12-2022

Rehabilitation length of stay in individuals with spinal cord injury paraplegia.

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REHABILITATION LENGTH OF STAY IN INDIVIDUALS WITH SPINAL CORD INJURY PARAPLEGIA

By

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B.A., King Abdul-Aziz University, 2008

M.Sc., University of New Haven, 2013

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 System Sciences

School of Public Health and Information Sciences

University of Louisville

Louisville, Kentucky

December 2022

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A Dissertation Approved on

November 15, 2022

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DEDICATION

I dedicate this dissertation to my wife, Maryam, who has been supportive, encouraging and patient since my first day in the PhD program and to my daughter, Sara, who always brings nothing but happiness to my life, I love you.

ACKNOWLEDGEMENTS

I would like to thank my dissertation chair, Dr. Chris Johnson for his constant support and encouragement during my dissertation. My academic advisor and mentor, Dr. Johnson has been always present when I need advice or assistance since the first day of my Ph.D. program. A very special thanks to Dr. Beatrice Ugiliweneza who worked beyond her duties to guide and support me in this dissertation. Also, I would like to extend my gratitude to Dr. Seyed Karimi for his guidance, feedback and help that had a significant impact on my dissertation. Dr. Karimi has been a fundamental source of support and encouragement during this dissertation. I also would like to thank Dr. Doug Lorenz for his valuable contribution throughout my PhD program. Dr Lorenz has been a role model for me since my first day in the program and I have developed tremendously as a student by his advice, knowledge and experience.

I would like to thank my colleague and friend, Sonali Salunkhe for sharing this journey with me all these years. We worked together on several research projects; she always supported and encouraged me. Additionally, I would like to express my gratitude to all my colleagues in the Department of Health Management and System Sciences for their continued support during the program.

I would like to thank my entire family, including my parents, siblings, nephews and nieces for their unconditional love and support during these years. And finally, I

would like to extend a big thank to my loving wife, Maryam, for being always supportive, helpful and caring.

ABSTRACT

REHABILITATION LENGTH OF STAY IN INDIVIDUALS WITH SPINAL CORD INJURY PARAPLEGIA

Sahal Alzahrani

November 15, 2022

Background: Spinal Cord Injury (SCI) is associated with functional and physical limitations as well as psychological challenges. Rehabilitation care is crucial to SCI individuals' overall health. It is recommended that individuals with SCI receive an intensive and early rehabilitation care to improve their health and avoid medical complications. Hospitals and rehabilitation facilities use length of stay (LOS) as a proxy to quantify rehabilitation care and a measure for quality of care.

Objectives: This dissertation has three aims: 1) to identify factors associated with rehabilitation LOS in paraplegia populations, 2) to examine trends of inpatients rehabilitation LOS in SCI paraplegia between 1988 and 2016 in the United States, 3) to evaluate the association between rehabilitation LOS and health outcomes in SCI paraplegia after one-year of inpatient rehabilitation discharge from 2000 to 2015 in the United States.

Methods: The first manuscript used a systematic review of the existing literature to identify the factors associated with rehabilitation LOS in paraplegia. The review included only peer-reviewed articles from the United States between 1980 to 2022. The search was conducted in three databases: PubMed, Embase, and CINAHL. The second manuscript used the National Spinal Cord Injury Statistic Center (NSCISC) database to examine the trends of rehabilitation LOS in SCI paraplegia between 1988 and 2016. The multivariable linear regression was used for statistical analysis with interaction term model between Functional Independence Measurement (FIM) score and years (1988-2016). The Donabedian model for quality of care was used to construct the manuscript and the selected variables. The third manuscript used the same database (NSCISC) that was used for the second manuscript. The International Classification of Function, Disability and Health (ICF) framework was applied to examine the association between the rehabilitation LOS and the health outcomes of individuals with SCI paraplegia after one-year of inpatient rehabilitation discharge. Seven health outcomes were examined in this manuscript including FIM scores, satisfaction of life scale (SWLF), rehospitalization, and four Craig Handicap Assessment and Reporting (CHART) scores (physical independence, mobility, occupation and social integration scores). Multivariable logistic, linear and quantile regressions were used for statistical analysis. In the second and third manuscripts, the sociodemographic disparities were evaluated.

Results: In manuscript 1, the systematic review identified 13 articles for final review. The results yielded 6 factors associated with rehabilitation LOS: age, gender, type of etiology, severity of injury, surgical intervention and body weight. Of the 6 factors, only age and severity of injury had significant effect on rehabilitation LOS, while the rest did

not show significant results. In manuscript 2, the finding of linear regression showed that rehabilitation LOS decreased by 1.4% on average each year from 1988 to 2016. Shorter rehabilitation was associated with younger age, being employed, having incomplete paraplegia, and having higher FIM scores. In manuscript 3, the first year of post-discharge outcomes became worse or did not improve from 2000 to 2015. Of the 7 health outcomes included in the study, FIM scores, physical independence scores, and rehospitalization rates showed significantly negative results over years. Moreover, old, unemployed, and with complete paraplegia had lower FIM score, higher rehospitalization rate, lower SWLF scores, and higher degree of handicap in physical independence, mobility, occupation, and social integration handicap. In addition, higher degree of handicap of physical independence, mobility, and occupation, lower FIM scores, lower SWLF and higher rate of rehospitalization were associated with longer rehabilitation LOS.

Conclusion: The dissertation's manuscripts found that age and severity of injury were the most factors affecting rehabilitation LOS. Also, rehabilitation LOS continued to decline over years with variation among sociodemographic factors. Patients who were young, employed with incomplete paraplegia and with higher FIM had shorter rehabilitation LOS. The health outcomes after inpatient rehabilitation discharge were worse or did not improve over years. Shorter rehabilitation was associated with better health outcomes in physical independence and mobility scores, FIM score, SWLF, and rehospitalization rates.

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CHAPTER 1. INTRODUCTION

1.1 BACKGROUND

Spinal cord injury (SCI) is a devastating incident associated with psychological and physical challenges (Eastwood, 1999; Peterson et al., 2022). SCI often causes intense motor and sensory impairments that lead to functional limitations, poor quality of life and lower participation in daily activities (Marino et al., 1999; Piatt et al., 2016; Wollaars et al., 2007). In the United States, the estimated incidence of SCI, as of 2021, is approximately 17,900 case each year and 40 % of these cases are paraplegic (National Spinal Cord Injury Statistic Center, 2021). There are estimated to be 299,000 Individuals with SCI living in the United States. Since 2015, the average age at injury has increased from 29 years at 1970s to 43 years old, with a majority male up to 78% (National Spinal Cord Injury Statistics Center, 2021). Traumatic SCI is the highest cause of paraplegia (vehicle accidents 38%, falls 32%, acts of violence 14%), followed by medical and surgical complications (National Spinal Cord Injury Statistics Center, 2021). In the United States, the average annual expenses, which include the healthcare cost and living expenses, of patients with paraplegia is roughly $567,011 in the first year and $75,112 in each subsequent year (National Spinal Cord Injury Statistics Center, 2021).

According to International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI), SCI are classified on the neurological level of injury and

the American Spinal Cord Injury Association (ASIA) Impairment Scale (AIS) scores (Rupp et al., 2021). Neurological level of injury is categorized into two major groups: complete or incomplete tetraplegia, and complete or incomplete paraplegia (Rupp et al., 2021). Whereas AIS score is used to quantify the degree of individuals' functional impairment and the scores are graded as A, B, C, D, and E grades according to severity of the impairment (Rupp et al., 2021).

In the rapidly increasing expenditure of healthcare, extensive effort has been placed to maintain healthcare efficiency, especially by reducing length of stay (LOS). Organizations often use LOS as a measure of performance and efficiency of healthcare systems (Agency for Healthcare Research and Quality, 2020). Munce et al (2012) found that inpatient rehabilitation care was the largest cost drive to healthcare system in individuals with traumatic SCI (Munce et al., 2013). Rehabilitation LOS is often used as a proxy of the quantity and intensity of rehabilitation care. Whiteneck et al (2011) found that the total hours of treatment were determined by rehabilitation LOS (Whiteneck, 2011).

