 | -0.267, 0.029 | 0.115 |
| West | 0.103 | -0.060, 0.265 | 0.215 |

[1] Based on *n* = 2241 inpatient encounters; due to sampling design a weighting variable (TRENDWT for 2006 to 2011 and DISCWT for 2012 to 2019) was used for the calculation of all statistics; dependent variable ln-transformed to correct for skewness (changed from right skewed to approximately normal distribution)

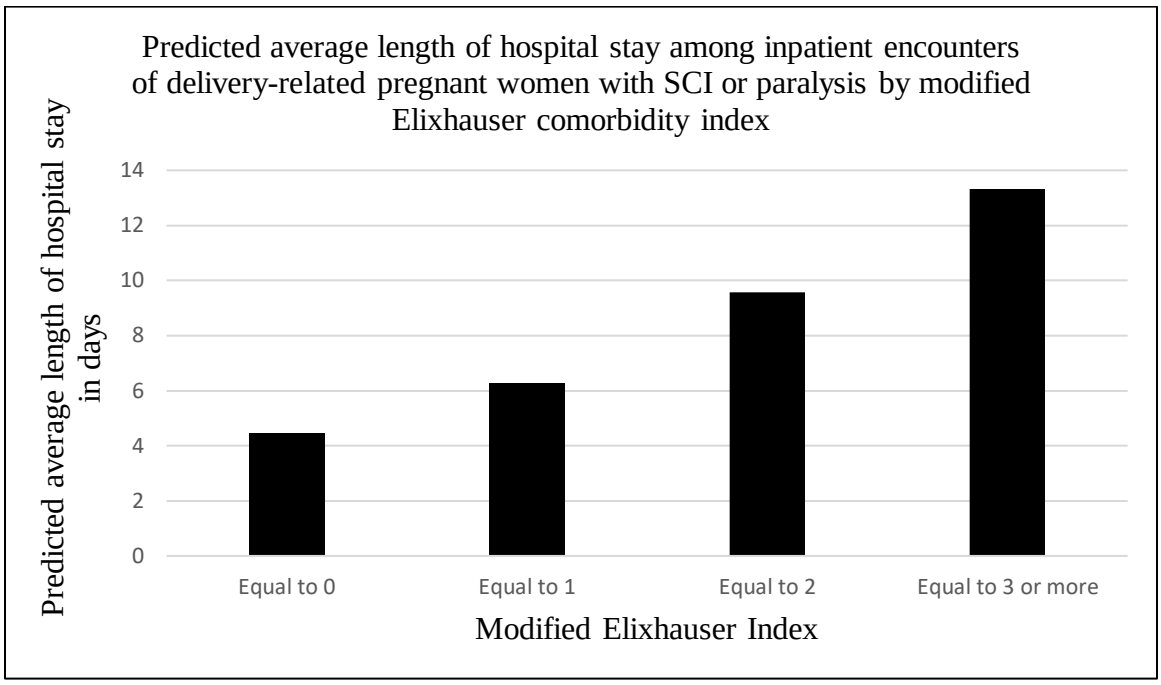



Figure 7: Predicted average length of hospital stay among inpatient encounters of delivery-related pregnant women with SCI/paralysis by modified Elixhauser comorbidity index

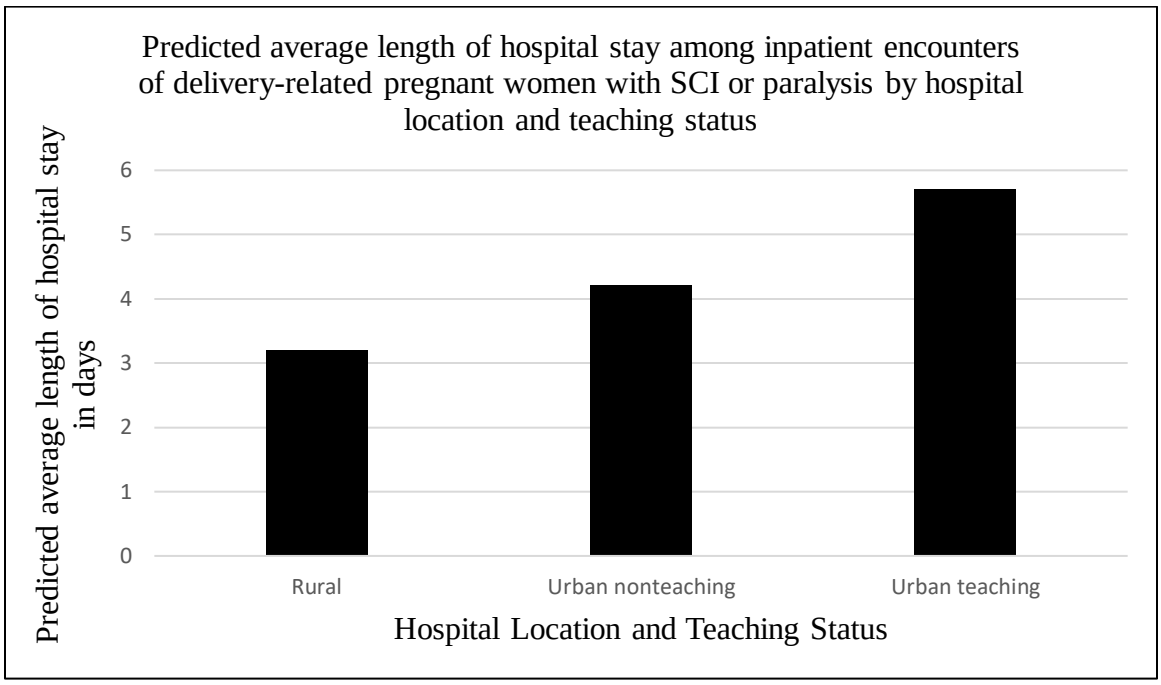



Figure 8: Predicted average length of hospital stay for inpatient encounters of delivery-related pregnant women with SCI/paralysis by hospital location/teaching status

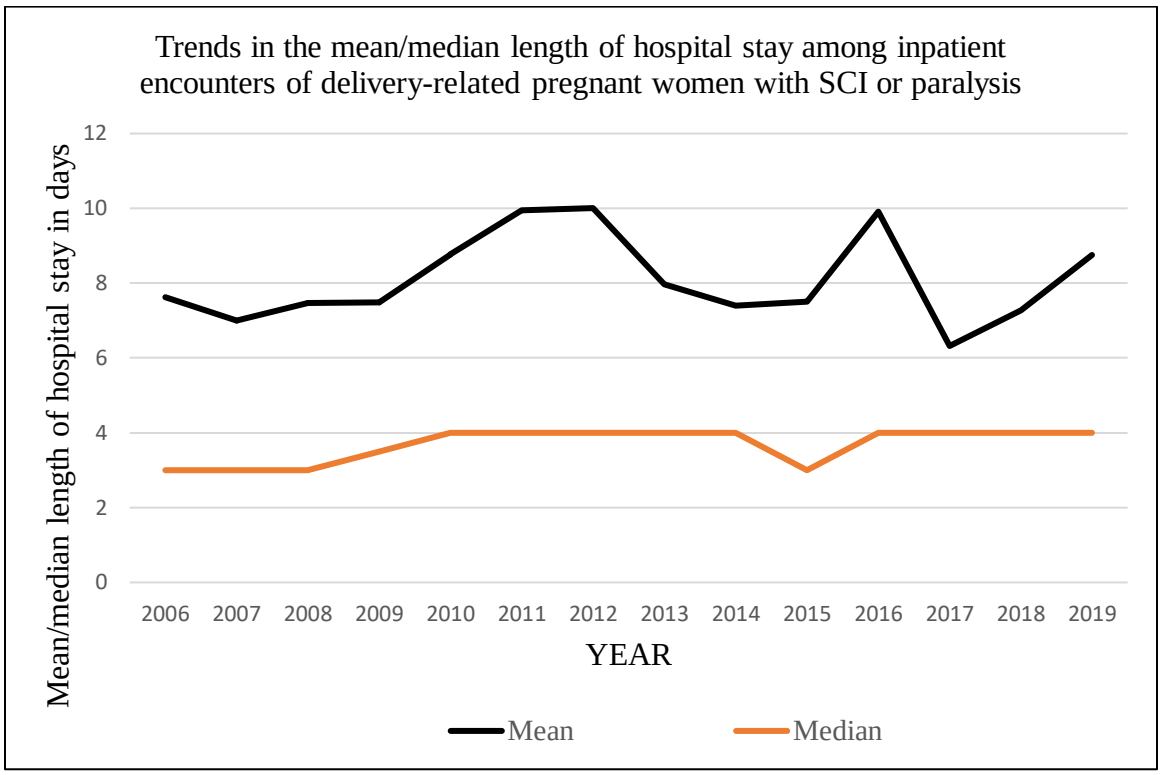



Figure 9: Trends in the mean/median length of hospital stay among inpatient encounters of delivery-related pregnant women with SCI/paralysis

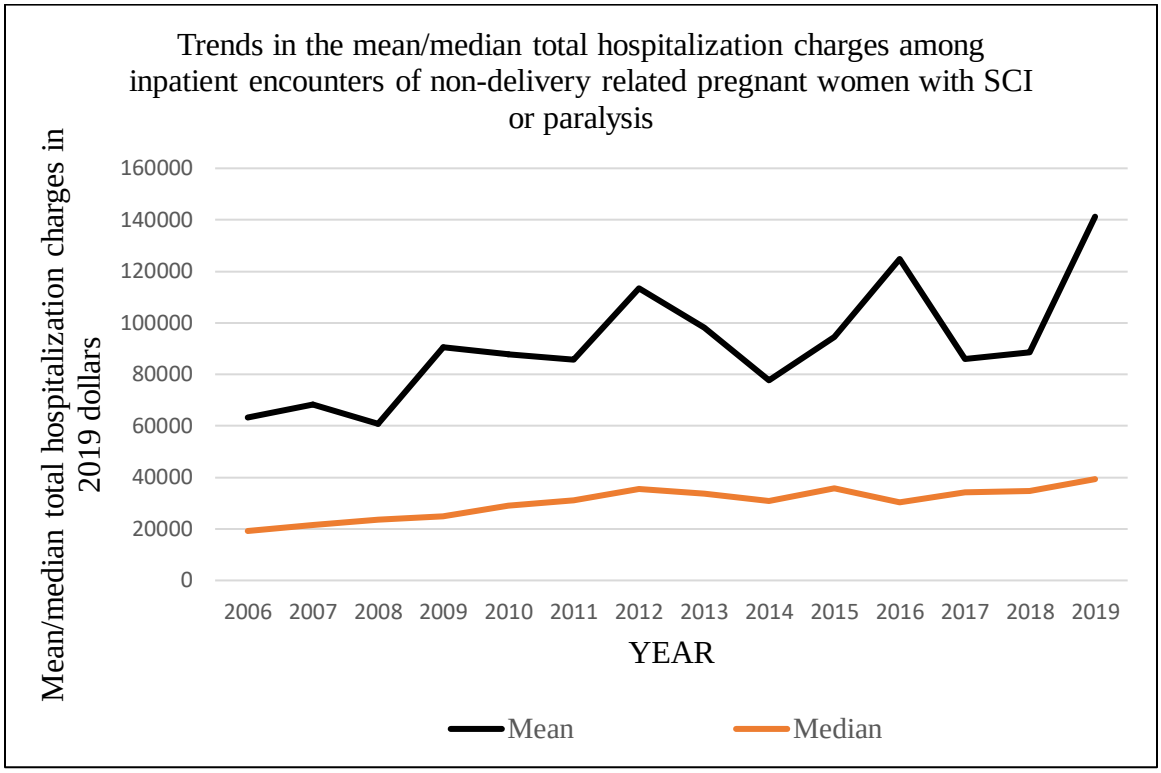



Figure 10: Trends in the mean/median total hospitalization charges among inpatient encounters of delivery-related pregnant women with SCI/paralysis

# CHAPTER 3: THE IMPACT OF SPINAL CORD INJURY OR PARALYSIS ON THE HEALTHCARE UTILIZATION OF PREGNANT WOMEN IN THE UNITED STATES

## OVERVIEW

The objective of this research study was to evaluate the impact of SCI/paralysis on the inpatient hospital utilization of pregnant women. We used the NIS data from 2006 to 2019. The independent variables were grouped into characteristics of the health delivery system and the characteristics of the population at risk. We employed propensity-score kernel matching to determine the impact of SCI/paralysis on the inpatient hospital utilization of pregnant women in two groups - with SCI/paralysis and without SCI/paralysis. The total encounters of pregnant women with SCI/paralysis and without SCI/paralysis in the sample population were 3,174 and 7,732,029, respectively. Pregnant women with SCI/paralysis had, on average, a length of stay of about three days (SE: 0.22) longer and a total hospitalization charge approximately $30,393.23 (SE: $2,484.01, in 2019 dollars) more than pregnant women without SCI/paralysis. The findings can be beneficial in informing policies to improve quality of care for this population.

Keywords: Pregnancy; spinal cord injury; paralysis; disabilities; length of stay; charges

## INTRODUCTION

In the United States, there are approximately 17,730 new SCIs per year, of which 22% are in women ("National Spinal Cord Injury Statistical Center," 2019). People with disabilities have health risk factors and a higher prevalence of other diseases and comorbidities when compared to those without disabilities (Khavjou et al., 2020). SCI and paralysis often lead to major challenges in individuals and accompanying disabilities. Serving the unique needs of patients with an SCI can create a burden for the healthcare system (Wyndaele & Wyndaele, 2006). Pregnancy alone leads to a longer length of hospital stay, more use of healthcare services, and higher costs (Law et al., 2015), and when pregnant women have disabilities like SCI or paralysis, the healthcare services utilization and hospital costs may be even more.

According to the Centers for Disease Control and Prevention's National Center for Health Statistics, in 2019, in the United States, the total hospital care expenditure was more than one-third of the total personal healthcare spending by individuals, making hospital care the largest component of healthcare spending ("Health, United States, 2020-2021," 2022). Research also suggests that after medical and surgical-related inpatient admissions, pregnancy, childbirth, and newborn care account for the highest number of hospital stays when compared to any other reason (McDermott, Elixhauser, & Sun, 2017). Overall, inpatient hospitalizations for pregnancy, labor, childbirth, and newborn care constituted 23.4% and 22.9% of all inpatient hospital stays in 2005 and 2014, respectively (McDermott et al., 2017).

Existing data on the burden of care for pregnant women with SCI or paralysis is very sparse. It is important for women with SCI/paralysis to know the anticipated

hospitalization charges for pregnancy-related inpatient visits so that they are financially prepared. Due to the sparsity of the available research and to improve care for pregnant women with SCI or paralysis, it is important to understand their healthcare services utilization. The findings can be beneficial in informing policies for pregnant women with disabilities. The objective of this research study was to evaluate the impact of SCI or paralysis on the inpatient department healthcare utilization of pregnant women compared to the inpatient department healthcare utilization of pregnant women without SCI or paralysis.