Ideally, reducing rehabilitation LOS would successfully reduce costs, medical utilization, and overall burden to healthcare systems. However, rehabilitation care is known as complex long-term care and consists of various phases with different approaches, which makes achieving healthcare efficiency challenging. Also, LOS is associated with multiple factors, including medical acuity, psychological and social status of patients, healthcare services, and payment methods. Some healthcare providers are concerned that rehabilitation LOS may be too short, which may place patients at risk of medical problems.

As a potential consequence of organizations' effort to maintain the cost, research found that hospital LOS and rehabilitation LOS in SCI decreased by 11.4 days and 62.6 days, respectively, over the past three decades in the United States (DeVivo, 2007). In paraplegia, the average LOS decreased from 82.2 days in 1991 to 46.7 days in 1995 (Morrison, 1999). Several factors impact rehabilitation LOS including sociodemographic characteristics, severity of injury, and functional status of individuals with SCI. For example, individuals with SCI who were older experienced longer rehabilitation LOS compared to younger people (Eastwood, 1999; Hsieh, 2013). Moreover, Black, or African American populations had shorter rehabilitation LOS when compared to White groups (Eastwood, 1999; Fyffe et al., 2014). Also, research found that individuals with severe injuries and poorer functional status had longer rehabilitation LOS (Catharine Craven, 2017; Tooth, 2003; Wu et al., 2013). Furthermore, Medicaid beneficiaries with SCI experienced longer LOS compared to non-Medicaid groups in West Virginia (Sedney, 2020). Additionally, individuals with non-traumatic SCI had shorter LOS compared to traumatic SCI (Al-Jadid & Robert, 2010; Cosar et al., 2010).

Previous research sought to examine the association between rehabilitation LOS and health outcomes of individuals with SCI. For instance, Kao et al (2022) found that longer rehabilitation LOS was associated with better Functional Independence Measure (FIM) scores (Kao, 2022). Also, research found shorter rehabilitation LOS was associated with increased rehospitalization occurrences and increased the needed assistance for bowel management (DeJong, 2013; Wilkinson, 2022). Also, Whiteneck et al (2012) found longer stay in rehabilitation predicts lower discharge functional status and lower mobility scores (Whiteneck, 2012). However, some research showed contrary results that

shorter LOS was associated with positive outcomes in functional status, social supports, and discharge to home (Eastwood, 1999).

Although previous research have examined SCI rehabilitation widely, there was little research that focused on rehabilitation LOS and its impact on health outcomes especially in individuals with paraplegia. Therefore, this research aimed to provide a comprehensive analysis to fill this gap in literature.

1.2 RESEARCH AIMS

The dissertation's manuscripts focus mainly on understanding rehabilitation LOS in paraplegic population. The three manuscripts comprised three aims: 1) to identify the factors associated with rehabilitation LOS in paraplegic, 2) to examine the trends of rehabilitation LOS in paraplegia SCI between 1988 and 2016 in the United States, 3) to investigate the association between rehabilitation LOS and health outcomes after one year of inpatient rehabilitation discharge in paraplegia SCI from 2000 to 2015 in the United States.

The manuscripts of this dissertation were designed to collectively explain the factors influencing rehabilitation LOS, and the trends of rehabilitation LOS over time and its impact on functional and health outcomes. Also, the dissertation's manuscripts were arranged in favor of that each aim informed the following aim.

In manuscript 1, a systematic review was performed to identify the factors associated with rehabilitation LOS in paraplegic population, which is the basis for this dissertation. The systematic literature review was conducted using the Preferred Reposting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. This

manuscript aimed to answer the first research question: "**what are the factors associated the rehabilitation LOS in individuals with paraplegia?**"

In manuscript 2, multivariable regression analysis was performed to capture the change of rehabilitation LOS between 1988 and 2016 using the national SCI database. This manuscript was grounded by the Donabedian model of quality framework, which is also known as structure, process, and outcome (SPO) framework. The (SPO) helps to structure the manuscript's goal and validate the variable selection. This manuscript sought to answer the second research question: "**what are the trends of inpatient rehabilitation LOS in patients with paraplegia after traumatic SCI between 1988 and 2016?".** The hypothesis is that rehabilitation LOS decreased in patients with SCI paraplegia between 1988 and 2016.

In the third manuscript, multivariable logistic, quantile, and linear analysis were conducted to examine the association between rehabilitation LOS and health and functional outcomes after one year of inpatient rehabilitation discharge. The national SCI database was used to evaluate the manuscript's objective. In this manuscript, the International Classification of Functioning, Disability, and Health (ICF) was used to construct the model and support the selected factors. The main objective of this manuscript was to answer the third research question: **"What is the association between rehabilitation LOS and health and functional outcomes after one year of discharge from inpatient rehabilitation care in individuals with SCI paraplegia?"** The hypothesis is that health outcomes are positively associated with rehabilitation LOS, and it is anticipated to find worse health outcomes from 2000 to 2015 if rehabilitation LOS continues to decline.

Together, the three manuscripts provide an integrated analysis of what factors influence rehabilitation LOS, what happens to rehabilitation LOS over time and what the impact of rehabilitation LOS is on individuals' overall health. Theoretically, these manuscripts give a full image of rehabilitation LOS that can help healthcare physicians, practitioners, and administrators to develop strategy and intervention to achieve the best health and functional outcomes, while maintaining health efficiency. Also, the result of these three manuscripts can be beneficial to public health professionals and policymakers to evaluate socio-demographic variation among individuals with paraplegia and provide the needed care to the underserved groups.

CHAPTER 2: FACTORS ASSOCIATED WITH REHABILITATION LENGTH OF STAY IN INDIVIDUALS WITH PARAPLEGIA

2.1 INRODUCTION

Rehabilitation length of stay (LOS) in spinal cord injury (SCI) has been reported and documented widely. Previous research aimed to investigate the change of rehabilitation LOS in SCI over time. For example, Eastwood et al. (1999) found that the average rehabilitation LOS in SCI declined from 74.1 days in 1990 to 60.8 days in 1997 (Eastwood, 1999). Also, DeVivo et al (2007) found similar results that rehabilitation LOS decreased by 62.6 days over the past three decades (DeVivo, 2007). In paraplegia, Morrison and Douglas (1999) found that the average LOS decreased from 82.2 days in 1991 to 46.7 days in 1995 (Morrison, 1999). Yet, research found that shorter rehabilitation LOS associated with lower functional status, higher needs of bowel management assistance, and higher rates of rehospitalization (DeJong, 2013; Kao, 2022; Wilkinson, 2022).

There are several factors influencing rehabilitation LOS such as severity of injury, patients' characteristics, insurance status, and medical and functional status of patients. Research revealed that functional independence measure (FIM) scores and patients' age were the most predictors of rehabilitation LOS (Eastwood, 1999).

Also, research found that individuals with complete tetraplegia, incomplete tetraplegia or complete paraplegia had longer rehabilitation LOS compared to incomplete paraplegia (Eastwood, 1999; Tooth, 2003). Furthermore, studies showed that individuals with traumatic SCI had longer LOS compared to non-traumatic SCI (Al-Jadid & Robert, 2010; Gupta, 2009). Moreover, research found significant racial and economic disparities in rehabilitation LOS. For instance, Lad et al (2013) found that African American and Hispanic groups with SCI were experienced longer LOS than White and Asian groups (Lad et al., 2013). Also, individuals with Medicaid beneficiary had longer LOS and higher hospital cost when compared to non-Medicaid groups (Sedney, 2020).

The purpose of this study is to examine the factors associated with rehabilitation LOS in individuals with paraplegia using systematic literature review.