## CONCEPTUAL FRAMEWORK

The conceptual framework for this research study was based upon Aday and Andersen's framework for the study of healthcare access and health services utilization (Aday & Andersen, 1974). Access to healthcare is determined by environment (healthcare system and external environment), population characteristics, health behavior, and outcomes (Andersen, 1995). The characteristics of the healthcare delivery system refer to the organization of the healthcare system, including the resources, whereas characteristics of the population at risk refer to the population's predisposing characteristics, enabling resources, and need factors (Andersen, 1995). This framework was used to identify variables for the characteristics of the health delivery system and the characteristics of the population at risk in order to examine the healthcare services utilization (Appendix A).

*Hypothesis 1:* The length of hospital stay for pregnant women with SCI/paralysis will be longer than the length of stay for pregnant women without SCI/paralysis.

*Hypothesis 2:* The total hospitalization charges for pregnant women with SCI/paralysis will be higher than the total hospitalization charges for pregnant women without SCI/paralysis.

## METHODS

### Data source and study population

The research study was retrospective in nature. The inpatient hospitalization discharge data from the NIS, developed and made available by HCUP, for a period from 2006 through 2019, were used for the study. The NIS is an approximately 20% stratified sample of inpatient hospitalization at nonfederal hospitals that is extracted from the data provided to the HCUP by the individual states ("NIS OVERVIEW," 2022). So, the data is representative of the U.S. population.

### Inclusion criteria

The sample comprised of inpatient encounters with all pregnant women from 2006 through 2019, extracted using the ICD codes (Appendices B and C). Additionally, encounters with SCI or paralysis were identified using ICD codes which are available in Appendices D and E.

### Outcome variables

The two outcome variables that were analyzed in this research paper were the length of hospital stay and total hospitalization charges. The length of hospital stay, reported in days (ranging from 0-365) and defined as the difference between the admission date and discharge date, was available in the NIS dataset. The variable total hospitalization charges, reported in dollars and rounded to the nearest dollar, were also available in the NIS dataset. However, the total hospitalization charges were adjusted to

2019 U.S. dollars using the medical component of the Consumer Price Index ("U.S. Bureau of Labor Statistics," n.d.).

**Independent Variables**

Drawing from the conceptual framework by Aday & Andersen (1974), independent variables were grouped into characteristics of the health delivery system and the characteristics of the population at risk.

*Characteristics of health delivery system*

Hospital bed size: The variable for the bed size of the hospital came with the data and was categorized into small, medium, and large, depending on the number of beds in the hospital. The bed size of the hospital was categorized depending on the region, urban-rural character, and teaching status of the hospital ("HCUP NIS Description of Data Elements," 2008a). For the purpose of this research study, small-bed size hospitals were treated as the reference group.

Hospital location/teaching status: The variable for hospital location and teaching status was categorical in nature and grouped into three categories - rural hospital (reference group), urban nonteaching hospital, and urban teaching hospital.

Hospital region: The independent variable, hospital region, denoted the location of the hospital in the United States and was grouped into the northeast region (reference category), Midwest region, southern region, and western region. The hospital region was categorized into these four categories according to the U.S. Census Bureau ((("HCUP NIS Description of Data Elements," 2008b).

*Characteristics of the population at-risk*

Age: The variable age was an integer variable that identified the pregnant women's age. However, since younger and advanced ages among pregnant women are associated with increased risk for complications (Cavazos-Rehg et al., 2015), the variable was re-coded by stratifying into the following age groups: <= 19 years old, 20-24 years old, 25-29 years old, 30-34 years old, 35 to 39 years old, and >= 40 years old, with 25-29 years old as the reference category.

Race/ethnicity: The pregnant woman's race/ethnicity was also a categorical variable with the following categories- White; Black; Hispanic; Other (Asian or Pacific Islander, Native American, and Other); and Unknown. The "White" category was treated as the reference group in this study.

Estimated median household income for patient's zip code: The estimated median household income for the patient's zip code was categorized into Quartile 1 (reference category), Quartile 2, Quartile 3, and Quartile 4.

Residential location: The variable for the residential location of the pregnant woman was grouped into four distinct categories, including a metropolitan area with more than or equal to one million residents (reference category), a metropolitan area with less than one million residents, a micropolitan area, and neither metropolitan nor micropolitan area.

Primary payer: The variable for the pregnant woman's primary payer was categorical in nature and comprised of five categories - Medicare. Medicaid, private, self-pay, and other (no charge and other). In this study, "private payer" was treated as the reference group.

Type of admission: The variable for the type of admission was binomial in nature and classified as non-elective and elective. For this study, non-elective admission was treated as the reference group.

Modified Elixhauser comorbidity index: An Elixhauser comorbidity index comprises of 31 comorbidities in all (Elixhauser et al., 1998; Sharma et al., 2021); however, since the sample comprised of SCI/paralysis, the comorbidity of paralysis was excluded from the index, which led to a total of 30 comorbidities in the modified Elixhauser comorbidity index. The modified Elixhauser comorbidity index was calculated using the Stata program and codes by Stagg (2015). The index was re-coded as a categorical variable (zero, one, two, three or more), where zero denoted a score of zero, one denoted a score of one, and so on. A modified Elixhauser comorbidity index of zero was treated as a reference group.

**Statistical Analysis**

*Summary Statistics*

For univariate analysis, the continuous variables were presented using the mean as the central tendency measure and standard deviation as a variability measure, whereas categorical variables we presented using percentages as a variability measure. The characteristics of the health delivery system and the characteristics of the population at-risk were compared between SCI/paralysis group and the non-SCI/paralysis group by the Pearson chi-square test, whereas continuous variables were compared using the t-test.

The null hypothesis was that the group means (m) for those with SCI/paralysis and without SCI/paralysis groups were not different from each other (Ho: diff = 0). We used a one-sided test as it was hypothesized that SCI/paralysis positively affects both the length of hospital stay and total hospitalization charges. Therefore, the alternative hypothesis for the test was Ha: diff < 0, which meant that the difference would be negative and pregnant women without SCI/paralysis would, on average, have a lower

length of hospital stay and lower total hospitalization charges when compared to inpatient encounters of pregnant women with SCI/paralysis (ΔmLength of stay = mLength of $stay_{Non\text{-}SCI}$ - mLength of $stay_{SCI}$ = Negative and ΔmTotal hospitalization charges = mTotal $hospitalization\ charges_{Non\text{-}SCI}$ - mTotal $hospitalization\ charges_{SCI}$ = Negative). A statistical test was performed to check if the treatment variable (SCI/paralysis) was associated with the two outcome variables, length of hospital stay and total hospitalization charges by employing the t-test, which compared means between the two treatment groups. But, this t-test cannot be considered very reliable because it did not take into account any correlations.

*Propensity score matching and success evaluation*

The research study employed propensity-score kernel matching to determine the impact of SCI or paralysis on the length of hospital stay and total hospitalization charges. Before conducting the propensity-score kernel matching, a t-test was conducted to check if the outcome variables, length of stay and total hospitalization charges, and the grouping variable, SCI/paralysis, were associated by comparing the means between the two groups. The variables used to estimate matching included characteristics of the pregnant women (age and race/ethnicity), estimated median household income, residential location, primary payer, type of admission, modified Elixhauser comorbidity index, and hospital characteristics (bed size, location/teaching status, and hospital region). In addition to the independent variables mentioned above, the model was controlled by adding the year of inpatient admission. In propensity-score kernel matching, each inpatient encounter of a pregnant woman with SCI or paralysis (treated group) is matched with many inpatient encounters of pregnant women without SCI or

paralysis (control group); however, it is done with weights that are inversely proportional to the distance between the observations from the treated and control groups. Therefore, the weights will be lower if the distance between the treated and control observation is more. The matching technique employed the default Stata settings for kernel matching, including the Epanechnikov kernel function and bwidth(pm), a pair-matching algorithm.

After both the models (length of hospital stay and total hospitalization charges) were estimated, model diagnostics were performed to verify if the assumptions were held. The first assumption check was for common support. Common support guarantees that the inpatient encounters of pregnant women with similar independent variable values have a positive probability of being in the SCI/paralysis and non-SCI/paralysis groups. The second assumption check was conducted on the inpatient encounters that were not included in the analysis, as those encounters could not be matched due to the lack of a good match. It is crucial to conduct this assumption check because if many inpatient encounters are not included in the analysis, then there is a possibility that the new sample might not be representative of the original sample. The first two assumption checks provide an average result for all the variables included in the model. In order to check each variable in the model, the standardized differences in means and variances were calculated for all the independent variables. The standardized difference was used to compare the differences in means by using the pooled standard deviation. This is beneficial in examining the similarities between the matched encounters, with the threshold for all the standardized differences $< 0.1$ determined to be an acceptable matching balance.

*Trends*

The statistical analyses were conducted by using a weighting variable - "TRENDWT" for encounters from 2006 to 2011 and "DISCWT" for encounters from 2012 to 2019. Additionally, trends in the length of stay and total hospitalization charges among inpatient encounters of pregnant women with SCI/paralysis and those without SCI/paralysis were plotted for comparison.

All statistical analyses and data modeling was conducted using STATA SE 17.0 (StataCorp, College Station, TX) statistical software and EXCEL was used to plot the trends graph. A P-value less than 0.05 was considered statistically significant.

## RESULTS

*Characteristics of the study sample:* The baseline characteristics of the population at risk and characteristics of the health delivery system for all inpatient encounters in the sample population are shown in Table 9. The total inpatient encounters of pregnant women with SCI/paralysis and without SCI/paralysis in the sample population were 3,174 and 7,732,029, respectively. The pregnant women in both groups were majorly White (45.15%) and in the age group of 25-29 years (26.21%). A majority of pregnant women with SCI/paralysis were on Medicaid (45.68%), as opposed to the pregnant women without SCI/paralysis, who were mainly using private insurance (47.66%) as their primary payer. Moreover, a majority of pregnant women with SCI/paralysis had a modified Elixhauser comorbidity index greater than or equal to one (56.46%) and had a non-elective inpatient admission to the hospital (67.14%). The pregnant women from both groups were largely from a metropolitan area with more than one million residents with an estimated median household income in Quartile 1. With respect to the characteristics of the health delivery system, pregnant women from both groups were

mainly admitted into an urban teaching hospital, a hospital with a large bed size, and a hospital located in the southern United States.

*Matching results:* A propensity-score kernel matching was performed with the covariates for characteristics of the health delivery system and characteristics of the population at risk and controlling the year of inpatient admission (see Table 10). As seen in Figure 12, the matched sample with ATE is seen as a single red line with no major deviations, as opposed to the raw data where, the treatment and control groups are seen as two different lines. This provides evidence that after the application of propensity-score kernel matching, the common support was satisfactory. With respect to the unmatched inpatient encounters, it is seen that the total sample and the matched sample almost overlap, suggesting that the final sample used for matching purposes was representative of the original sample (see Figure 13). Table 11 provides detailed standardized differences in means and variances for all independent variables before and after matching. The standardized differences in means after matching are within the threshold of 0.1. The standardized differences in variances after matching are all close to one, except for one category of primary payer - Medicare. Here, although the variance of standardized differences is a little away from one, it is still less than the variance of standardized differences of the raw data for these variables.

*Length of hospital stay:* The average length of hospital stay among pregnant women with SCI/paralysis was 7.74 days (+/- 14.88), whereas the length of hospital stay for pregnant women without SCI/paralysis was 2.87 days (+/- 3.01). The average treatment effect (ATE) for the length of hospital stay was approximately three (SE: 0.22) days, which suggests that inpatient encounters of pregnant women with SCI/paralysis have a length of

stay on average, about three days longer than the length of stay of pregnant women without SCI/paralysis. The average treatment effect for the treated (ATT) was also calculated, which showed the length of stay for the pregnant women who actually had SCI/paralysis. So, assuming these pregnant women had a counterfactual instead, i.e., if they did not have SCI/paralysis, the difference in the length of hospital stay would be about four (SE: 0.26) days. Similarly, the average treatment effect for the control (ATC) was calculated for the pregnant women from the control group in the dataset who do not have SCI/paralysis. So, supposing these pregnant women would have had SCI/paralysis, then their length of stay would be roughly three (SE: 0.22) days longer.

*Total hospitalization charges:* The average total hospitalization charges for pregnant women with SCI/paralysis was $73,479.32 (+/- 165,376.3, in 2019 dollars), whereas the total hospitalization charges for pregnant women without SCI/paralysis was $17,136.64 (+/- 20,057.04, in 2019 dollars). The ATE for total hospitalization charges of a pregnant woman with an SCI/paralysis was $30,393.23 (SE: $2,484.01, in 2019 dollars), indicating that pregnant women with SCI/paralysis have a total hospitalization charge, on average, approximately $30,393.23 more when compared to the total hospitalization charges for a pregnant woman without SCI/paralysis. With respect to the total hospitalization charges, the ATC was $30,380.7 (SE: $2,484.34, in 2019 dollars) more, and the ATT was $59,461.79 (SE: $3,288.18, in 2019 dollars). The ATT of $59,461.79 means that if the pregnant women who actually have SCI/paralysis were imagined having had a counterfactual (no SCI/paralysis), then the difference in the total hospitalization charges would be $59,461.79.

*Trends:* Trends in both the mean and the median length of stay and total hospitalization charges for inpatient encounters of pregnant women with SCI/paralysis and without SCI/paralysis were plotted for comparison (see Figures 14-17). The trends from 2006 through 2019 showed that the mean and the median length of stay for pregnant women with SCI/paralysis has been consistently greater than that of pregnant women without SCI/paralysis; however, there is no evident increase or decrease in the trends of the length of hospital stay. On the other hand, the total hospitalization charges showed an increasing trend in both the mean and median charges for pregnant women with SCI/paralysis when compared to pregnant women without SCI/paralysis.

## DISCUSSION

Pregnant women with SCI/paralysis have a greater burden of care, as examined by the length of hospital stay and total hospitalization charges compared to pregnant women without SCI/paralysis. Findings from this study revealed that pregnant women in both groups (with and without SCI/paralysis) were predominantly White, in the age group of 25 to 29 years, residing in a metropolitan area with more than one million residents, and had an estimated median household income in the first Quartile. There were differences in the primary payer used by pregnant women in both groups - Medicaid was majorly used by pregnant women with SCI/paralysis, and private insurance was mainly used by those without SCI/paralysis. These findings align with a research study conducted by Mitra and colleagues (2015), which reported that recent mothers with disabilities were more likely to be on public insurance and from a lower-income household. Pregnant women with SCI/paralysis, as compared to those without SCI/paralysis, were more likely to have other medical comorbidities, as evidenced by a

modified Elixhauser comorbidity index greater than or equal to one in more than half of the sample population of pregnant women with SCI/paralysis. This finding is also similar to results from a previous study which showed that women with disabilities have a higher probability of having other medical complications during their course of pregnancy (Mitra et al., 2015).

This research study also demonstrates the significant disparities related to healthcare utilization between pregnant women with and without SCI/paralysis, as evidenced by the length of hospital stay and total hospitalization charges. The average length of hospital stay among pregnant women with SCI/paralysis was 7.74 days, whereas the length of hospital stay for pregnant women without SCI/paralysis was 2.87 days. The findings from this study showed that inpatient encounters of pregnant women with SCI/paralysis have a length of stay, on average, approximately three days longer than the length of stay of pregnant women without SCI/paralysis. There are different reasons that could explain the longer length of hospital stay in pregnant women with SCI/paralysis. Pregnant women with SCI/paralysis have other comorbidities which can contribute to an even longer hospital stay. A qualitative research study of 25 participants to assess the pregnancy experiences of women with physical disabilities revealed that these women have unmet medical needs and need support during their course of pregnancy (Mitra, Long-Bellil, Iezzoni, Smeltzer, & Smith, 2016). Length of hospital stay is a key indicator of health services usage and plays an important role in evaluating the quality of care that patients receive and the efficiency of hospital management (Baek et al., 2018). A decreased length of hospital stay reduces the chances of contracting opportunistic infections in the hospital, improves the treatment outcome, and reduces

hospital mortality rates (Baek et al., 2018). Trends in the median length of hospital stay among inpatient encounters of pregnant women revealed that the ones without SCI/paralysis had a hospital stay of two days from 2006 to 2019. On the other hand, those with SCI/paralysis had a median length of stay of three days from 2006 to 2010, which increased to four days in 2012, dropped back to three days in 2013, and then increased back to around three and a half to four days of hospital stay by 2019. In 2014 the Affordable Care Act required insurance plans to provide coverage to a minimum of ten essential health benefits, of which maternal and newborn care was one (Bagley & Levy, 2014).

With respect to the total hospitalization charges, the findings revealed that for pregnant women with SCI/paralysis, the average total hospitalization charge was $73,479.32 (+/- 165,376.3, in 2019 dollars) as compared to those without SCI/paralysis where the charges were $17,136.64 (+/-20,057.04, in 2019 dollars). Furthermore, the matching results demonstrated that pregnant women with SCI/paralysis have a total hospitalization charge, on average, approximately $30,393.23 (SE: $2,484.01, in 2019 dollars) more when compared to the total hospitalization charges for a pregnant woman without SCI/paralysis. Overall, the average total and out-of-pocket healthcare costs associated with pregnancy, including childbirth and post-partum care, are approximately $18,865 and $2,854, respectively (Rae, Cox, & Dingel, 2022). The dollar amounts suggest that pregnant women with disabilities like SCI/paralysis encounter a total hospitalization charge of approximately $50,000 more than pregnant women without disabilities. Trends in the median total hospitalization charges among inpatient encounters of pregnant women with SCI/paralysis compared to those without

SCI/paralysis showed that the total hospitalization charges in both groups have been increasing from 2006 through 2019. In 2019, the difference in the median total hospitalization charges of both groups was over $20,000. Also, the rise in the total hospitalization charges from 2006 to 2019 for pregnant women with SCI/paralysis is more than the other group.

Motherhood and disability are considered two distinct things in a healthcare setting and in the policy world (Mitra et al., 2016). There must be an informed effort undertaken to address the needs of pregnant women with disabilities like SCI/paralysis so that they are able to receive the required healthcare. This could mean that all hospitals, irrespective of their bed sizes and location, must be equipped to care for such a population.

*Limitations:* There were limitations to this research study. Firstly, although the NIS is a representative sample of hospitalizations in the U.S., it is only limited to inpatient hospitalizations. Therefore, the data regarding any follow-up visits after the patient is discharged from the hospital is lacking. The sample for our study was extracted using ICD codes only. Additionally, it is important to note that the ICD-9 codes were used until the first three quarters of 2015, after which ICD-10 codes were used. Therefore, the extraction of encounters was achieved using both ICD-9 and ICD-10 codes. This can lead to misclassification bias. One NIS observation corresponds to one encounter or one hospitalization and not the patient, and hence, there is a possibility of multiple records for one patient if that particular patient is hospitalized multiple times within the study period from 2006 through 2019 (Memtsoudis, 2009). And finally, although total hospitalization

charges are a potential metric for financial implications, it does not reflect the true cost to the consumers or patients.

## CONCLUSIONS

The findings from this research study indicate that pregnant women with SCI/paralysis have greater healthcare services utilization when compared to pregnant women without SCI/paralysis. The results from our research study add to the existing literature on maternal hospitalizations and showed that pregnancy compounded by conditions like SCI/paralysis leads to an increased length of hospital stay. It is essential for a healthcare delivery system to understand the extent of healthcare utilization of pregnant women with SCI/paralysis in order to be able to develop effective programs and policies to address the needs of this population. In addition to the knowledge of the different SCI/paralysis-related issues faced by pregnant women with SCI/paralysis, obstetrician-gynecologists who care for these pregnant women should also know about the healthcare utilization of these pregnant women. The results from this research study can be used as a starting point for healthcare providers to be able to stratify the risks for pregnant women with SCI/paralysis based on their demographic and socioeconomic characteristics to make informed decisions regarding the need for increasing the frequency of outpatient prenatal care visits for this population. Future research studies must focus on understanding the prenatal and postnatal healthcare utilization of pregnant women with disabilities like SCI and paralysis so that the healthcare system is equipped to deliver quality care for this target population during their entire course of pregnancy, childbirth, and postnatal periods.

Table 9: Independent and outcome variables of inpatient encounters of pregnant women with SCI/paralysis vs. without SCI/paralysis

| Variables | Total inpatient encounters (N = 8175481) | | |
|---|---|---|---|
| | Pregnant women inpatient encounters | | p-value |
| | With SCI/paralysis (N = 3,174) | Without SCI/paralysis (N = 7,732,029) | |
| **Length of hospital stay (in days)** | 7.74 (+/-14.88) | 2.87 (+/- 3.01) | <.001 |
| **Total hospitalization charges (in 2019 dollars)** | 73479.32 (+/- 165376.3) | 17136.64 (+/-20057.04) | <.001 |
| **Year** | | | .032 |
| **2006** | 220 (6.93%) | 566,666 (7.33%) | |
| **2007** | 216 (6.81%) | 592,267 (7.66%) | |
| **2008** | 227 (7.15%) | 564,234 (7.30%) | |
| **2009** | 191 (6.02%) | 533,935 (6.91%) | |
| **2010** | 213 (6.71%) | 520,360 (6.73%) | |
| **2011** | 240 (7.56%) | 532,123 (6.88%) | |
| **2012** | 197 (6.21%) | 529,855 (6.85%) | |
| **2013** | 220 (6.93%) | 529,131 (6.84%) | |
| **2014** | 217 (6.84%) | 548,947 (7.10%) | |
| **2015** | 214 (6.74%) | 564,149 (7.30%) | |
| **2016** | 248 (7.81%) | 566,151 (7.32%) | |
| **2017** | 264 (8.32%) | 562,346 (7.27%) | |
| **2018** | 248 (7.81%) | 561,285 (7.26%) | |
| **2019** | 259 (8.16%) | 560,580 (7.25%) | |
| **Age-group** | | | <.001 |
| **19 years or less** | 191 (6.02%) | 614,641 (7.95%) | |
| **20 to 24 years** | 658 (20.73%) | 1,749,578 (22.63%) | |
| **25 to 29 years** | 832 (26.21%) | 2,136,523 (27.63%) | |
| **30 to 34 years** | 819 (25.80%) | 1,931,723 (24.98%) | |
| **35 to 39 years** | 528 (16.64%) | 1,039,275 (13.44%) | |
| **40 years or more** | 146 (4.60%) | 260,289 (3.37%) | |
| **Race/Ethnicity** | | | <.001 |
| **White** | 1,433 (45.15%) | 3,580,520 (46.31%) | |
| **Black** | 634 (19.97%) | 1,184,203 (15.32%) | |
| **Hispanic** | 529 (16.67%) | 1,391,480 (18.00%) | |
| **Other** | 224 (7.06%) | 695,615 (9.00%) | |
| **Unknown** | 354 (11.15%) | 880,211 (11.38%) | |
| **Estimated median household income** | | | <.001 |
| **Quartile 1** | 1,089 (34.31%) | 2,271,892 (29.38%) | |
| **Quartile 2** | 823 (25.93%) | 1,968,481 (25.46%) | |
| **Quartile 3** | 708 (22.31%) | 1,875,348 (24.25%) | |
| **Quartile 4** | 554 (17.45%) | 1,616,308 (20.90%) | |
| **Residential location** | | | .003 |
| **Metropolitan >= 1 million** | 1,739 (54.79%) | 4,426,484 (57.25%) | |
| **Metropolitan < 1 million** | 926 (29.17%) | 2,221,729 (28.73%) | |
| **Micropolitan** | 304 (9.58%) | 670,637 (8.67%) | |
| **Not metro/micropolitan** | 205 (6.46%) | 413,179 (5.34%) | |
| **Primary Payer** | | | <.001 |
| **Medicare** | 385 (12.13%) | 72,431 (0.94%) | |
| **Medicaid** | 1,450 (45.68%) | 3,516,710 (45.48%) | |

| | | | |
|---|---|---|---|
| **Private** | 1,147(36.14%) | 3,685,212 (47.66%) | |
| **Self-pay** | 90 (2.84%) | 225,493 (2.92%) | |
| **Other** | 102 (3.21%) | 232,183 (3.00%) | |
| **Type of Admission** | | | <.001 |
| **Non-elective** | 2,131 (67.14%) | 4,077,212 (52.73%) | |
| **Elective** | 1,043 (32.86%) | 3,654,817 (47.27%) | |
| **Modified Elixhauser Comorbidity Index** | | | <.001 |
| **Equals zero** | 1,382 (43.54%) | 5,376,147 (69.53%) | |
| **Equals one** | 857 (56.46%) | 1,827,279 (30.47%) | |
| **Equals two** | 533 (16.79%) | 406,934 (5.26%) | |
| **Equals three or more** | 402 (12.67%) | 121,669 (1.57%) | |
| **Hospital Bed size** | | | <.001 |
| **Small** | 284 (8.95%) | 1,054,547 (13.64%) | |
| **Medium** | 654 (20.60%) | 2,132,017 (27.57%) | |
| **Large** | 2,236 (70.45%) | 4,545,465 (58.79%) | |
| **Hospital Location/Teaching** | | | <.001 |
| **Rural** | 205 (6.46%) | 759,410 (9.82%) | |
| **Urban nonteaching** | 681 (21.46%) | 2,393,428 (30.95%) | |
| **Urban teaching** | 2,288 (72.09%) | 4,579,191 (59.22%) | |
| **Hospital Region** | | | <.001 |
| **Northeast** | 398 (12.54%) | 1,249,477 (16.16%) | |
| **Midwest** | 704 (22.18%) | 1,666,773 (21.56%) | |
| **South** | 1,331 (41.93%) | 3,079,265 (39.82%) | |
| **West** | 741 (23.35%) | 1,736,514 (22.46%) | |
| Note: t-test used to generate p-value for length of stay and total hospitalization charges; Pearson chi-square test used to generate p-value for all categorical variables | | | |

Table 10: Propensity-score kernel matching

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Number of observations = 7,716,245 | | | | | | | |
| Kernel = epan | | | | | | | |
| Treatment: SCI = 1 | | | | | | | |
| Covariates: Year, Age, Race, Estimated median household income, Patient location, Type of admission, Modified Elixhauser Index, Hospital bed size, Hospital location and teaching status, Hospital region | | | | | | | |
| PS model: logit (pr) | | | | | | | |
| **Matching statistics** | | | | | | | |
| | Matched | | | Controls | | | Bandwidth |
| | Yes | No | Total | Used | Unused | Total | |
| Treated | 3123 | 43 | 3166 | 6823278 | 889801 | 7713079 | 4.50e-07 |
| Untreated | 7253032 | 460047 | 7713079 | 3133 | 33 | 3166 | 7.76e-07 |
| Combined | 7256155 | 460090 | 7716245 | 6826411 | 889834 | 7716245 | |

| Treatment-effects estimation | | | | |
|---|---|---|---|---|
| | Coefficient | P>\|t\| | [95% conf. interval] | |
| Length of hospital stay | | | | |
| ATE | 2.482 | <.001 | 2.060 | 2.904 |
| ATT | 4.213 | <.001 | 3.708 | 4.717 |
| ATC | 2.481 | <.001 | 2.059 | 2.903 |
| Total hospitalization charges | | | | |
| ATE | 30393.23 | <.001 | 25524.67 | 35261.79 |
| ATT | 59461.79 | <.001 | 53017.08 | 65906.51 |
| ATC | 30380.7 | <.001 | 25511.48 | 35249.93 |