2.2 METHODS

This systematic review was conducted based on the Preferred Reposting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. We performed a search of PubMed, EMBASE, and CINAHL databases using the following keywords: *rehabilitation, rehabilitation/paraplegia, paraplegia, paraplegic, length of stay, duration of stay, stay length* (See **Table 2.1**). The study's inclusion criteria included peer reviewed articles, published in United States between 1980 and 2022, in English language, and evaluated factors associated with rehabilitation LOS among patients or individuals with paraplegia. Also, we used subject heading tools or controlled vocabulary (i.e., Medical Subject Headings "MeSH") with the keywords to enhance inclusive search of topics with different terminology but the same concepts. We conducted title and abstract screening for relevant topics, followed by full texts review to conclude the final articles for analysis

(**Fig. 2.1**). The final sample of articles were summarized according to factors associated with rehabilitation LOS, study population, methodology, and main outcomes (See **Table 2.2**).

2.3 RESULTS

The search strategy identified 645 potential articles (**Fig 2.1**). After reviewing the titles and removing the duplicated articles, we excluded 372 articles. Then, we excluded 247 articles after evaluating abstracts and retrieved 26 articles for full-text review. A total of 13 articles were excluded after full-text evaluation, reducing the search to 13 articles to be included in this systematic review.

Among the thirteen articles identified, two examined elderly populations (65-74 years), six had adults 18 or older, and five included all age groups. Study design of identified articles included retrospective studies (10), and prospective studies (3). Most of the articles used rehabilitation LOS as main outcomes (12) only one article used rehabilitation LOS as other outcome measures. For methodological analysis, six articles used students t-tests, two used matching designs (i.e., matching for age, gender, type of injury) with one-way ANOVA and post hoc test for comparison between groups, three used one-way ANOVA with post hoc tests, one article used stepwise regression of log rehabilitation LOS, and one article used ANCOVA. Study data sources as reported by the papers comprised the Medicare beneficiary database (2), the National Institute on Disability and Rehabilitation Research (NIDRR) (3), a level 1 tertiary trauma center (2), a level 1 tertiary university trauma center (1), the National Spinal Cord Injury Statistic Center (NSCISC) (1), a comprehensive rehabilitation facility (3), and the Spinal Cord Injury Rehabilitation (SCIRehab) project (1). Sample sizes ranged from the smallest

(n=60) to the largest (n=3,904). Six studies examined exclusively the paraplegia population, and seven articles examined the SCI population while controlling for level of injury by using a matching approach, or appropriate methodological analysis (i.e., adjusted for level of injury).

Of the thirteen articles in this review, six categories were identified as potential factors associated with rehabilitation LOS in paraplegia populations. The six factors included age, gender, types of etiology, severity of injury, surgical intervention, and body weight. Only age and severity of injury showed significant association with rehabilitation LOS, where individuals who were older or with severe injury experienced longer rehabilitation LOS.

2.4 DISCUSSION

The main goal of this systematic review was to identify factors associated with rehabilitation LOS; the discussion will focus on identified factors as having or not having a significant effect on rehabilitation LOS. This study yielded six categories of factors associated with rehabilitation LOS: age, gender, types of etiology, level of injury, surgical intervention, and body weight.

2.4.1 Role of age in rehabilitation LOS

Of the thirteen identified articles, two studies examined the effect age on rehabilitation LOS (Cifu, 1999; Seel, 2001). Both studies included adults (18 or older) with paraplegia SCI and found significant differences between age groups in terms of rehabilitation LOS, which older adults had longer rehabilitation LOS than younger adults.

Previous research found similar results that older SCI had longer rehabilitation LOS than younger groups (Hsieh, 2013).

However, some of previous studies found inconsistent results that rehabilitation LOS was not different between age groups (DeVivo, 1990; New & Epi, 2007). In fact, Roth et al (1992) found the opposite results that rehabilitation LOS was longer in young older adults (55-64 years) compared to old older adults (65 or older) (Roth, 1992). Noteworthy, older patients were more likely to discharge to nursing home than younger aged groups where they receive and continue rehabilitation care (DeVivo, 1999). However, some of these studies did not account for the influence of other factors in their analysis, (i.e., level of injury, discharge destination), which may lead to inconsistent outcomes.

2.4.2 Role of gender in rehabilitation LOS

Among the articles included in the systematic review, two articles investigated the effects of gender on rehabilitation LOS (Greenwald, 2001; E. D. Kay, A.; Chen, D.; Semik, P.; Rowles, D., 2010). One of two studies investigated the gender difference in incomplete paraplegia due to nontraumatic SCI, while the other study examined gender difference in matched sample of SCI. Both studies found similar outcomes that there was no significant difference between the gender groups in rehabilitation LOS except in Degenerative Spinal Disorder (DSD) etiology, where men had significantly longer rehabilitation LOS than women. The outcomes of these two studies were supported by previous research that rehabilitation LOS was not different between gender groups (Equebal et al., 2013; New & Epi, 2007; Osterthun et al., 2009; Scivoletto et al., 2004).

2.4.3 Role of etiology in rehabilitation LOS

Our systematic review identified five articles that compared rehabilitation LOS among spinal cord etiology groups (E. D. Kay, A.; Chen, D.; Manheim, L.; Rowles, D., 2010; McKinley, 2002; McKinley, 2011; Yarkony, 1990; Zeilig et al., 1996). Three studies compared traumatic spinal cord injury (TSCI) with other SCI etiologies (vascular related SCI, metastatic spinal cord lesion, spinal stenosis). One study compared between low and high paraplegia of complete thoracic SCI, and one study conducted a comparison analysis between non-traumatic SCI etiologies including Degenerated Spinal Disorder (DSD), benign spinal tumor, malignant spinal tumor, spinal abscess, and vascular ischemia. Four studies had similar outcomes that there was no significant difference in rehabilitation LOS between the etiology groups. However, one study found that the vascular ischemia group had significantly longer rehabilitation LOS than all other groups, while benign tumor, malignant tumor, and spinal abscess had comparable rehabilitation LOS.

The findings of these five studies were supported by previous research (Fortin et al., 2015; Gupta et al., 2008; McKinley, 1999). For example, Fortin et al (2015) compared malignant spinal cord compression with non-traumatic spinal cord injury and found that rehabilitation LOS was not different between two groups (Fortin et al., 2015). Moreover, research found comparable rehabilitation LOS between traumatic and non-traumatic spinal cord injury (Gupta et al., 2008; McKinley, 1999).

2.4.4 Role of severity of injury in rehabilitation LOS

Two studies were identified that examined the effect of level and severity of injury on rehabilitation LOS (Eastwood, 1999; Macciocchi, 2012). Eastwood et al (1999) investigated the changes of rehabilitation in traumatic SCI while controlling for the neurological impairments. The study found that complete paraplegia had longer rehabilitation LOS than incomplete paraplegia. The other study, Macciocchi et al (2012) evaluated rehabilitation LOS across the level of traumatic brain injury (TBI). Authors classified TBI groups as follows; severe, moderate, mild and no TBI groups and found persons with severe TBI had longer rehabilitation LOS compared to no or mild TBI.

These results were supported by previous studies (High et al., 1996; Osterthun et al., 2009; Tooth, 2003). For example, research found that complete paraplegia had longer rehabilitation LOS compared to incomplete paraplegia (Tooth, 2003). Also, High et al (1996) found that traumatic brain injury patients with severe injury had significantly greater rehabilitation LOS compared with relatively mild and moderate groups (High et al., 1996).

2.4.5 Role of surgical intervention on rehabilitation LOS

The study identified two studies that examine the role of surgical interventions in rehabilitation LOS (Wilmot, 1986; Yarkony, 1990). Wilmot and Hall (1986) conducted a two-year period study in 95 patients with traumatic paraplegia to evaluate the outcomes of acute surgical intervention in neurological status, medical complications, and rehabilitation LOS. Also, Yarkony et al (1990) examined the effects of surgical stabilization on rehabilitation outcomes in complete thoracic SCI. Both studies found similar outcomes that there was no statistical difference between both groups in rehabilitation LOS. Similarly, McKinley et al (2004) compared medical, functional and

neurological outcomes between non-surgical, early surgical, and late surgical groups in acute SCI and found that there was no significant difference between all three groups in rehabilitation LOS (McKinley, 2004).