Table 11: Standardized differences in means for all independent variables after matching

| Means | Raw | | | Matched (ATE) | | |
|---|---|---|---|---|---|---|
| | With SCI /paralysis | Without SCI / paralysis | StdDiff | With SCI /paralysis | Without SCI / paralysis | StdDiff |
| | | | | | | |
| **Year** | | | | | | |
| **2006** [2] | | | | | | |
| **2007** | 0.064 | 0.074 | -0.036 | 0.090 | 0.075 | 0.055 |
| **2008** | 0.068 | 0.070 | -0.006 | 0.085 | 0.071 | 0.057 |
| **2009** | 0.058 | 0.068 | -0.041 | 0.069 | 0.069 | 0.001 |
| **2010** | 0.067 | 0.066 | 0.003 | 0.067 | 0.067 | 0.002 |
| **2011** | 0.072 | 0.065 | 0.028 | 0.059 | 0.064 | -0.019 |
| **2012** | 0.064 | 0.070 | -0.027 | 0.062 | 0.070 | -0.033 |
| **2013** | 0.071 | 0.070 | 0.003 | 0.074 | 0.070 | 0.018 |
| **2014** | 0.070 | 0.073 | -0.011 | 0.065 | 0.073 | -0.030 |
| **2015** | 0.069 | 0.075 | -0.022 | 0.064 | 0.074 | -0.041 |
| **2016** | 0.080 | 0.075 | 0.019 | 0.064 | 0.075 | -0.041 |
| **2017** | 0.085 | 0.075 | 0.039 | 0.078 | 0.074 | 0.013 |
| **2018** | 0.080 | 0.074 | 0.021 | 0.074 | 0.073 | 0.002 |
| **2019** | 0.084 | 0.074 | 0.034 | 0.061 | 0.073 | -0.046 |
| **Age-group** | | | | | | |
| **25 to 29 years** [2] | | | | | | |
| **<=19 years** | 0.059 | 0.079 | -0.077 | 0.087 | 0.080 | 0.027 |
| **20 to 24 years** | 0.207 | 0.226 | -0.046 | 0.223 | 0.227 | -0.010 |
| **30 to 34 years** | 0.259 | 0.251 | 0.019 | 0.230 | 0.251 | -0.048 |
| **35 to 39 years** | 0.167 | 0.135 | 0.090 | 0.131 | 0.133 | -0.006 |
| **>=40 years** | 0.046 | 0.034 | 0.064 | 0.037 | 0.032 | 0.025 |
| **Race/Ethnicity** | | | | | | |
| **White** [2] | | | | | | |
| **Black** | 0.200 | 0.153 | 0.122 | 0.143 | 0.150 | -0.017 |
| **Hispanic** | 0.166 | 0.180 | -0.035 | 0.179 | 0.182 | -0.010 |
| **Other** | 0.071 | 0.090 | -0.073 | 0.082 | 0.093 | -0.041 |
| **Unknown** | 0.110 | 0.113 | -0.007 | 0.129 | 0.113 | 0.051 |
| **Median Household Income** | | | | | | |
| **Quartile 1** | | | | | | |
| **Quartile 2** | 0.259 | 0.254 | 0.012 | 0.274 | 0.253 | 0.049 |
| **Quartile 3** | 0.222 | 0.242 | -0.047 | 0.221 | 0.244 | -0.053 |
| **Quartile 4** | 0.175 | 0.209 | -0.087 | 0.197 | 0.214 | -0.045 |
| **Location** | | | | | | |
| **Metro >= 1million** [2] | | | | | | |
| **Metro < 1million** | 0.290 | 0.287 | 0.009 | 0.295 | 0.287 | 0.020 |
| **Micropolitan** | 0.095 | 0.086 | 0.031 | 0.089 | 0.085 | 0.014 |
| **Not metro or micro** | 0.064 | 0.053 | 0.047 | 0.055 | 0.051 | 0.020 |
| **Primary Payer** | | | | | | |
| **Private** [2] | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Medicare** | 0.120 | 0.009 | 0.462 | 0.005 | 0.002 | 0.014 |
| **Medicaid** | 0.456 | 0.45 | 0.004 | 0.467 | 0.453 | 0.028 |
| **Self-pay** | 0.028 | 0.029 | -0.005 | 0.027 | 0.029 | 0.014 |
| **Other** | 0.032 | 0.030 | 0.012 | 0.032 | 0.029 | 0.012 |
| **Type of Admission** | | | | | | |
| **Non-elective** [2] | | | | | | |
| **Elective** | 0.326 | 0.473 | -0.302 | 0.510 | 0.481 | 0.059 |
| **Modified Elixhauser Comorbidity Index** | | | | | | |
| **Equals zero** [2] | | | | | | |
| **Equals one** | 0.271 | 0.237 | 0.077 | 0.241 | 0.235 | 0.013 |
| **Equals two** | 0/168 | 0.053 | 0.373 | 0.034 | 0.030 | 0.014 |
| **Equals three or more** | 0.128 | 0.016 | 0.445 | 0.006 | 0.005 | 0.006 |
| **Hospital Bed size** | | | | | | |
| **Small** [2] | | | | | | |
| **Medium** | 0.207 | 0.277 | -0.169 | 0.269 | 0.282 | -0.030 |
| **Large** | 0.705 | 0.588 | 0.246 | 0.603 | 0.585 | 0.038 |
| **Hospital Location/Teaching** | | | | | | |
| **Rural** [2] | | | | | | |
| **Urban nonteaching** | 0.211 | 0.306 | -0.218 | 0.312 | 0.312 | -0.003 |
| **Urban teaching** | 0.725 | 0.596 | 0.275 | 0.577 | 0.590 | -0.027 |
| **Hospital Region** | | | | | | |
| **Northeast** [2] | | | | | | |
| **Midwest** | 0.223 | 0.218 | 0.012 | 0.202 | 0.216 | -0.033 |
| **South** | 0.418 | 0.396 | 0.045 | 0.403 | 0.396 | 0.013 |
| **West** | 0.232 | 0.223 | 0.022 | 0.240 | 0.225 | 0.036 |

Table 12: Standardized differences in variances for all independent variables after matching

| Variances | Raw | | | Matched (ATE) | | |
|---|---|---|---|---|---|---|
| | With SCI /paralysis | Without SCI / paralysis | StdDif | With SCI /paralysis | Without SCI / paralysis | StdDif |
| | | | | | | |
| **Year** | | | | | | |
| **2006** [2] | | | | | | |
| **2007** | 0.060 | 0.068 | 0.884 | 0.082 | 0.070 | 1.168 |
| **2008** | 0.064 | 0.065 | 0.979 | 0.078 | 0.066 | 1.187 |
| **2009** | 0.055 | 0.063 | 0.864 | 0.064 | 0.064 | 1.055 |
| **2010** | 0.063 | 0.0619 | 1.012 | 0.063 | 0.062 | 1.007 |
| **2011** | 0.067 | 0.061 | 1.101 | 0.056 | 0.060 | 0.930 |
| **2012** | 0.060 | 0.065 | 0.912 | 0.058 | 0.066 | 0.892 |
| **2013** | 0.066 | 0.065 | 1.012 | 0.069 | 0.065 | 1.062 |
| **2014** | 0.065 | 0.068 | 0.966 | 0.061 | 0.067 | 0.901 |
| **2015** | 0.064 | 0.069 | 0.930 | 0.060 | 0.069 | 0.869 |
| **2016** | 0.0737 | 0.069 | 1.061 | 0.060 | 0.069 | 0.864 |
| **2017** | 0.078 | 0.069 | 1.130 | 0.072 | 0.069 | 1.044 |
| **2018** | 0.074 | 0.069 | 1.070 | 0.068 | 0.068 | 1.006 |
| **2019** | 0.077 | 0.069 | 1.114 | 0.057 | 0.068 | 0.842 |
| **Age-group** | | | | | | |
| **25 to 29 years** [2] | | | | | | |
| **19 years or less** | 0.056 | 0.073 | 0.770 | 0.079 | 0.074 | 1.077 |
| **20 to 24 years** | 0.164 | 0.175 | 0.939 | 0.173 | 0.175 | 0.987 |
| **30 to 34 years** | 0.192 | 0.188 | 1.023 | 0.177 | 0.188 | 0.943 |
| **35 to 39 years** | 0.139 | 0.117 | 1.194 | 0.114 | 0.115 | 0.987 |
| **40 years or more** | 0.044 | 0.033 | 1.351 | 0.036 | 0.031 | 1.148 |
| **Race/Ethnicity** | | | | | | |
| **White** [2] | | | | | | |
| **Black** | 0.160 | 0.130 | 1.233 | 0.123 | 0.127 | 0.963 |
| **Hispanic** | 0.139 | 0.147 | 0.942 | 0.147 | 0.149 | 0.985 |
| **Other** | 0.066 | 0.082 | 0.798 | 0.075 | 0.084 | 0.891 |
| **Unknown** | 0.098 | 0.100 | 0.982 | 0.112 | 0.100 | 1.123 |
| **Median Household Income** | | | | | | |
| **Quartile 1** | | | | | | |
| **Quartile 2** | 0.192 | 0.190 | 1.013 | 0.200 | 0.189 | 1.054 |
| **Quartile 3** | 0.173 | 0.184 | 0.942 | 0.172 | 0.184 | 0.935 |
| **Quartile 4** | 0.145 | 0.1656 | 0.874 | 0.158 | 0.168 | 0.939 |
| **Location** | | | | | | |
| **Metro >= 1million** [2] | | | | | | |
| **Metro < 1million** | 0.206 | 0.204 | 1.008 | 0.208 | 0.204 | 1.018 |
| **Micropolitan** | 0.086 | 0.079 | 1.0928 | 0.081 | 0.077 | 1.042 |
| **Not metro or micro** | 0.060 | 0.050 | 1.192 | 0.052 | 0.048 | 1.089 |
| **Primary Payer** | | | | | | |
| **Private** [2] | | | | | | |
| **Medicare** | 0.106 | 0.009 | 11.335 | 0.005 | 0.002 | 2.607 |
| **Medicaid** | 0.248 | 0.248 | 1.001 | 0.249 | 0.248 | 1.005 |
| **Self-pay** | 0.027 | 0.028 | 0.972 | 0.031 | 0.028 | 1.078 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Other** | 0.031 | 0.029 | 1.069 | 0.030 | 0.028 | 1.070 |
| **Type of Admission** | | | | | | |
| **Non-elective** [2] | | | | | | |
| **Elective** | 0.220 | 0.249 | 0.882 | 0.250 | 0.250 | 1.001 |
| **Modified Elixhauser Comorbidity Index** | | | | | | |
| **Equals zero** [2] | | | | | | |
| **Equals one** | 0.198 | 0.181 | 1.091 | 0.183 | 0.180 | 1.017 |
| **Equals two** | 0.140 | 0.050 | 2.785 | 0.033 | 0.029 | 1.145 |
| **Equals three or more** | 0.112 | 0.016 | 7.155 | 0.066 | 0.004 | 1.342 |
| **Hospital Bed size** | | | | | | |
| **Small** [2] | | | | | | |
| **Medium** | 0.164 | 0.200 | 0.820 | 0.197 | 0.202 | 0.972 |
| **Large** | 0.208 | 0.242 | 0.859 | 0.239 | 0.243 | 0.986 |
| **Hospital Location/Teaching** | | | | | | |
| **Rural** [2] | | | | | | |
| **Urban nonteaching** | 0.166 | 0.212 | 0.784 | 0.214 | 0.215 | 0.998 |
| **Urban teaching** | 0.199 | 0.241 | 0.828 | 0.244 | 0.242 | 1.009 |
| **Hospital Region** | | | | | | |
| **Northeast** [2] | | | | | | |
| **Midwest** | 0.173 | 0.170 | 1.017 | 0.161 | 0.169 | 0.953 |
| **South** | 0.243 | 0.239 | 1.017 | 0.241 | 0.239 | 1.006 |
| **West** | 0.178 | 0.173 | 1.029 | 0.182 | 0.174 | 1.046 |

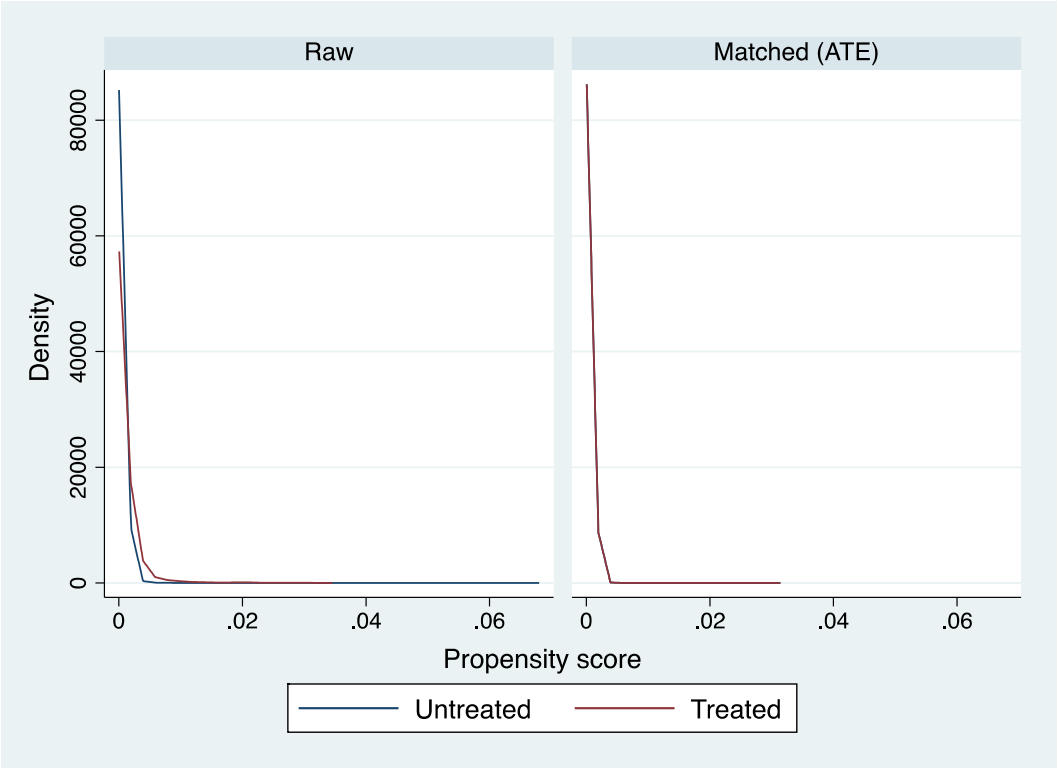



Figure 11: Common support

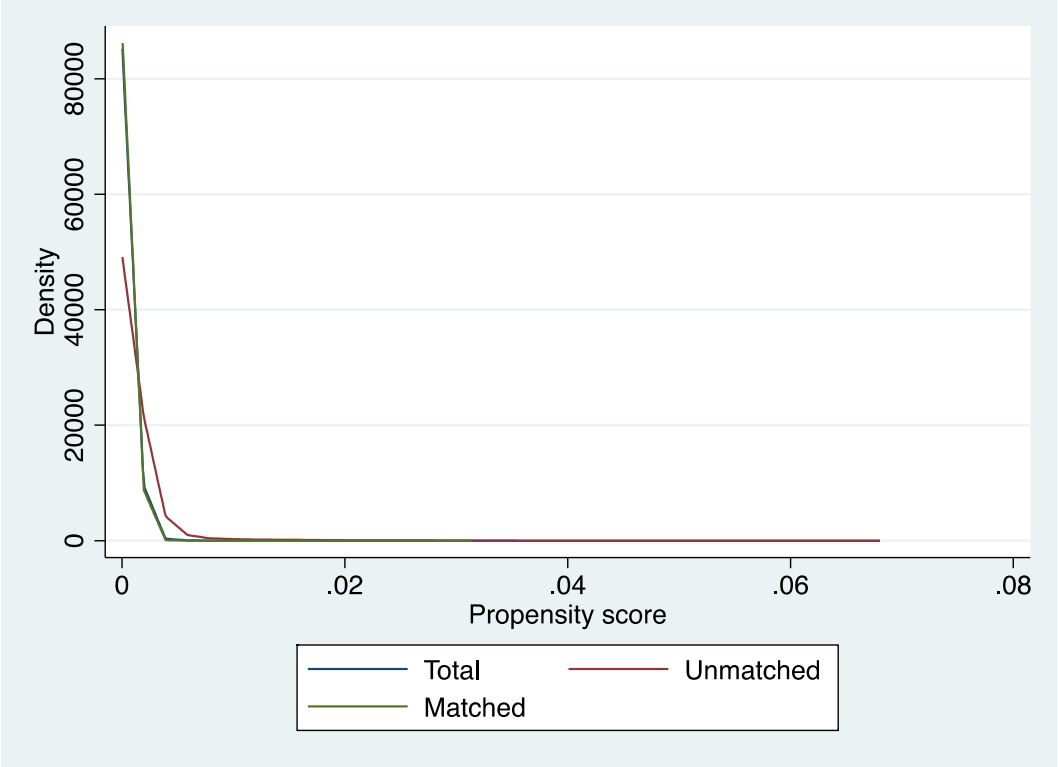



Figure 12: Unmatched cases

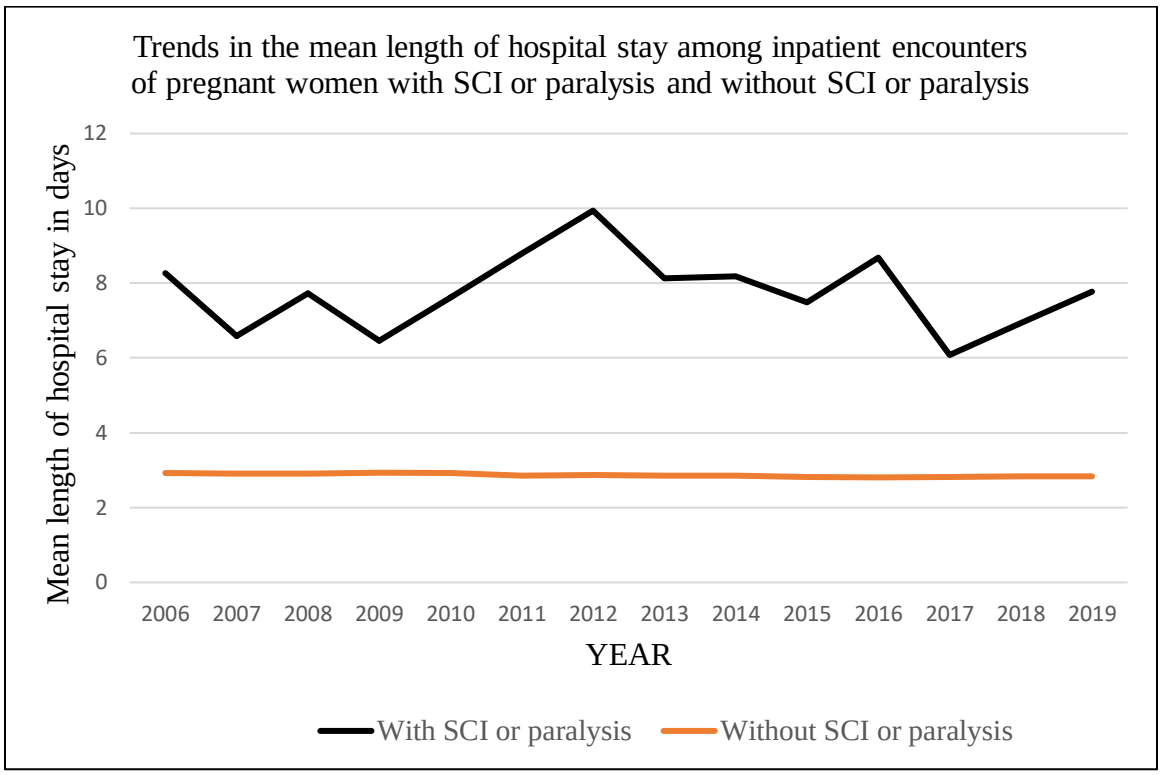



Figure 13: Trends in the mean length of hospital stay among inpatient encounters of pregnant women with SCI or paralysis and without SCI or paralysis

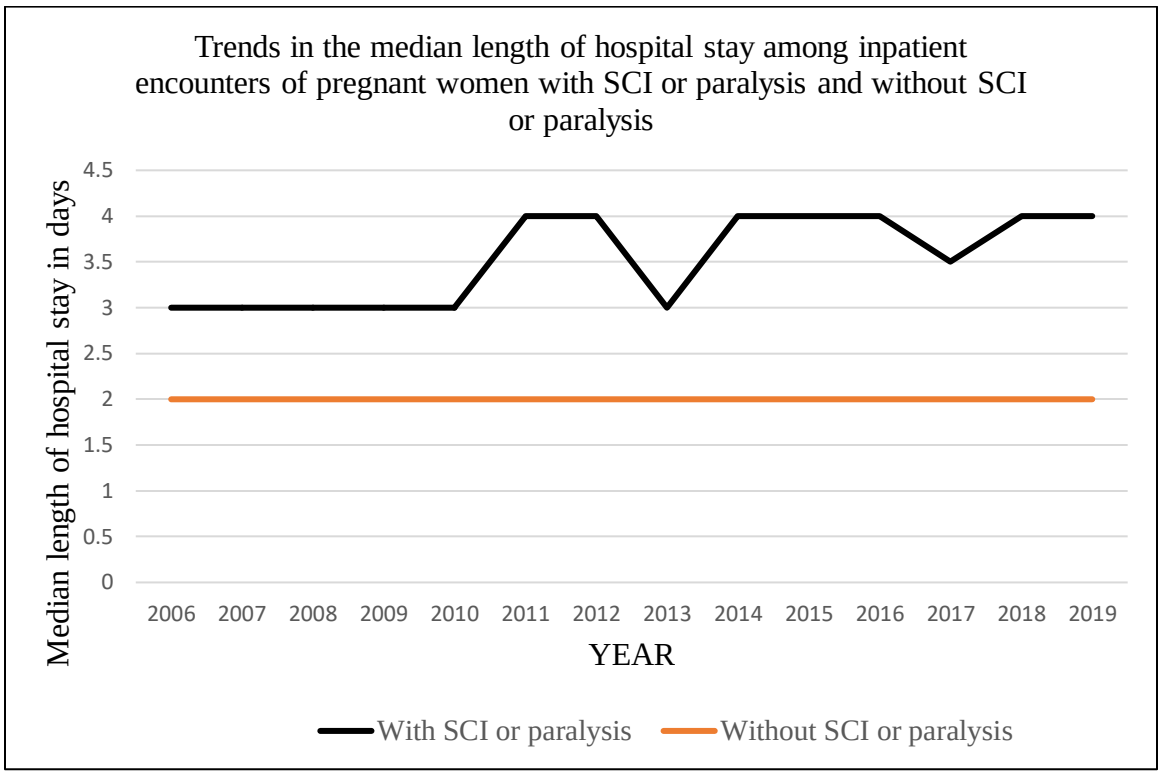



Figure 14: Trends in the median length of hospital stay among inpatient encounters of pregnant women with SCI or paralysis and without SCI or paralysis

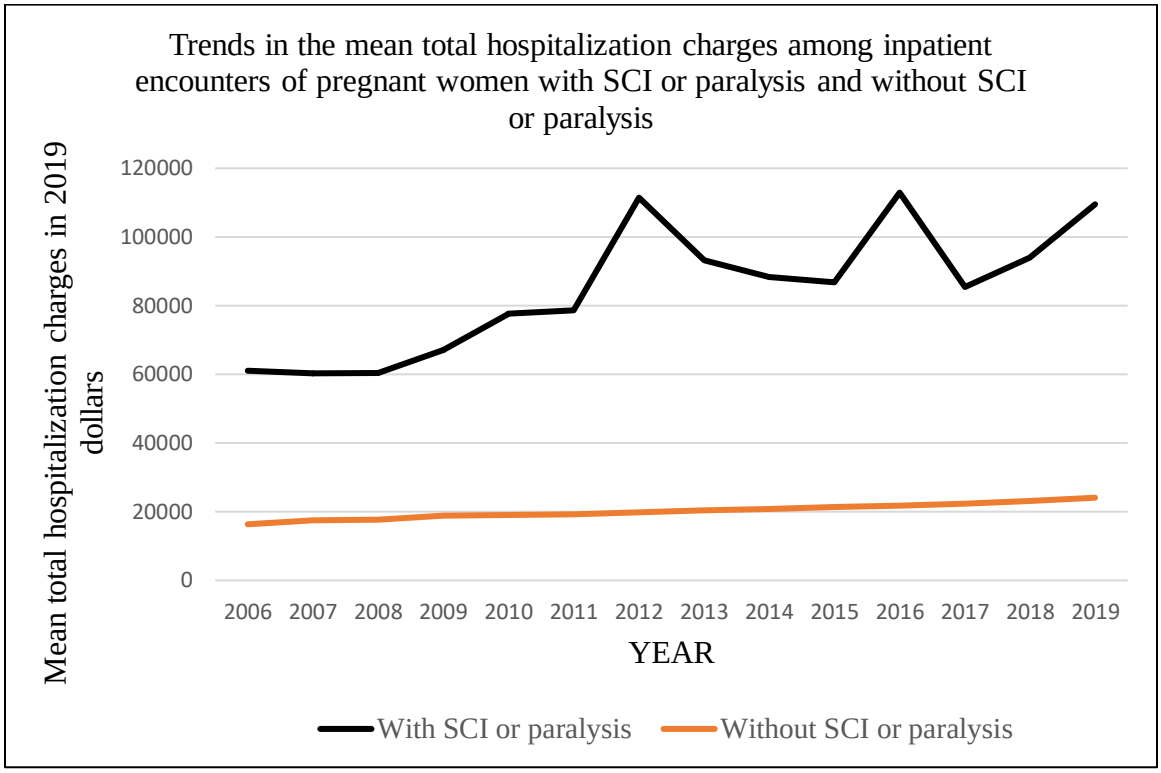



Figure 15: Trends in the mean total hospitalization charges among inpatient encounters of pregnant women with SCI or paralysis and without SCI or paralysis

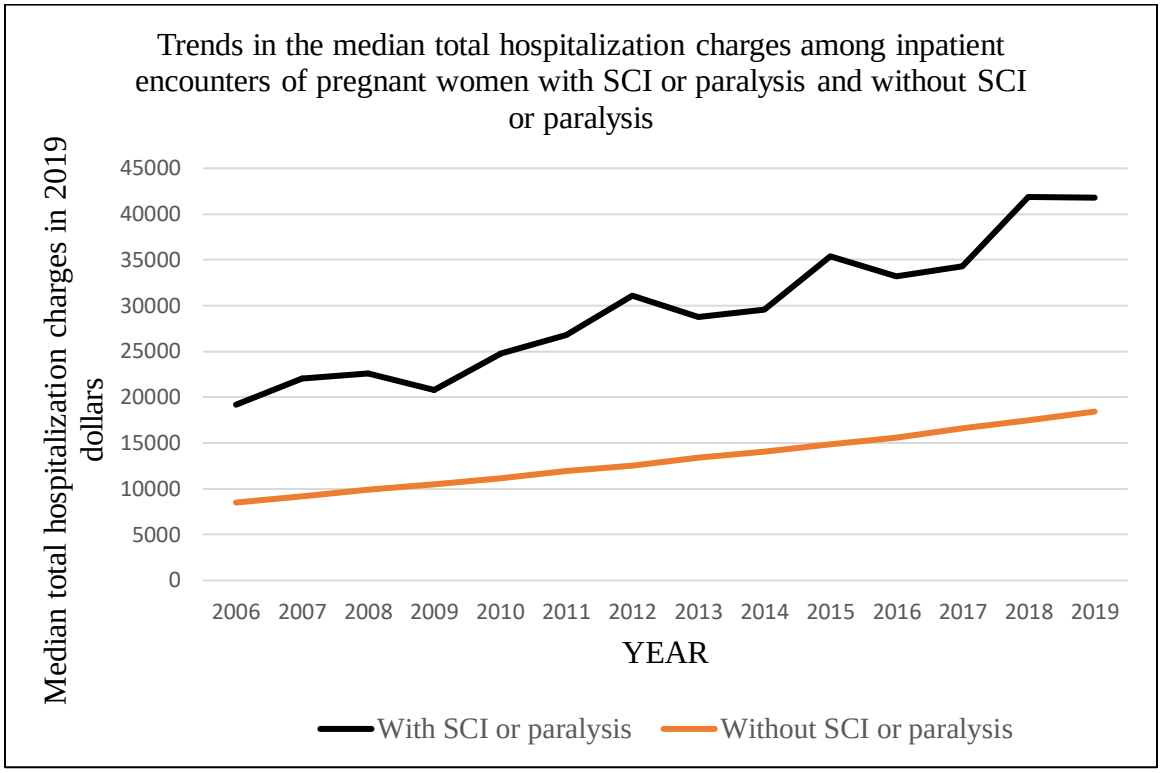



Figure 16: Trends in the median total hospitalization charges among inpatient encounters of pregnant women with SCI or paralysis and without SCI or paralysis

# CONCLUSION

The Triple Aim framework describes an approach to improving health system performance ("The IHI Triple Aim," 2021). It is essential to consider the relationship between access to healthcare and health outcomes at the population level. SCI results from damage to the spinal cord that leads to a temporary or permanent alteration in the spinal cord's normal function, which usually leads to severe morbidity and lifelong disability in the individual (Ahuja et al., 2017; Bennett et al., 2022) and SCI is one of the major causes of paralysis (Armour et al., 2016). Although research studies have reported that there is no evidence that SCI affects a woman's ability to get pregnant (Iezzoni et al., 2015; Jackson & Lindsey, 1998; McLain et al., 2016), this assertion has not been proven (Iezzoni et al., 2015), and so information on healthcare utilization pregnant women with SCI is limited. This dissertation aimed to address the existing research gaps pertaining to the healthcare utilization of pregnant women with disabilities like SCI or paralysis by employing the framework for the study of access and utilization developed by Aday and Andersen in 1974 (Aday & Andersen, 1974) to create the conceptual framework for the three manuscripts and using NIS, the largest inpatient hospitalization data in the United States.

The first manuscript in this dissertation assessed the healthcare utilization and trends of non-delivery related healthcare utilization for pregnant women with SCI/ paralysis in the United States, in terms of length of hospital stay and hospitalization

charges. The research study employed a hurdle model to examine the length of stay and linear regression to assess the hospitalization charges for inpatient department admissions of non-delivery-related pregnant women with SCI or paralysis. The OLS model with the outcome variable of total hospitalization charges (see Table 2). The average length of hospital stay and total hospitalization charges for pregnant women with SCI/paralysis admitted for non-delivery-related reasons were 7.85 days (median: 4 days, SD: +/- 14.85, IQR: 2 - 7 days) and $85,676.47 (median: $29,181.31, SD: +/-188,288.8, IQR: $15,757.56 - $70,767.22, in 2019 dollars). The total hospitalization charges for pregnant women with SCI/paralysis increased if they were Black, Hispanic, or Other as compared to White. Also, the average length of hospital stays for pregnant women with SCI/ paralysis aged 19 years or younger was 50.3% higher, and aged 40 years or above was 30.7% higher than the average length of stay for pregnant women with SCI/paralysis aged 25 to 29 years. The findings from this manuscript are beneficial in identifying characteristics associated with higher healthcare utilization among those with SCI or paralysis, offering evidence for which women may need more support and services while pregnant. This research study also highlighted the necessity for improved surveillance of pregnant women with disabilities.