2.4.6 Role of body weight in rehabilitation LOS

Tian et al (2013) examined the association of body weight and rehabilitation outcomes in people with SCI (Tian et al., 2013) . Based on body mass index (BMI), patients were classified into four groups: underweight, normal, overweight, obese. The study results found that there was no significant difference between body weight groups in patients with paraplegia. However, Padwal et al (2012) found incompatible results that severe obesity had significant longer rehabilitation LOS compared to the control groups in patients with rehabilitation needs (orthopedic surgery, acute medical illness, stroke, or SCI) (Padwal et al., 2012) . Noteworthy, patients with SCI or stroke had similar rehabilitation LOS in severe obesity and control groups.

2.5 LIMITATION

This study is not without its limitations. The majority of identified articles (N=9) in the systematic review had small sample sizes and poor methodological analysis to control for confounding factors. Also, selected studies were limited to peer-reviewed articles from the United States between 1980 and 2022.

Over 42 years, this study identified only 13 articles that evaluate factors associated with rehabilitation LOS in paraplegic population, which indicates a lack of research on this topic in the literature. For instance, there was a scarcity of articles that address the role socio-economic factors (i.e., insurance status, type of payers, family

incomes) on rehabilitation LOS, which is one of the most influencing factors on rehabilitation LOS.

2.6 CONCLUSION

This systematic review identified 6 factors that were potentially associated with rehabilitation LOS in individuals with paraplegia. Only age and severity of injury revealed significant associations with rehabilitation LOS. The finding showed that older groups experienced longer rehabilitation LOS compared to younger groups. Also, Individual with severe level of injury (i.e., complete paraplegia, severe TBI) were more likely to have longer rehabilitation LOS compare to mild or moderate level of injury (incomplete paraplegia, mild or moderate TBI). However, other factors include type of etiology, gender, surgical intervention, and body weight did not show significant association with rehabilitation LOS.

This study's results provide essential assessments of factors associated with rehabilitation LOS that can help physicians and healthcare professionals to provide rehabilitation care more effectively and efficiently. Also, healthcare policymakers and administrators can have better measurements of rehabilitation efficiency with considerations to the factors that are addressed in this study. The limited identified article indicates a necessity for future research to focus on this topic. Also, future research should identify other factors that have a potential impact on rehabilitation LOS such as socio-economic factors, racial and ethnic backgrounds, and types and intensity of rehabilitation care.

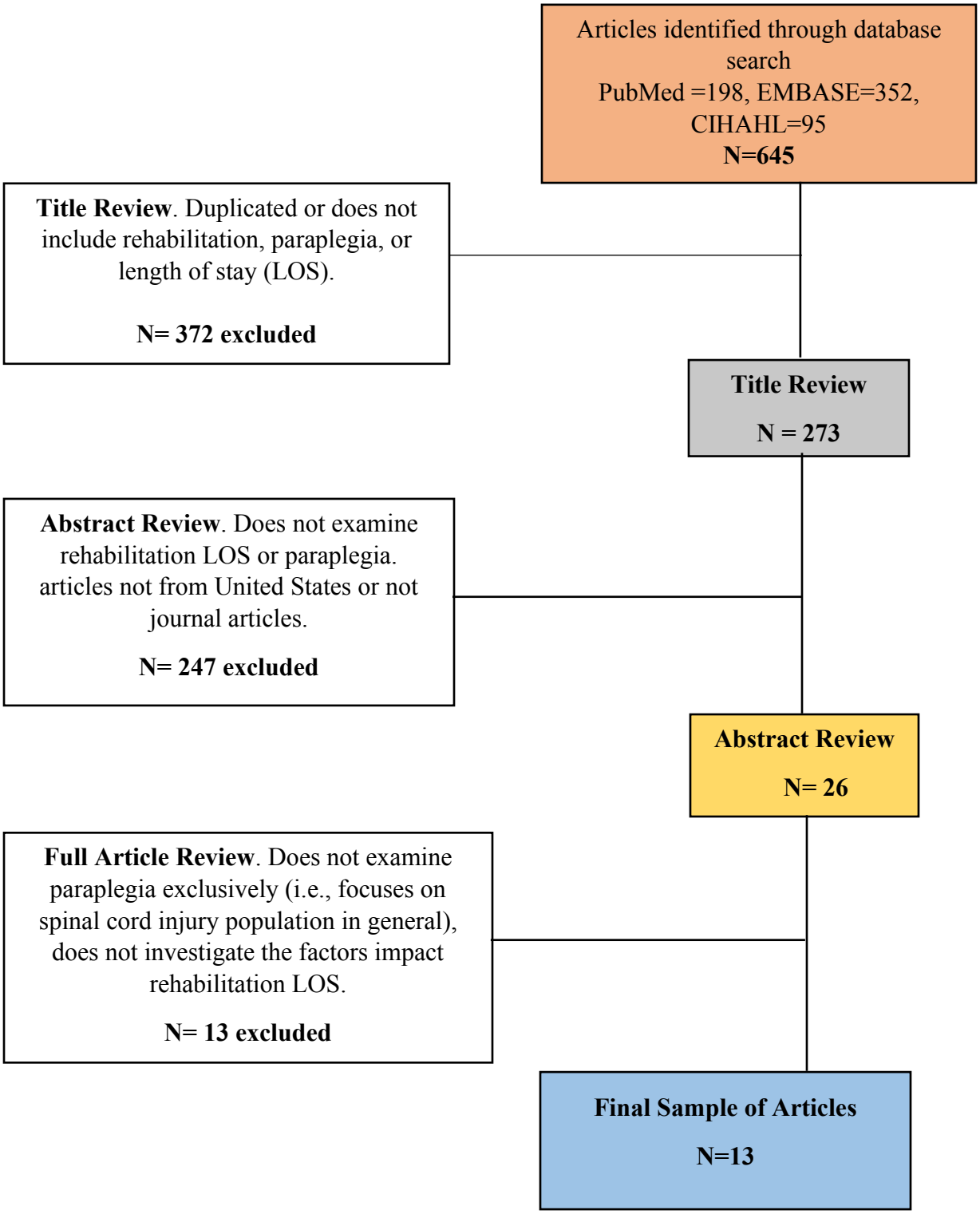


Fig 2. 1 PRISMA Flowchart of Inclusive and Exclusive Criteria for The Study

Table 2. 1 Keyword search in the databases

	Embase	PubMed	CINAHL
1	('rehabilitation'/exp OR rehabilitation) AND [1980-2023]/py N= 916,568	Rehabilitation [Mesh] OR rehabilitation OR "Paraplegia/rehabilitation"[Mesh] N= 671,326	MH "Rehabilitation+" OR rehabilitation N= 411,667
2	('paraplegia'/exp OR paraplegi* OR paralysis) AND [1980-2023]/py N=152,314	Paraplegia [Mesh] OR paraplegi* OR paralysis N=99,146	MH "Paraplegia+" OR paraplegi* OR paralysis N=16,568
3	('length of stay'/exp OR 'length of stay' OR 'duration of stay' OR 'stay length') AND [1980-2023]/py N=256,782	Length of Stay [Mesh] OR "length of stay" OR "duration of stay" OR "stay length" N= 137,715	MH "Length of Stay" OR "length of stay" OR "duration of stay" OR "stay length" N=62,410
2 & 3	2,445	854	251
1& 2 & 3	352	198	95
Total	645		

Table 2. 2 Summary tables of factors associated with the rehabilitation LOS in the study