The second manuscript examined the inpatient department healthcare utilization and the associated trends in the healthcare utilization of pregnant women with SCI/paralysis who are admitted to the hospital only for delivery or labor-related things. The research study used a negative binomial regression model for the length of hospital stay and the ordinary least squares regression with natural log transformation for total hospitalization charges. The average length of hospital stay in this population was 8.11

days (median: 4 days, SD: +/-15.27, IQR: 2 - 8 days) and the average total hospitalization charges were $79,027.84 (median: $30,043.4, SD: +/-186,048.9, IQR: $16,164.16 - $78,386.09, in 2019 dollars). The findings from this study inform healthcare providers about the need for delivery and labor-related inpatient hospitalization of pregnant women with disabilities such as SCI/paralysis, which can be leveraged when determining the frequency and number of prenatal care visits for this population. Furthermore, the results can also be beneficial in mentally or emotionally preparing pregnant women with disabilities well in advance regarding the higher probability of an extended length of hospital stay.

Finally, the third manuscript evaluated the impact of SCI/paralysis on the inpatient department healthcare utilization of pregnant women. It employed propensity-score kernel matching to determine the impact of SCI/paralysis on the healthcare services utilization for inpatient hospitalization encounters of pregnant women divided into groups - with SCI/paralysis and without SCI/paralysis. The results showed that pregnant women with SCI/paralysis had, on average, a length of stay of about three days (SE: 0.22) longer and a total hospitalization charge of approximately $30,393.23 (SE: $2,484.01, in 2019 dollars) more than the pregnant women without SCI/paralysis. The findings from this research study indicate that pregnant women with SCI/paralysis have greater healthcare services utilization when compared to pregnant women without SCI/paralysis.

**Implications for Policy and Practice**

To our best knowledge, this is the first study to look at the hospital utilization of pregnant women with spinal cord injury or paralysis. The results are beneficial in making recommendations for addressing the healthcare needs of pregnant women with

disabilities like SCI/paralysis. The findings from the first manuscript suggested that, on average pregnant women with SCI/paralysis who are 19 years or younger and 40 years or older have a longer length of hospital stay related to non-delivery related care when compared to pregnant women with SCI/paralysis in the age-group of 25-29 years. These findings suggests that the number and frequency of prenatal care visits may be increased for younger and older pregnant women with disabilities. Also, it was seen that the average length of hospital stay was longer and average total hospitalization charges were higher for pregnant women with SCI/paralysis who had a modified Elixhauser comorbidity index of one or more when compared to those with an index of zero. Therefore, it is crucial that in addition to the fact that pregnant women with disabilities are considered as high-risk pregnancies, a team of healthcare providers must work together to provide the necessary care for these patients because they have other comorbidities in addition to SCI/paralysis.

**Future research**

The findings from this dissertation provide a rationale for designing targeted interventions and healthcare policies to improve healthcare services utilization for this vulnerable population while also considering its financial implications. Future research studies must focus on understanding the prenatal and postnatal healthcare utilization of pregnant women with disabilities like SCI and paralysis so that the healthcare system is equipped to deliver quality care for this target population during their entire course of pregnancy, childbirth, and postnatal periods. Future research should also focus on examining these healthcare utilization outcomes if prenatal care visits of pregnant women with SCI/paralysis are increased. Additionally, it is important to quantify the out-of-

pocket costs of maternity care and delivery-related inpatient hospitalization for pregnant women with disabilities like SCI/paralysis.

REFERENCES

Aday, L. A., & Andersen, R. (1974). A framework for the study of access to medical care. *Health services research*, 9(3), 208-220.

Ahuja, C. S., Wilson, J. R., Nori, S., Kotter, M. R. N., Druschel, C., Curt, A., & Fehlings, M. G. (2017). Traumatic spinal cord injury. *Nature Reviews Disease Primers, 3*(1), 17018. doi:10.1038/nrdp.2017.18

Andersen, R. M. (1995). Revisiting the behavioral model and access to medical care: does it matter? *J Health Soc Behav, 36*(1), 1-10.

Armour, B. S., Courtney-Long, E. A., Fox, M. H., Fredine, H., & Cahill, A. (2016). Prevalence and Causes of Paralysis-United States, 2013. Am J Public Health, 106(10), 1855-1857. doi:10.2105/ajph.2016.303270

Baek, H., Cho, M., Kim, S., Hwang, H., Song, M., & Yoo, S. (2018). Analysis of length of hospital stay using electronic health records: A statistical and data mining approach. *PLoS One, 13*(4), e0195901. doi:10.1371/journal.pone.0195901

Bagley, N., & Levy, H. (2014). Essential health benefits and the Affordable Care Act: law and process. *Journal of health politics, policy and law, 39*(2), 441-465. doi:10.1215/03616878-2416325

Barr, J. K., Giannotti, T. E., Van Hoof, T. J., Mongoven, J., & Curry, M. (2008). Understanding barriers to participation in mammography by women with disabilities. *Am J Health Promot, 22*(6), 381-385. doi:10.4278/ajhp.22.6.381

Bennett, J., Das, J. M., & Emmady, P. D. (2022). Spinal Cord Injuries. In *StatPearls*. Treasure Island (FL): StatPearls Publishing.

Berwick, D. M., Nolan, T. W., & Whittington, J. (2008). The triple aim: care, health, and cost. *Health affairs (Project Hope), 27*(3), 759-769. doi:10.1377/hlthaff.27.3.759

Cardenas, D. D., Hoffman, J. M., Kirshblum, S., & McKinley, W. (2004). Etiology and incidence of rehospitalization after traumatic spinal cord injury: a multicenter analysis. *Arch Phys Med Rehabil, 85*(11), 1757-1763. doi:10.1016/j.apmr.2004.03.016

Carrasquillo, O. (2013). Health Care Utilization. In M. D. Gellman & J. R. Turner (Eds.), *Encyclopedia of Behavioral Medicine* (pp. 909-910). New York, NY: Springer New York.

Cavazos-Rehg, P. A., Krauss, M. J., Spitznagel, E. L., Bommarito, K., Madden, T., Olsen, M. A., . . . Bierut, L. J. (2015). Maternal age and risk of labor and delivery complications. *Matern Child Health J, 19*(6), 1202-1211. doi:10.1007/s10995-014-1624-7

Coffey, N. T., Cassese, J., Cai, X., Garfinkel, S., Patel, D., Jones, R., . . . Weinstein, A. A. (2017). Identifying and Understanding the Health Information Experiences and Preferences of Caregivers of Individuals With Either Traumatic Brain Injury, Spinal Cord Injury, or Burn Injury: A Qualitative Investigation. *J Med Internet Res, 19*(5), e159. doi:10.2196/jmir.7027

Crosby, E., St-Jean, B., Reid, D., & Elliott, R. D. (1992). Obstetrical anaesthesia and analgesia in chronic spinal cord-injured women. *Canadian Journal of Anaesthesia, 39*(5), 487-494. doi:10.1007/BF03008714

Dawood, R., Altanis, E., Ribes-Pastor, P., & Ashworth, F. (2014). Pregnancy and spinal cord injury. *The Obstetrician & Gynaecologist, 16*(2), 99-107. doi:10.1111/tog.12083

Dryden, D. M., Saunders, L. D., Rowe, B. H., May, L. A., Yiannakoulias, N., Svenson, L. W., . . . Voaklander, D. C. (2004). Utilization of health services following spinal cord injury: a 6-year follow-up study. *Spinal cord, 42*(9), 513-525. doi:10.1038/sj.sc.3101629

Elgendy, I. Y., Gad, M. M., Mahmoud, A. N., Keeley, E. C., & Pepine, C. J. (2020). Acute Stroke During Pregnancy and Puerperium. *Journal of the American College of Cardiology, 75*(2), 180-190. doi:10.1016/j.jacc.2019.10.056

Elixhauser, A., Steiner, C., Harris, D. R., & Coffey, R. M. (1998). Comorbidity measures for use with administrative data. *Med Care, 36*(1), 8-27. doi:10.1097/00005650-199801000-00004

Emergency Department and Inpatient Utilization and Cost for Pregnant Women: Variation by Expected Primary Payer and State of Residence, 2019. (2021). *Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality.* Retrieved from https://hcup-us.ahrq.gov/reports/ataglance/HCUPanalysisHospUtilPregnancy.pdf

Ghidini, A., Healey, A., Andreani, M., & Simonson, M. R. (2008). Pregnancy and women with spinal cord injuries. *Acta Obstet Gynecol Scand, 87*(10), 1006-1010. doi:10.1080/00016340802356909

Hambly, P. R., & Martin, B. (1998). Anaesthesia for chronic spinal cord lesions. *Anaesthesia, 53*(3), 273-289. doi:https://doi.org/10.1046/j.1365-2044.1998.00337.x

Hamilton, R., Driver, S., Noorani, S., Callender, L., Bennett, M., & Monden, K. (2017). Utilization and access to healthcare services among community-dwelling people living with spinal cord injury. *The journal of spinal cord medicine, 40*(3), 321-328. doi:10.1080/10790268.2016.1184828

HCUP NIS Description of Data Elements. Healthcare Cost and Utilization Project (HCUP). (2008a). *Agency for Healthcare Research and Quality.* Retrieved from https://hcup-us.ahrq.gov/db/vars/hosp_bedsize/nisnote.jsp

HCUP NIS Description of Data Elements. Healthcare Cost and Utilization Project (HCUP). (2008b). *Agency for Healthcare Research and Quality.* Retrieved from https://hcup-us.ahrq.gov/db/vars/h_region/nisnote.jsp

HCUP Overview. Healthcare Cost and Utilization Project. (2022). *Agency for Healthcare Research and Quality.* Retrieved from https://hcup-us.ahrq.gov/overview.jsp

Health, United States, 2020-2021: Health Care Expenditures. (2022). *Centers for Disease Control and Prevention. National Center for Health Statistics.* Retrieved from https://www.cdc.gov/nchs/hus/topics/health-care-expenditures.htm

Hocaloski, S., Elliott, S., Hodge, K., McBride, K., Hamilton, L., McBride, C. B., & Basso, M. (2017). Perinatal Care for Women with Spinal Cord Injuries: A Collaborative Workshop for Consensus on Care in Canada. *Topics in spinal cord injury rehabilitation, 23*(4), 386-396. doi:10.1310/sci16-00036

Horner-Johnson, W., Darney, B. G., Biel, F. M., & Caughey, A. B. (2020). Prolonged postpartum length of hospital stay among women with disabilities. *Disabil Health J, 13*(4), 100934. doi:10.1016/j.dhjo.2020.100934

Hughes, S. J., Short, D. J., Usherwood, M., & Tebbutt, H. (1991). Management of the pregnant woman with spinal cord injuries. *BJOG: An International Journal of Obstetrics & Gynaecology, 98*(6), 513-518. doi:10.1111/j.1471-0528.1991.tb10361.x

Iezzoni, L. I., Chen, Y., & McLain, A. B. (2015). Current pregnancy among women with spinal cord injury: findings from the US national spinal cord injury database. *Spinal cord, 53*(11), 821-826. doi:10.1038/sc.2015.88

Jackson, A. B., & Lindsey, L. (1998). Pregnancy and Women with SCI. *United Spinal Association. Spinal Cord Resource Center.* Retrieved from https://askus-resource-center.unitedspinal.org/index.php?pg=kb.page&id=1586

Johnson, R. L., Gerhart, K. A., McCray, J., Menconi, J. C., & Whiteneck, G. G. (1998). Secondary conditions following spinal cord injury in a population-based sample. *Spinal cord, 36*(1), 45-50. doi:10.1038/sj.sc.3100494

Khavjou, O. A., Anderson, W. L., Honeycutt, A. A., Bates, L. G., Razzaghi, H., Hollis, N. D., & Grosse, S. D. (2020). National Health Care Expenditures Associated With Disability. *Med Care, 58*(9), 826-832. doi:10.1097/mlr.0000000000001371

Law, A., McCoy, M., Lynen, R., Curkendall, S. M., Gatwood, J., Juneau, P. L., & Landsman-Blumberg, P. (2015). The prevalence of complications and healthcare costs during pregnancy. *J Med Econ, 18*(7), 533-541. doi:10.3111/13696998.2015.1016229

Longer Hospital Stays For Childbirth. (2015). *National Center for Health Statistics. Centers for Disease Control and Prevention.* Retrieved from https://www.cdc.gov/nchs/data/hestat/hospbirth/hospbirth.htm

MacDonald, S. C., McElrath, T. F., & Hernández-Díaz, S. (2019). Pregnancy Outcomes in Women With Multiple Sclerosis. *Am J Epidemiol, 188*(1), 57-66. doi:10.1093/aje/kwy197

Matin, B. K., Williamson, H. J., Karyani, A. K., Rezaei, S., Soofi, M., & Soltani, S. (2021). Barriers in access to healthcare for women with disabilities: a systematic review in qualitative studies. *BMC Womens Health, 21*(1), 44. doi:10.1186/s12905-021-01189-5

McDermott, K. W., Elixhauser, A., & Sun, R. (2017). Statistical Brief #225. Trends in Hospital Inpatient Stays in the United States, 2005–2014. *U.S. Department of Health and Human Services, Agency for Health Care Research and Quality, Healthcare Cost and Utilization Project.* Retrieved from https://hcup-us.ahrq.gov/reports/statbriefs/sb225-Inpatient-US-Stays-Trends.pdf

McLain, A. B., Massengill, T., & Klebine, P. (2016). Pregnancy and Women With Spinal Cord Injury. *Archives of Physical Medicine and Rehabilitation, 97*(3), 497-498. doi:10.1016/j.apmr.2015.10.078

Memtsoudis, S. G. (2009). Limitations associated with the analysis of data from administrative databases. *Anesthesiology, 111*(2), 449; author reply 450-441. doi:10.1097/ALN.0b013e3181adf739

Mitra, M., Clements, K. M., Zhang, J., Iezzoni, L. I., Smeltzer, S. C., & Long-Bellil, L. M. (2015). Maternal Characteristics, Pregnancy Complications, and Adverse Birth

Outcomes Among Women With Disabilities. *Med Care, 53*(12), 1027-1032. doi:10.1097/mlr.0000000000000427