Factors		Study population	Study design & Methodology	Main outcomes	Cited by
Age		180 adults with paraplegia	Retrospective, block design, matching procedure. ANOVA and Tukey post hoc test of the succussed matching.	Older patients had significantly longer rehabilitation LOS than younger patients.	(Seel, 2001)
		2,169 patients with paraplegia SCI	Retrospective. ANOVA procedures and The Tukey post hoc Test	Older patients had significantly longer rehabilitation LOS	(Cifu, 1999)
Gender		1,645 patients with incomplete paraplegia.	Retrospective. Mean differences ± SD.	Among three etiology groups, DSD, malignant tumor, or vascular ischemia, only significant difference was found in DSD, which men had longer rehabilitation LOS than women.	(E. D. Kay, A.; Chen, D.; Semik, P.; Rowles, D., 2010)
		1,074 patients with SCI, 537 for each gender group.	Retrospective, block design, matching procedure. ANOVA procedures and Tukey post hoc Test.	No statistical difference between gender groups in rehabilitation LOS.	(Greenwald, 2001)
Type of etiology	Spinal stenosis SS vs TSCI	183 patients. 55 paraplegia SS and 35 paraplegia TSCI.	Prospective review. Independent t-test with Levene's test for equality of variance.	No statistical difference between two groups in rehabilitation LOS	(McKinley, 2002)
	Metastatic vs T-SCI	44 paraplegics; 20	Retrospective. Independent Student t-test.	No significant difference between the two groups in rehabilitation LOS.	(Zeilig et al., 1996)

		metastatic & 24 TSCI			
	Vascular related (VR-SCI) vs T-SCI	30 patients with VR-SCI and 30 T-SCI.	Retrospective. Paired t-tests for matched sample of VR-SCI with T-SCI.	No significant difference between two groups in rehabilitation LOS.	(McKinley, 2011)
	Non-traumatic spinal cord injury	1,780 patients with incomplete paraplegia.	Retrospective. One-way ANOVA and the Games Howell post-hoc test for multiple comparison of groups with unequal variance.	Vascular ischemia group had longer LOS than all other etiologies. The benign tumor, malignant tumor, and spinal abscess had comparable LOS.	(E. D. Kay, A.; Chen, D.; Manheim, L.; Rowles, D., 2010)
	Complete thoracic spinal cord injury	184 patients with complete thoracic paraplegia, 79 high paraplegia, 105 low paraplegia	Retrospective. Student's t-test with Bonferroni's correction for multiple comparison.	No statistical difference between two groups in rehabilitation LOS	(Yarkony, 1990)
Level of injury	Traumatic brain injury (TBI) and acute spinal injury	189 with SCI and co-occurring TBI.	Prospective. Analysis of covariance (ANCOVA) with Bonferroni post hoc tests	Persons with sever TBI had longer rehabilitation LOS compared to no TBI or mild TBI	(Macciocchi, 2012)
	Complete paraplegia vs incomplete paraplegia	3,904 persons with SCI, 40% with paraplegia.	Retrospective. Stepwise regression analysis of natural log of rehabilitation LOS	Complete paraplegia had longer rehabilitation LOS than incomplete paraplegia.	(Eastwood, 1999)
Body weight		1,017 patients with TSCI, 36.2% with paraplegia.	ANOVA with post hoc analysis	There was no statistical difference between BMI groups in rehabilitation LOS.	(Tian et al., 2013)
Surgical intervention		95 patients with paraplegia, 76% had	Retrospective. Student's t-test.	No statistical difference between non-surgical and	(Wilmot, 1986)

	surgical intervention		surgical groups in rehabilitation LOS	
	184 patients with complete thoracic paraplegia, 79 high paraplegia, 105 low paraplegia	Retrospective. Student's t-test with Bonferroni's correction for multiple comparison.	No statistical difference between non-surgically stabilized and surgically stabilized groups in rehabilitation LOS	(Yarkony , 1990)

CHAPTER 3: TRENDS OF REHABILITATION LENGTH OF STAY IN PATIENT WITH SPINAL CORD INJURY PARAPLEGIA BETWEEN 1988 AND 2016

3.1 INTRODUCTION

Rehabilitation length of stay (LOS) in patients with spinal cord injury (SCI) paraplegia is critically important due to its influences on patients' functional outcomes, quality of life, living setting after discharge, and social integration (Eastwood, 1999). Research shows that patients with SCI may be at risk of secondary complications, poor quality of life and increased psychological symptoms when they are not receiving adequate rehabilitation care (Paker, 2006; Truchon, 2017). Despite the importance of rehabilitation, previous research found that rehabilitation LOS in paraplegic patients has decreased drastically over time (De Vivo et al., 1991; Morrison, 1999).

Rehabilitation LOS often differs according to patients' sociodemographic factors and level and severity of injury. For example, research found that age significantly affects rehabilitation LOS in patients with paraplegia (Cifu, 1999). Moreover, African Americans had a longer LOS compared with white or Hispanic groups (Mahmoudi, 2014).

Also, patients with complete paraplegia had longer rehabilitation LOS when compared to incomplete paraplegia (Eastwood, 1999; Tooth, 2003). Additionally, patients who have vocational rehabilitation benefits or worker's compensations experienced greater LOS than those without benefits (DeVivo, 1989) Although rehabilitation in SCI has been studied extensively, there is little research of rehabilitation LOS in patients with paraplegia in particular. This research aims to examine the trends of change of inpatient rehabilitation LOS in patients with paraplegia after traumatic SCI between 1988 and 2016 in the United States. Concurrently, we evaluate sociodemographic disparities that are associated with rehabilitation LOS. We hypothesize that rehabilitation LOS continues to decline over years with significant variations between sociodemographic groups in patients with paraplegia.

3.2 CONCEPTUAL FRAMEWORK: DONABEDIAN MODEL

The Donabedian model proposed that quality of care should be examined in 3 domains: structure, process and outcome, which is also known as structure, process and outcome (SPO) quality assessment model (Donabedian, 1988). Donabedian emphasized that the three domains should be applied collectively to examine healthcare quality. The Donabedian model has been used in numerous studies for evaluating rehabilitation care and quality (Eldar, 2000; Qu, 2010). We used the SPO model to structure and justify the goals of this study and validate the selected variables (**Fig 3.1**).

According to Donabedian, structure represents the components of settings in which care occurs includes material resources, human resources, and organizational structure (Donabedian, 1988). We used patients' characteristics as structure elements,

which includes patients' sociodemographic variables (age, gender, race, occupation, marital status) and severity of injury.

Process of care indicates the actual value in giving and receiving care (Donabedian, 1988). In rehabilitation setting, process is rehabilitation interventions and additional activities such as patient functional assessment (Eldar, 2000). Several studies have used Functional Independence Measurement (FIM) scores to predict the rehabilitation LOS and patient discharge (Amundson, 2004; Ancheta, 2000; Grant, 2014; Thorpe, 2018). We applied FIM score as process domain to evaluate the rehabilitation LOS.

The third domain in the SPO model is outcome of care. This domain refers to the effect of care in the health status of patients and population (Donabedian, 1988). Rehabilitation LOS was used as an outcome element for our analysis.

However, rehabilitation care is known as long-term care and consists of various phases with different approaches according to each phase. For example, rehabilitation LOS as an outcome could be indirect measure of process element (FIM) and would provide a second step in evaluating whether the process continues to be adequately specified and measured. Therefore, it would be useful to measure process and outcomes factors of each phase simultaneously (Eldar, 2000).