Mitra, M., Long-Bellil, L. M., Iezzoni, L. I., Smeltzer, S. C., & Smith, L. D. (2016). Pregnancy among women with physical disabilities: Unmet needs and recommendations on navigating pregnancy. *Disability and Health Journal, 9*(3), 457-463. doi:10.1016/j.dhjo.2015.12.007

Mitra, M., Smith, L. D., Smeltzer, S. C., Long-Bellil, L. M., Sammet Moring, N., & Iezzoni, L. I. (2017). Barriers to providing maternity care to women with physical disabilities: Perspectives from health care practitioners. *Disabil Health J, 10*(3), 445-450. doi:10.1016/j.dhjo.2016.12.021

Moore, J. E., Witt, W. P., & Elixhauser, A. (2014). Complicating Conditions Associated With Childbirth, by Delivery Method and Payer, 2011. *HCUP Statistical Brief #173.* Retrieved from https://www.hcup-us.ahrq.gov/reports/statbriefs/sb173-Childbirth-Delivery-Complications.pdf

National Spinal Cord Injury Statistical Center. Spinal Cord Injury Facts and Figures at a Glance. (2019). Retrieved from https://www.nscisc.uab.edu/Public/Facts%20and%20Figures%202019%20-%20Final.pdf

National Spinal Cord Injury Statistical Center. Spinal Cord Injury Model System. Traumatic Spinal Cord Injury Facts and Figures at a Glance. (2022). Retrieved from https://www.nscisc.uab.edu/public/Facts%20and%20Figures%202022%20-%20English%20Final.pdf

NIS OVERVIEW. HCUP Databases. Healthcare Cost and Utilization Project (HCUP). (2022). *Agency for Healthcare Research and Quality.* Retrieved from https://hcup-us.ahrq.gov/nisoverview.jsp

Owens, P. L., Liang, L., Barrett, M. L., & Fingar, K. R. (2022). Comorbidities Associated With Adult Inpatient Stays, 2019. HCUP Statistical Brief #303. *Agency for Healthcare Research and Quality.* Retrieved from https://hcup-us.ahrq.gov/reports/statbriefs/sb303-Comorbidities-Adult-Hospitalizations-2019.pdf

Piatt, J. A., Nagata, S., Zahl, M., Li, J., & Rosenbluth, J. P. (2016). Problematic secondary health conditions among adults with spinal cord injury and its impact on social participation and daily life. *The journal of spinal cord medicine, 39*(6), 693-698. doi:10.1080/10790268.2015.1123845

Rae, M., Cox, C., & Dingel, H. (2022). Health Costs Associated with Pregnancy, Childbirth, and Postpartum Care. *Kaiser Family Foundation.* Retrieved from https://www.kff.org/health-costs/issue-brief/health-costs-associated-with-pregnancy-childbirth-and-postpartum-care/

Richardson, A., Samaranayaka, A., Sullivan, M., & Derrett, S. (2021). Secondary health conditions and disability among people with spinal cord injury: A prospective cohort study. *The journal of spinal cord medicine, 44*(1), 19-28. doi:10.1080/10790268.2019.1581392

Robertson, K., Dawood, R., & Ashworth, F. (2020). Vaginal delivery is safely achieved in pregnancies complicated by spinal cord injury: a retrospective 25-year

observational study of pregnancy outcomes in a national spinal injuries centre. *BMC Pregnancy and Childbirth, 20*(1), 56. doi:10.1186/s12884-020-2752-2

Roy, C. M., Bollman, E. B., Carson, L. M., Northrop, A. J., Jackson, E. F., & Moresky, R. T. (2021). Assessing the indirect effects of COVID-19 on healthcare delivery, utilization and health outcomes: a scoping review. *Eur J Public Health, 31*(3), 634-640. doi:10.1093/eurpub/ckab047

Sharma, N., Schwendimann, R., Endrich, O., Ausserhofer, D., & Simon, M. (2021). Comparing Charlson and Elixhauser comorbidity indices with different weightings to predict in-hospital mortality: an analysis of national inpatient data. *BMC Health Services Research, 21*(1), 13. doi:10.1186/s12913-020-05999-5

Shepard, C. L., Yan, P. L., Hollingsworth, J. M., & Kraft, K. H. (2018). Pregnancy among mothers with spina bifida. *Journal of Pediatric Urology, 14*(1), 11.e11-11.e16. doi:https://doi.org/10.1016/j.jpurol.2017.08.001

Siddique, S. M., Tipton, K., Leas, B., Greysen, S. R., Mull, N. K., Lane-Fall, M., . . . Tsou, A. Y. (2021). Interventions to Reduce Hospital Length of Stay in High-risk Populations: A Systematic Review. *JAMA network open, 4*(9), e2125846-e2125846. doi:10.1001/jamanetworkopen.2021.25846

Sikka, S., Callender, L., Driver, S., Bennett, M., Reynolds, M., Hamilton, R., . . . Petrey, L. (2019). Healthcare utilization following spinal cord injury: Objective findings from a regional hospital registry. *The journal of spinal cord medicine, 42*(2), 194-200. doi:10.1080/10790268.2018.1505330

Spinal cord injury. (2013). *World Health Organization.* Retrieved from https://www.who.int/news-room/fact-sheets/detail/spinal-cord-injury

Stagg, V. (2015). ELIXHAUSER: Stata module to calculate Elixhauser index of comorbidity. *Statistical Software Components*.

Sun, B. C., Hsia, R. Y., Weiss, R. E., Zingmond, D., Liang, L. J., Han, W., . . . Asch, S. M. (2013). Effect of emergency department crowding on outcomes of admitted patients. *Ann Emerg Med, 61*(6), 605-611.e606. doi:10.1016/j.annemergmed.2012.10.026

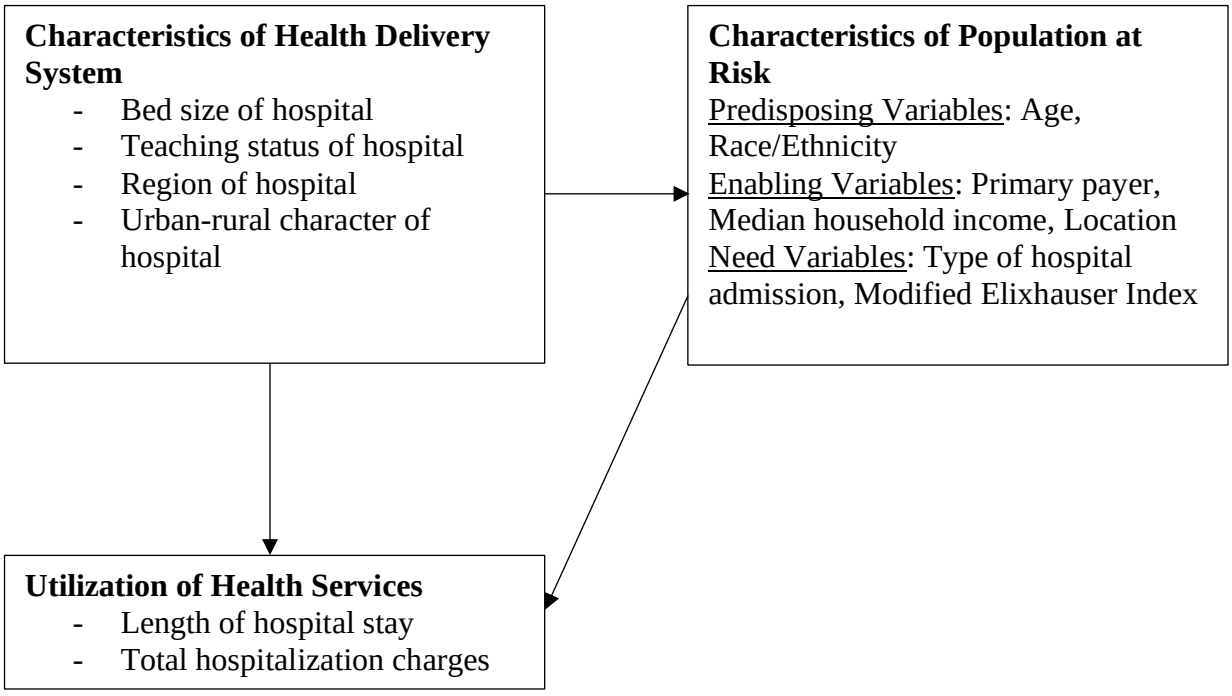
The IHI Triple Aim. (2021). *Institute for Healthcare Improvement.* Retrieved from http://www.ihi.org/Engage/Initiatives/TripleAim/Pages/default.aspx

U.S. Bureau of Labor Statistics. (n.d.). Databases, Tables & Calculators by Subject. *U.S. Bureau of Labor Statistics.* Retrieved from https://data.bls.gov/pdq/SurveyOutputServlet

Wyndaele, M., & Wyndaele, J. J. (2006). Incidence, prevalence and epidemiology of spinal cord injury: what learns a worldwide literature survey? *Spinal cord, 44*(9), 523-529. doi:10.1038/sj.sc.310189

APPENDICES

Appendix A: Conceptual model (adapted from Aday and Andersen's Framework for the Study of Access/Utilization)



Appendix B: Pregnancy codes - ICD-9

| Description | ICD-9 codes |
|---|---|
| Ectopic and molar pregnancy | 630 - 633.91 |
| Other pregnancy with abortive outcomes | 634.00 - 639.9 |
| Complications mainly related to pregnancy | 640.00 - 649.82 |
| Supervision of normal first pregnancy | V22.0 |
| Supervision of other normal pregnancy | V22.1 |
| Pregnant state, incidental | V22.2 |
| Supervision of high-risk pregnancy with history of infertility | V23.0 |
| Supervision of high-risk pregnancy with history of trophoblastic disease | V23.1 |
| Supervision of high-risk pregnancy with history of abortion | V23.2 |
| Supervision of high-risk pregnancy with grand multiparity | V23.3 |
| Pregnancy with history or preterm labor | V23.41 |
| Pregnancy with history of ectopic pregnancy | V23.42 |
| Pregnancy with other poor obstetric history | V23.49 |
| Supervision of high-risk pregnancy with other poor reproductive history | V23.5 |
| Supervision of high-risk pregnancy with insufficient prenatal care | V23.7 |
| Supervision of high-risk pregnancy with elderly prima gravida | V23.81 |
| Supervision of high-risk pregnancy with elderly multigravida | V23.82 |
| Supervision of high-risk pregnancy with young prima gravida | V23.83 |
| Supervision of high-risk pregnancy with young multigravida | V23.84 |
| Pregnancy resulting from assisted reproductive technology | V23.85 |
| Pregnancy with history of in utero procedure during previous pregnancy | V23.86 |
| Pregnancy with inconclusive fetal viability | V23.87 |
| Supervision of other high-risk pregnancy | V23.89 |
| Supervision of unspecified high-risk pregnancy | V23.9 |
| Pregnancy examination or test, positive result | V72.42 |

Appendix C: Pregnancy codes - ICD-10

| Description | ICD-10 codes |
|---|---|
| Pregnancy with abortive outcomes | O00-O08 |
| Supervision of high-risk pregnancy | O09 |
| Edema, proteinuria, and hypertensive disorders in pregnancy, childbirth, and the puerperium | O10-O16 |
| Other maternal disorders predominantly related to pregnancy | O20-O29 |
| Maternal care related to the fetus and amniotic cavity and possible delivery problems | O44-O48 |
| Maternal infectious and parasitic diseases classifiable elsewhere but complicating pregnancy, childbirth and the puerperium | O98 |
| Other maternal diseases classifiable elsewhere but complicating pregnancy, childbirth and the puerperium | O99 |
| Maternal malignant neoplasms, traumatic injuries and abuse classifiable elsewhere but complicating pregnancy, childbirth and the puerperium | O9A |
| Preterm labor without delivery | O60.0 (O60.0, O60.00, O60.02, O60.03) |
| Obstetrical tetanus | A34 |
| Encounter for pregnancy test, result positive | Z32.01 |
| Pregnant state | Z33 |
| Encounter for supervision of normal pregnancy | Z34 |

Appendix D: SCI/paralysis codes - ICD-9

| Description | ICD-9 codes |
|---|---|
| SCI sequelae | 905.1 |
| SCI sequelae | 907.2 |
| SCI sequelae | 806 |
| SCI sequelae | 952 |
| Paralysis | 342 |
| Other paralytic syndromes | 344 |

Appendix E: SCI/Paralysis codes - ICD-10

| Description | ICD-10 codes |
|---|---|
| SCI sequelae | S12.9XXS |
| SCI sequelae | S14 |
| SCI sequelae | S24 |
| SCI sequelae | S34 |
| Paralysis | G81 |
| Other paralytic syndromes | G82, G83 |

Appendix F: Delivery codes - ICD-9

| Description | ICD-9 codes |
|---|---|
| Normal delivery, and other indications for care in pregnancy, labor, and delivery | 650 - 659.93 |
| Complications occurring mainly in the course of labor and delivery | 660.00 - 669.94 |
| Complications of the puerperium | 670.00 - 677 |
| Other maternal and fetal complications | 678.00 - 679.14 |

Appendix G: Delivery codes - ICD-10

| Description | ICD-10 codes |
|---|---|
| Maternal care related to the fetus and amniotic cavity and possible delivery problems | O30 - O43 |
| Complications of labor and delivery | O60.1-O60.14, O61-O77 |
| Encounter for delivery | O80-O82 |
| Complications predominantly related to the puerperium | O85-O92 |
| Sequelae of complication of pregnancy, childbirth, and the puerperium | O94 |

CURRICULUM VITAE

Sonali S. Salunkhe, MD, MPH
485 E. Gray Street, Louisville, KY 40202
sonali.salunkhe@louisville.edu

## EDUCATION

**University of Louisville** — Louisville, KY
Doctor of Philosophy in Public Health Sciences — May 2023 (Expected)
Major: Health Management and Policy
Concentration: Health Policy Research
Dissertation: *Inpatient Department Hospital Utilization among Pregnant Women with Spinal Cord Injury or Paralysis in the United States*
Dissertation Committee: *Liza M. Creel, PhD, MPH (chair), Christopher E. Johnson, PhD, Beatrice Ugiliweneza, PhD, MSPH, Robert M. Carini, PhD*

**University of Louisville** — Louisville, KY
Master of Public Health — May 2019
Concentration: Health Policy

**Saratov State Medical University** — Saratov, Russia
Doctor of Medicine — June 2011

## EMPLOYMENT

**University of Louisville** — Louisville, KY
**School of Public Health and Information Sciences** — January 2019 - present
**Department of Health Management and Systems Sciences**
**NSF Center for Health Organization Transformation**
*Graduate Research Assistant*