3.3 METHODS

3.3.1 Data source

The study's analysis used the latest version of de-identified data that are freely available for to the public from the National Spinal Cord Injury Statistics Center (NSCISC) (National Spinal Cord Injury Statistic Center, 2021). The NSCISC is part of Spinal Cord Injury Model Systems (SCIMS) program and currently contains data from 18 SCIMS centers (National Spinal Cord Injury Statistic Center, 2022). SCIMS was established in 1973 and funded by the National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR) (Stover et al., 1999). In 1984, the University of Alabama at Birmingham (UAB) SCI Model System established NSCISC to direct and supervise the collection, management and analysis of the SCIMS database (Stover et al., 1999). The SCI participant's enrollment is different in each five years funding cycle due to three main reasons: 1) numbers of funded system, 2) eligibility criteria, and 3) size of funded systems (National Spinal Cord Injury Statistic Center, 2021). The list of SCIMS that participate in the database is provided from 1985 to 2016 (see **Table 3.1).** The number of SCIMS centers changed over time in each date cycle. There were 7 centers that were presented in all cycles (Birmingham, Denver, Atlanta, Chicago, Ann Arbor, Philadelphia, Houston), 4 centers in 5 data cycles (Boston, Mt. Sinai, West Orange, Seattle), 1 center in 4 data cycles (Downey), 3 centers in 3 data cycles (Detroit, San Jose, Cleveland), 4 centers in 2 data cycles (Pittsburgh, Washington, Columbia, Richmond), and 5 centers in one data cycle (Fishersville, Rochester, NYU, Milwaukee, Miami). Since 70% of centers were included in 5 or 6 data cycles, the impact of changes in the composition on the results is limited.

At the end of 2016, there were 32,159 persons with traumatic SCI enrolled in the database, which makes it the world's largest SCI research database. The NSCISC

captures data on an estimated 6% of new SCI cases that occur each year in United States and contains injury characteristics and demographic information as well as functional, medical, psychosocial, and employment outcomes. Despite the fact that the NSCISC captures only 6% of new SCI, rigid scientific criteria have been established for the collection, management and analysis of information entered into the database to ensure equivalence of data. Also, The NSCISC staffs have developed quality control procedures to ensure the reliability and validity of the database. The information of each individual with SCI in this data is placed into two datafiles: data from form I includes data of individuals' first enrollment in the system until discharge, and data from form II captures data at post-injury years from 1, in increments of 5, up to 40 years.

3.3.2 Study population

This study examined only patients with paraplegia caused by traumatic SCI. Those with tetraplegia, normal, or unknow neurological impairments were excluded. Also, patients with unknown rehabilitation LOS, age, gender, date of injury, race, occupation, marital status, or FIM scores were excluded (see **Fig 3.2**). Excluded group was compared to included group to ensure the comparability in the database (see **Table 3.2**, **Fig 3.3**).

3.3.3 Main outcome

The main outcome of this study was rehabilitation length of stay (LOS). This variable represents the total length of stay in the system's inpatient rehabilitation unit from admission to discharge. Rehabilitation LOS is reported in days that institution charges are incurred; therefore, short-term discharge days during rehabilitation stay are not included in this total.

3.3.4 Independent variables

The main independent variable was years (1988-2016). The years' boundary started from 1 when years was 1988 to 29 when years was 2016. The control variables were the patients' sociodemographic variables at the hospital admission (age, gender, race, occupation, marital status), severity of injury as defined by the American Spinal Injury Association (ASIA) Impairment Scale (AIS A, B, C, and D), and FIM scores at inpatient rehabilitation admission. The age groups comprised four categories: 0-29 years old, 30-44 years old, 45-59 years old, and 60 or older. The study had two gender groups: males and females. There were four race group in this study including White, Black or African American, other or multiracial, and unknown. Also, there were four groups in occupation groups: employed, retired, student and unemployed group. Moreover, the sample involved three marital statuses: single, married and separated, widowed or divorced.

FIM scores measure the functional status of patients and grade the independence level of motor function. We used total FIM ranging from 13 to 91 where the lower score implies lower functional performance, and higher score indicates higher functional performance (Granger & Hamilton, 1993). The total FIM score is the calculation of four categories including self-care, sphincter control, mobility and locomotion. There are eight scales to measure these categories: (7) complete independent, (6) modified independent, (5) supervision or setup, (4) minimal contact assistance, (3) moderate assistance, (2) maximal assistance, (1) total assistance and (0) no activity occurs.

3.3.5 Statistical analysis

Categorical variables were summarized with frequency count and percentage. Continuous variables were summarized by means with standard deviation if normally distributed per the Kolmogorov-Smirnov test, or median with 1st and 3rd quartiles if not normally distributed.

The trend of rehabilitation LOS (i.e., the time effect) was evaluated using multivariable linear regression model. Since rehabilitation LOS was positively skewed, we used natural logarithm of rehabilitation LOS to satisfy normality assumption of the model. Also, we assessed the interaction between FIM scores and years to capture the effect of time on rehabilitation LOS when the average FIM scores changes. In order to graph this effect, we created a categorical subgroup of FIMs (20 or below, 21-30, 31-40, 41-50, 51 or above) and plotted rehabilitation LOS by this subgroup between 1988 and 2016. Moreover, we examined omitted variable biases (OVB) by creating a cumulative regression model starting with simple regression of the outcome (rehabilitation LOS) and main independent variable (years), followed by multiple regressions where control factors (independent variables described above) were added one by one into the model.

While the NSCISC database did not have enough information about patients' insurance status, which is important factors for explaining the trends of rehabilitation LOS, we designed a variable to estimate the insurance status using a combination of age and occupation groups. We categorized this variable into three groups: 1) likely Medicare (patients 60-year-old or older), 2) likely insured (patients who were 15-59 years old and employed, student or retired), 3) likely uninsured (patients who were 15-59 years old and unemployed).

All tests were 2-sided with a significance level set to 0.05. Statistical analyses were performed in Stata/IC 15.1 (StataCorp, 2017). Visualization of rehabilitation LOS was performed by Microsoft Power BI (Microsoft Power BI, 2022).

3.4 RESULTS

3.4.1 Patients' characteristics

Of the total 7,594 patients with paraplegia, 4,253 (56%) were classified as complete paraplegic (AIS A) and 3,359 (44%) were incomplete paraplegic (AIS B, C, and D) (see **Table 3.3**). The majority of the sample was men (80%), mostly white (62%), and predominantly single (57%). Individuals between 0 to 29 years old comprised 50% of the sample population. Also, the workers represented the majority by 61%. The mean of FIM score at rehabilitation admission was 31.74 (SD ± 11.48). The distributions of patients' characteristics by groups and rehabilitation LOS from 1988 to 2016 were presented in **Fig 3.4** and **Fig 3.5**. There was some variations in patients' characteristics over the years. For example, there was a notable increase in the older age groups, specifically in 45-59 years old group. Also, the unknow race group presented only between 1988 and 2002. The rest of patients' characteristics showed fairly similar trends over the years (**Fig 3.4**). Moreover, the downward trends of rehabilitation LOS over the years was somewhat consistent across subgroups defined by different categorical variables (**Fig 3.5**).

Both excluded and included groups were slightly, but not too significantly, different from each other in term of rehabilitation LOS. Excluded and included groups showed significant decreased over years by 1.2% and 1.1% on average, respectively, between 1988 and 2016 (**Table. 3.2**). Moreover, the comparison between excluded and

included groups was plotted in a graph and showed that both groups experienced a drop in rehabilitation LOS over years (**Fig 3.3**). Although the excluded groups showed surprising elevation in rehabilitation LOS in 2004 and 2005, these increases were inflated by the small sample size of excluded groups at that time (N=16 in 2004, N=10 in 2005).

3.4.2 Rehabilitation LOS

The median rehabilitation LOS in patient with paraplegia was 41 days (Q1=28, Q3=60) (**Fig. 3.6**). As shown in the previous graph, rehabilitation LOS sharply decreased from 1988 until 2000, then moderately increased between 2000 and 2003 followed by another drop till 2016. The adjusted data showed that rehabilitation LOS decreased by 1.4% on average each year from 1988 to 2016. (See **Table 3.4**). Compared to complete AIS A, patients with incomplete AIS B, C, D had shorter rehabilitation LOS by 5.1%, 6.2% and 30.4%, respectively. Moreover, patients who were 60 years or above, 45 to 59 years and 30 to 44 years had longer rehabilitation LOS compared to 0 to 29 years old by 21.4%, 14.7%, and 6.4%, respectively. Also, married patients and divorced, separated, or widowed patients had shorter rehabilitation LOS by 8.1% and 6.7% when compared with single group. Furthermore, 10 unit increase of FIM score at rehabilitation admission was associated with 16.4 % lower rehabilitation LOS. Unemployed and retired patients have shorter rehabilitation LOS compared to employed individuals by 4.2% and 15.3%, respectively. There were no statistical differences between gender and race groups, except multiracial or other and unknown groups who had longer rehabilitation LOS by 11.4% and 19.6% compared to white groups (**Table 3.4**).

We aimed to investigate the effect of insurance on the trends of rehabilitation LOS by plotting the three insurance groups (likely Medicare, likely insured, likely

uninsured) that we created into the graph (see **Fig 3.7)**. The graph revealed that the major drop in rehabilitation LOS in the early 2000s started in likely Medicare groups, then likely insured and uninsured patients. However, the graph showed similar trends in rehabilitation LOS between the three groups. Noteworthy, the similar trends between groups might be a result of the overlap between age groups. For example, Medicare includes patients 65 or older, and 19 or younger, but we included patients who were 60-15 years old due to limited information in the database.

3.4.3 The interaction between years and FIM score

The interaction term between years and FIM revealed that the coefficient of years (the effect of time) on rehabilitation LOS had an additional decrease by 0.58 days when FIMs at rehabilitation admission increased by one score. This interaction term was statistically significant (P=000) indicating that the effect of years on rehabilitation LOS depends on the value of FIM, which is supported by SPO conceptual model (see **Table 3.5**). The difference can be noticed when we examine rehabilitation LOS at first and last year of the study cohort. When FIMs at rehabilitation admission increased by one score, rehabilitation LOS in 1988 was estimated to decreased by 0.005 while rehabilitation LOS in 2016 declined by 0.168. Similarly, the interaction effect can be observed at 25^{th} quantile and 75^{th} quantile of FIMs. For each additional year, patients who were at 25^{th} quantile FIMs experienced decreased rehabilitation LOS by 0.093 while rehabilitation LOS declined by 0.144 for patients with 75^{th} quantile FIMs. In other words, the decline in rehabilitation LOS over years was accelerated for low functionally impaired group.

The interaction graph of the FIMs subgroup with years is presented in **Fig 3.8.** The graph showed that the effect of years on rehabilitation LOS was slightly lower, but

still significant, for those with low FIM score. But, when the FIM scores get higher, the effect of years on rehabilitation LOS became extremely negative.

3.4.4 The Omitted Variable Bias (OVB) model

We tested the omitted biases of control factors on years to capture any confounding effect (see **Table 3.6**). We found that the coefficient of years had greater reduction when we added FIM scores to the model, however, no change was noticed with other control variables. Based on omitted variable bias (OVB) concept, the observed reduction is a result of a positive bias indicating that the estimated value (1.4% decline of rehabilitation LOS) equals the true value (1.1% decline of rehabilitation LOS) plus an additional value (0.3 %) as a result of omitted effect. Notable, we examined the trend of change of FIM scores after discharge from the acute care, which is also the point where patient transfer to rehabilitation care, between 1988 and 2016 and observed that patients had lower FIM score by 0.27 on average each year (See **Table 3.7**). Also, we graphed the trends of FIM at inpatient rehabilitation admission along with acute-care LOS between 1988 and 2016 (see **Fig 3.9**). In brief, this suggests that efforts to maintain rehabilitation efficiency by reducing rehabilitation LOS could have been constrained because patients experienced lower FIM after acute care over years.

3.5 DISCUSSION

The results of this research revealed that rehabilitation LOS in patients with SCI paraplegia decreased by 1.4% on average each year from 1988 to 2016 in the United States. The finding that rehabilitation LOS declined over years is supported by previous studies (DeVivo, 2007; Eastwood, 1999; Truchon, 2017). Our analysis showed fluctuated

trends of rehabilitation LOS between 1988 and 2016. Rehabilitation LOS decreased drastically from 1988 to 2000, then sharply increased between 2000 and 2003 followed by a major drop to 2016.

There are mostly four plausible explanations of the declined rehabilitation LOS. First, increased the number of comprehensive outpatient rehabilitation clinics and outpatient rehabilitation utilizations. Studies found rapidly increase in the number of outpatients rehabilitation clinics and utilizations over recent years, which helped to discharged patients earlier from inpatient rehabilitation while they continued rehabilitation care in outpatient clinics (Kogos, 2004; Whiteneck, 2011). Second, increased discharge to skill nursing facilities (SNFs). Eastwood et al. (1999) reported a significant increase in discharge to (SNFs) between 1990 and 1997 (Eastwood, 1999). Third, implementation of inpatient rehabilitation facilities prospective payment system (IRF-PPS). IRF-PPS was introduced by Centers for Medicare in 2000 and implemented in 2002 as an approach to reduce the healthcare costs by improving the efficiency of rehabilitation care (Center for Medicare & Medicaid Services, 2022). Rehabilitation LOS significantly decreased after IRF-PPS implementation, particularly for Medicare consumers (Qu, 2011).Our finding showed that the major drop in rehabilitation LOS in the early 2000s started first in likely Medicare groups, then likely insured and uninsured patients, which possibly explain the effect of IRF-PPS on Medicare and the spillover effect of IRF-PPS on other two groups. Fourth, cost containment measures and variation of payment policy to reduce healthcare costs. Research found significant changes in acute-care and rehabilitation LOS, charges, rehospitalization after one year of injury, time to admission, and discharge to a nursing home when Managed Care and Diagnostic

Related Groups (DRGs) were introduced (Fiedler, 1999). Fiedler, Laud, Maiman, & Apple (1999) found the LOS was sharply decreased after three years of Managed care entered Atlanta market (Fiedler, 1999).

Rehabilitation LOS in patients with paraplegia was different across sociodemographic variables. Shorter rehabilitation LOS was associated with younger age, being married, divorced, widowed, or separated, being unemployed or retired, with AIS B, C or D and having high FIM scores. Our results were similar to previous studies. Research found younger patients had shorter rehabilitation stays when compared with older patients (Cifu, 1999; Eastwood, 1999; Hsieh, 2013). Also, FIM scores and severity of injury level were the strongest predictors of rehabilitation LOS (Eastwood, 1999).

For the best of our knowledge, the comparison of rehabilitation LOS among employment groups has not been covered in literature. Our results showed that retired and unemployed patients had shorter rehabilitation LOS when compared to employed. One explanation is that retirees, who tend to be older than employed people, were more likely to be discharged to nursing home, compared to employed individuals. Studies found that age is the strongest predictor of discharge to nursing home (DeVivo, 1999; DeVivo, 1990). Our finding showed similar results to Greenwald et al. (2001) where there was no significant difference in rehabilitation LOS between gender groups (Greenwald, 2001).

Our results suggested that the change of rehabilitation LOS over years was depended on FIM scores. The interaction model between years and FIM scores showed individuals with low FIM score experienced minimum decreased of rehabilitation LOS, while patients with high FIM scores had larger decreased of rehabilitation LOS over time.

Also, the OVB model revealed a positive bias of the effect of years on rehabilitation LOS when FIM was held constant. Positive bias suggested that the observed effect of years on rehabilitation equaled the true estimated value plus an additional value. In other words, rehabilitation LOS was predicted to be lower than the estimated simple model.

The efforts to achieve rehabilitation efficiency are massive and the reduction of rehabilitation LOS is expected to be larger than estimated model. Yet, these efforts are limited by low FIM that patients experienced after discharge from acute care. In fact, we investigated the changes of FIM scores after discharge from acute care between 1988 to 2016 and we found that FIM scores decreased by 0.27 scores on overage each additional year.