- Writing study reports, research briefs, and manuscripts
- Conducting quantitative and qualitative data analysis
- Presenting project findings and updates (oral and poster) at academic conferences
- Conducting systematic literature review

- Collaborating with industry partners
- Performing data management
- Obtaining IRB approval from the University of Louisville

**University of Louisville** Louisville, KY
**School of Medicine** Dec. 2017 to Nov. 2018
**Department of Infectious Disease**
*Research Assistant*

- Audited the data collection for additional questions added to the HAPPI study
- Collaborated with clinicians
- Presented findings (poster) at the 2018 Research Louisville
- Audited all the screened patients for the SHARP study
- Performed quality checks of the entered data as a member of the Quality management team
- Conducted data collection from the electronic medical records of the hospitals
- Conducted telephone-based data collection

**Dr. Balabhai Nanavati Hospital** Mumbai, India
**Accident and Emergency Department** Feb. 2017 to July 2017
*Emergency Medical Officer*

**Jaslok Hospital and Research Centre** Mumbai, India
**Emergency Medical Services** Feb. 2016 to Oct. 2016
*Emergency Medical Officer*

**Wockhardt Hospital** Mumbai, India
**Emergency Medicine Department/ Intensive Care Unit** Jan. 2015 to Sept. 2015
*Resident Medical Officer*

## TEACHING EXPERIENCE

**University of Louisville**
**School of Public Health and Information Sciences**

*Guest Lecturer* 2023 (Spring)
PHMS 530: Comparative Health Systems
Topic: "India's Health System"

*Co-Instructor* 2022 (Fall)
PHMS 501: Introduction to Public Health and Administration

*Teaching Assistant* 2022 (Fall)

PHMS: 715: Health Policy Research

*Co-Instructor* 2021 (Fall)
PHMS 501: Introduction to Public Health and Administration

*Guest Lecturer* 2021 (Fall)
PHMS 662: Health Economics
Topic: "A Manager's Guide to Government in the Marketplace"

## INTERNSHIPS / VOLUNTEERSHIPS

**Louisville Metro Public Health Department and Wellness** Louisville, KY
Center for Health Equity Aug. 2018 to Nov. 2018

**Terna Medical College and Hospital** Navi Mumbai, India
**Navi Mumbai Municipal Hospital** Dec. 2011 to Dec. 2012

## PEER-REVIEWED PUBLICATIONS

Ezekekwu, E., **Salunkhe, S. S.**, Jennings, J., & Kelly Pryor, B. N. (2021). Community-based and System-level Interventions for Improving Food Security and Nutritious Food Consumption: A Systematic Review. *Journal of Hunger and Environmental Nutrition*, 1-21. doi: 10.1080/19320248.2021.2021120

Lister, C., **Salunkhe, S. S.**, O'Keefe, M., Payne, H., & Edmonds, T. (2021). Cultural Wellbeing Index: A Dynamic Cultural Analytics Process for Measuring and Managing Organizational Inclusion as an Antecedent Condition of Employee Wellbeing and Innovation Capacity. *Journal of Organizational Psychology*. 21(4), 21-40. https://doi.org/10.33423/jop.v21i4

Karimi, S. M.[+], **Salunkhe, S. S.**[+], White, K. B.[+], Little, B. B., McKinney, W. P., Mitra, R., Chen, Y., Adkins, E. R., Barclay, J. A., Ezekekwu, E., He, C. X., Hurst, D. M., Popescu, M. M., Swinney, D. N., Johnson, D. A., Hollenbach, R., Moyer, S. S., & DuPré, N. C. (2021). Prevalence of unmasked and improperly masked behavior in indoor public areas during the COVID-19 pandemic: Analysis of a stratified random sample from Louisville, Kentucky. *PloS one,* 16(7), e0248324. https://doi.org/10.1371/journal.pone.0248324

Edmonds, T., Drake, H., Miller, J., Trabue, N., Lister, C., **Salunkhe, S. S.**, O'Keefe, M., Alzahrani, S., White, K., & Levinson, A. (2021). A Framework for

Integrating Arts, Science, and Social Justice into Culturally Responsive Public Health Communication and Innovation Designs. *Health Promotion Practice*, 22(1_suppl), 70S-82S. https://doi.org/10.1177/1524839921996796

Karimi, S.[+], **Salunkhe, S. S.**[+], White, K.[+], Alzahrani, S., Little, B., Chen, Y., McKinney, W. P., Mitra, R., Popescu, M. M., Adkins, E. R., Barclay, J. A., Ezekekwu, E., He, C. X., Hurst, D. M., Kothagadi, A. R., Shakib, S. H., Swinney, D. N., Johnson, D. A., Hollenbach. R., Moyer, S. S., & DuPré, N. C. (2021). Facial Mask Use and COVID-19 Protection Measures in Jefferson County, Kentucky: Results from an Observational Survey, November 5−11, 2020. *The University of Louisville Journal of Respiratory Infections*, 5(1), Article no. 7. doi:10.18297/jri/vol5/iss1/7

O'Keefe, M., **Salunkhe, S. S.**, Lister, C., Johnson, C., & Edmonds, T. (2020). Quantitative and Qualitative Measures to Assess Organizational Inclusion: A Systematic Review. *Journal of Business Diversity*, 20(5), 49-70. doi:https://doi.org/10.33423/jbd.v20i5.3928

Alhasan, F., **Salunkhe, S.**, & Lippmann, S. (2019). Ebola 101. *South Med J*, 112(1), 54. doi:10.14423/smj.0000000000000909

[+]Authors had an equal contribution to the manuscript.

## ORAL PRESENTATIONS

**Salunkhe, S. S.***, Alzahrani, S., Wang, D., & Ugiliweneza, B. (2022). *"Trends and hospital care burden of abuse and neglect in individuals with spinal cord injury."* The American Public Health Association 2022 Annual Meeting & Expo. Boston, MA. November 2022.

**Salunkhe, S. S.***, Wang, D., Alzahrani, S. & Ugiliweneza, B. *"Insurance disparities in twelve-month healthcare utilization and cost in children with idiopathic scoliosis undergoing surgery."* The American Public Health Association 2021 Annual Meeting & Expo (Virtual). Denver, CO. October 2021.

**Salunkhe, S. S.*** & Ugiliweneza, B. *"Disparities in drug-related mortality in Appalachian and non-Appalachian regions of Kentucky."* The 2nd Edition of Global Conference on Addiction Medicine, Behavioral Health and Psychiatry (Virtual). Orlando, FL. October 2021.

**Salunkhe, S. S.***, Wang, D., Alzahrani, S., Boakye, M, & Ugiliweneza, B. *"The effect of the Patient Protection Affordable Care Act on Glioblastoma Multiforme cancer care and outcomes."* The 7th International conference on Public Health 2021 (Virtual). Sri Lanka. August 2021.

Karimi, S. M.*, **Salunkhe, S. S.**, White, K., Little, B., McKinney, W. P., DuPre, N., Mitra, R., Shakib, S., Chen, Y., Adkins, E., Alobaydullah, A., Alzahrani, S., Barclay, J., Ezekekwu, E., He, C., Hurst, D., Kothagadi, A., Popescu, M., Swinney, D., Johnson, D., Hollenbach, R., & Moyer, S. *"Observing Mask Use in the Jefferson County, KY: results from Stratified Random Sampling Studies."* 2021 Kentucky Public Health Association Annual Conference (Virtual). April 2021.

Karimi, S. M.*, Hamid, Z., LaZur, R., Little, B., McKinney, P. W., DuPre, N., Mitra, R., Chen, Y., Patel, N., **Salunkhe, S. S.**, Hollenbach, R., Moyer, S., Schutze, M. *"County and Regional Projections of COVID-19 Trends in Kentucky."* 2021 Kentucky Public Health Association Annual Conference (Virtual). April 2021.

**Salunkhe, S. S.*** & Ugiliweneza, B. *"Drug-related mortality in association with diversity, earnings and geographic elevation in Kentucky counties."* The 14th Annual Graduate Student Regional Research Conference (Virtual). March 2021.

**Salunkhe, S. S.*** & Edmonds, T. *"Cultural Wellbeing Index: A Scientific Approach Using Public Health to Improve Business."* Breakout Session at 2020 National Network of Public Health Institutes Annual Conference (Cancelled due to COVID-19). New Orleans, LA. May 2020.

**Salunkhe, S. S.*** & Edmonds, T. *"Arts-based interventions and youth emotional wellbeing."* CHOT Industry Advisory Board meeting. Malvern, PA. March 2019.

**Salunkhe, S. S.*** & Edmonds, T. *"Arts-based interventions and youth emotional wellbeing."* CHOT Partner meeting. Louisville, KY. March 2019.

Ezekekwu, E.* & **Salunkhe, S. S.*** *"Systematic Review of Effective Community-Based and System Level Interventions for Improving Food Security."* CHOT Partner meeting. Louisville, KY. March 2019.

*Presenter

## POSTER PRESENTATIONS

**Salunkhe, S. S.***, Alzahrani, S., Wang, D., & Ugiliweneza, B. (2022). *"Trends and burden of pediatric non-traumatic spinal cord injury care in the United States."* The American Public Health Association 2022 Annual Meeting & Expo. Boston, MA. November 2022.

**Salunkhe, S. S.**, Alzahrani, S.* & Ugiliweneza, B. (2022). "*Disparities in Mortality between Appalachian and Non-Appalachian Regions of Kentucky."* The 2022 AcademyHealth Annual Research Meeting. June 2022.

**Salunkhe, S. S.***, Alzahrani, S., Denghzi, W., Boakye, M. & Ugiliweneza, B. (2022). *"Racial Disparities and the Effect of the Patient Protection and Affordable Care Act on Glioblastoma Multiforme Cancer Care and Outcomes."* The 2022 Kentucky Public Health Association Annual Conference. April 2022.

**Salunkhe, S. S.**, Alzahrani, S.* & Ugiliweneza, B. (2022). *"Disparities in Mortality between Appalachian and Non-Appalachian Regions of Kentucky."* The 2022 Kentucky Public Health Association Annual Conference. April 2022.

Ezekekwu, E., **Salunkhe, S. S.***, Jennings, J.C., & Kelly-Pryor, B.N. (2022). *"Systematic Review of Effective Community-Based and System Level Interventions for Improving Food Security."* The CHOT 2022 Spring IAB Meeting. Louisville, KY. March 24, 2022.

Curnutte, M.*, **Salunkhe, S. S.**, Eggen, M., Alam, M., Johnson, C. E., Bai, L., & Bewley, L. (2022). *"Primary Care Access Expansion to Reduce Health Disparities."* The CHOT 2022 Spring IAB Meeting. Louisville, KY. March 24, 2022.

**Salunkhe, S. S**., Wang, D., & Ugiliweneza, B. (2021). *"Trend and hospital care burden of abuse and neglect in pediatric spinal cord injury."* Research Louisville 2021. Louisville, KY. October 27, 2021.

**Salunkhe, S. S.*** (2021). *"The effects of Medicaid Expansion under the Affordable Care Act on the quality of cancer care: A systematic review."* The American Public Health Association 2021 Annual Meeting & Expo (Virtual). Denver, CO. October 2021.

O'Keefe, M., **Salunkhe, S. S.***, Lister, C., Johnson, C., & Edmonds, T. (2021). *"Quantitative and qualitative measures to assess organizational inclusion: A Systematic Review."* The 2021 AcademyHealth Annual Research Meeting (Virtual). June 2021.

**Salunkhe, S. S.***, Brown, A., & Edmonds, T. (2021). *"Arts-based interventions and emotional wellbeing of the youth: A systematic review."* The 2021 Kentucky Public Health Association Annual Conference (Virtual). April 2021.

**Salunkhe, S. S.*** & Ugiliweneza, B. (2021). *"Drug-related mortality in association with diversity, earnings and geographic elevation in Kentucky counties."* The 2021 Kentucky Public Health Association Annual Conference (Virtual). April 2021.

**Salunkhe, S. S.*** & Ugiliweneza, B. (2021). *"Drug-related mortality in association with diversity, earnings and geographic elevation in Kentucky counties."* The 14th Annual Graduate Student Regional Research Conference (Virtual). March 2021.

**Salunkhe, S.S.** (2020). *"Association between socio-demographic factors and sleep duration."* Won the Delta Omega Student Poster Competition 2020. The American Public Health Association 2020 Annual Meeting & Expo (Virtual). San Francisco, CA. October 2020.

Ezekekwu, E.*, **Salunkhe, S. S.**, Jennings, J.C., & Kelly-Pryor, B.N. (2020). *"Systematic Review of Effective Community-Based and System Level Interventions for Improving Food Security."* The 2020 AcademyHealth Annual Research Meeting (Virtual). Boston, MA. June 2020.

Ezekekwu, E.*, **Salunkhe, S. S.**, Jennings, J.C., & Kelly-Pryor, B.N. (2020). *"Systematic Review of Effective Community-Based and System Level Interventions for Improving Food Security."* The 2020 Kentucky Public Health Association Annual Conference (Virtual). Covington, KY. April 2020.

**Salunkhe, S. S.***, & Edmonds, T. (2019). *"Cultural Wellbeing, Inclusion and Innovation Capacity in the Careforce- Specific focus: Non-clinical Home Care Workers."* The CHOT 2019 Fall IAB Meeting. Seattle, WA. October 17, 2019.

**Salunkhe, S. S.***, & Edmonds, T. (2019). *"HopeBox Health: Cultural Innovation for Population Health Improvement."* The CHOT 2019 Fall IAB Meeting. Seattle, WA. October 17, 2019.

**Salunkhe, S.***, Gautam, S., Patel, N., Sajjad, R., Trail, W., Tahboub, M., & Arnold, F. (2018). *"Streptococcus pneumoniae urinary antigen detection is the most accurate test for diagnosis of pneumococcal pneumonia."* Research Louisville 2018. Louisville, KY. October 10, 2018.

Tahboub, M.*, **Salunkhe, S.**, Ghouri, Y., Aboelnasr, A., Trail, W., & Burns, M. (2018). *"The presence of bacteremia in hospitalized patients with pneumococcal pneumonia is not associated with an increased risk of death."* Research Louisville 2018. Louisville, KY. October 10, 2018.

Aboelnaser, A.*, Jibril, O., Sutrawe, A., **Salunkhe, S.**, Trail, W., & Raghuram, A. (2018). *"Arrhythmia is the most frequent cardiovascular event in hospitalized patients with pneumococcal pneumonia."* Research Louisville 2018. Louisville, KY. October 10, 2018.

Alhasan, F.*, Aboelnaser, A., Chitekela, J., **Salunkhe, S.**, Trail, W., Tahboub, M., & Ramirez, J. (2018). *"The risk of developing pneumonia in the adult Louisville*

*population: The number of adults needed to diagnose one episode of pneumonia."* Research Louisville 2018. Louisville, KY. October 10, 2018.

*Presenter