3.6 LIMITATION

This study is not without its limitations. Although the healthcare facilities in the NSCISC are specialized centers, the characteristics of these facilities (i.e., size, type, location, number of beds) are not provided in the database. Moreover, we did not have enough information about patients' insurance status, which is an essential factor to explain the change of rehabilitation LOS. Since NSCISC captures only 6% estimated of all new cases in United States, it is possible that trends in this model outcomes are not representative in outcomes for patients treated elsewhere. However, these being among the best specialized institutions for SCI, these data most likely provide the best-case scenarios of the decline of length of stay. Although 70 % of SCIMS centers were presented in most of the data cycles, eliminating the consequences of these changes over time on rehabilitation LOS might not be guaranteed. Lastly, the NSCISC lacks additional

predictor variables to describe the tremendous amount of heterogeneity in the traumatic SCI paraplegic population.

3.7 CONCLUSION

Rehabilitation LOS significantly declined by 1.4% on average between 1988 and 2016 in the United States. Also, we found sociodemographic variations of rehabilitation LOS among patients with SCI paraplegia. Patients who are young, employed, with AIS B, C, or D, and having higher FIM score experienced shorter rehabilitation LOS.

Our analysis suggests that LOS declined regardless of socio-demographics status except for FIM. Lower FIM score at rehabilitation admission was associated with lower, but still significant, decrease in LOS over the years. We also noted that, over the years 1988-2016, FIM scores at rehabilitation admission decreased by 0.21 annually, which points to status of the individuals at acute care discharge. Future research should focus on exploring deeper the impact of declined rehabilitation LOS on individuals' medical and functional health in their day-to-day life after discharge.

The finding of this study demonstrated significant changes of rehabilitation LOS over years. This can be beneficial to rehabilitation physicians, healthcare professionals and providers to evaluate rehabilitation LOS with sustaining rehabilitation efficiency. The study suggests that keeping FIM scores as high as possible after discharge from acute care is the core factor to reduce LOS. These findings can help healthcare professionals to develop strategies to achieve healthcare efficiency while maintaining health and functional outcomes. Moreover, this study revealed sociodemographic variation in rehabilitation LOS. This can inform public health officials and healthcare providers to create plans and programs to identify the needs and demands for targeted groups

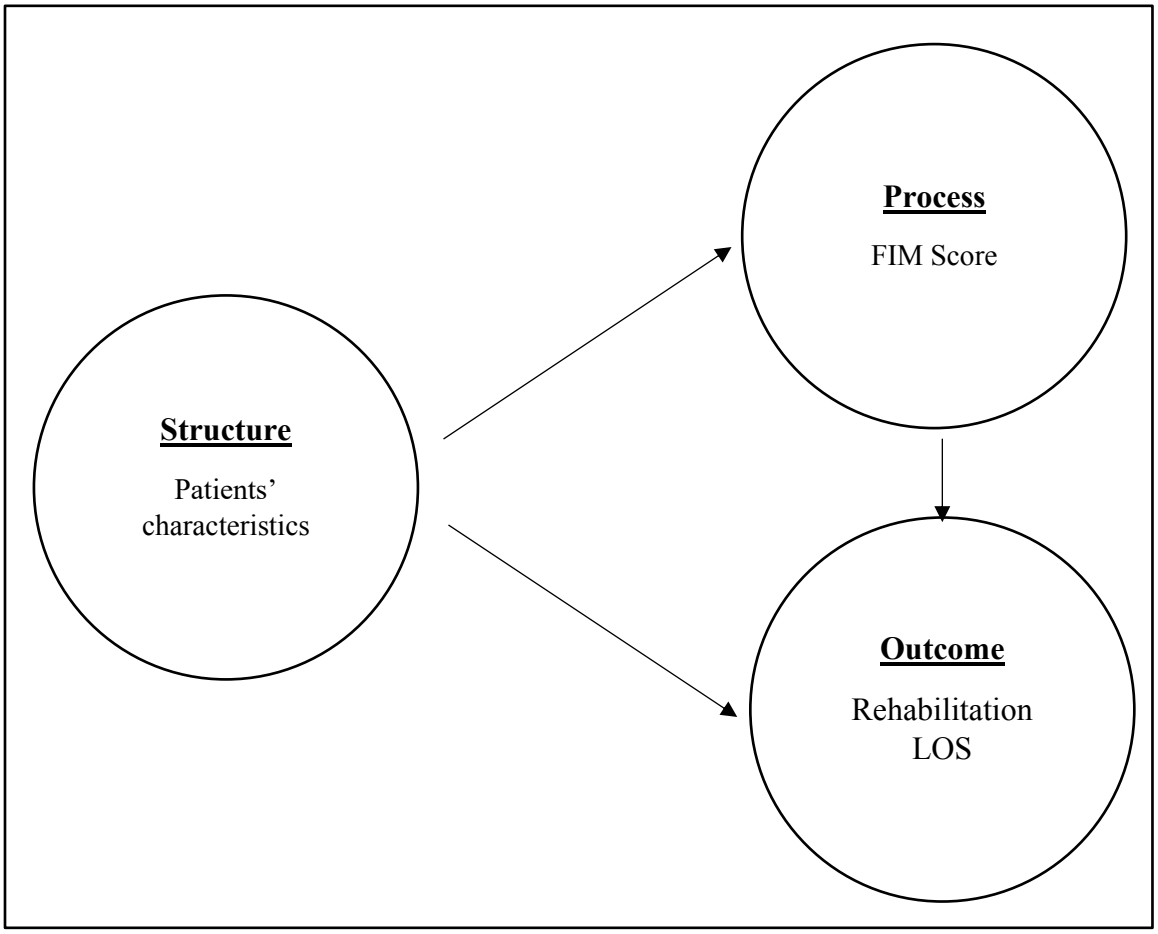


Fig 3. 1 Donabedian Model of Quality

Table 3. 1 List of the SCIMS centers from 1985-2016

Years	1985-1990	1990-1995	1995-2000	2000-2006	2006-2011	2011-2016
# Of centers	13	13	18	16	14	14
Presented in all data cycles	AL, Birmingham CO, Denver GA, Atlanta IL, Chicago MI, Ann Arbor PA, Philadelphia TX, Houston	AL, Birmingham CO, Denver GA, Atlanta IL, Chicago MI, Ann Arbor PA, Philadelphia TX, Houston	AL, Birmingham CO, Denver GA, Atlanta IL, Chicago MI, Ann Arbor PA, Philadelphia TX, Houston	AL, Birmingham CO, Denver GA, Atlanta IL, Chicago MI, Ann Arbor PA, Philadelphia TX, Houston	AL, Birmingham CO, Denver GA, Atlanta IL, Chicago MI, Ann Arbor PA, Philadelphia TX, Houston	AL, Birmingham CO, Denver GA, Atlanta IL, Chicago MI, Ann Arbor PA, Philadelphia TX, Houston
Presented in 5 data cycles	MA, Boston	NY, Mt. Sinai NJ, West Orange WA, Seattle	MA, Boston NY, Mt. Sinai NJ, West Orange WA, Seattle	MA, Boston NJ, West Orange NY, Mt. Sinai WA, Seattle	NY, Mt. Sinai WA, Seattle MA, Boston NJ, West Orange	NY, Mt. Sinai WA, Seattle MA, Boston NJ, West Orange
Presented in 4 data cycles	CA, Downey	CA, Downey	CA, Downey	CA, Downey	-	-
Presented in 3 data cycles	MI, Detroit	CA, San Jose MI, Detroit	CA, San Jose MI, Detroit OH, Cleveland	CA, San Jose	OH, Cleveland	OH, Cleveland
Presented in 2 data cycles			VA, Richmond MO, Columbia	MO, Columbia VA, Richmond	PA, Pittsburgh DC. Washington	PA, Pittsburgh DC. Washington
Presented in 1 data cycle	NY, NYU NY, Rochester VA, Fishersville		WI, Milwaukee	FL, Miami		

Some of former sites continue as subcontracted centers to submit follow-up data.

The NSCISC grants cycle fund the center for 5 years.

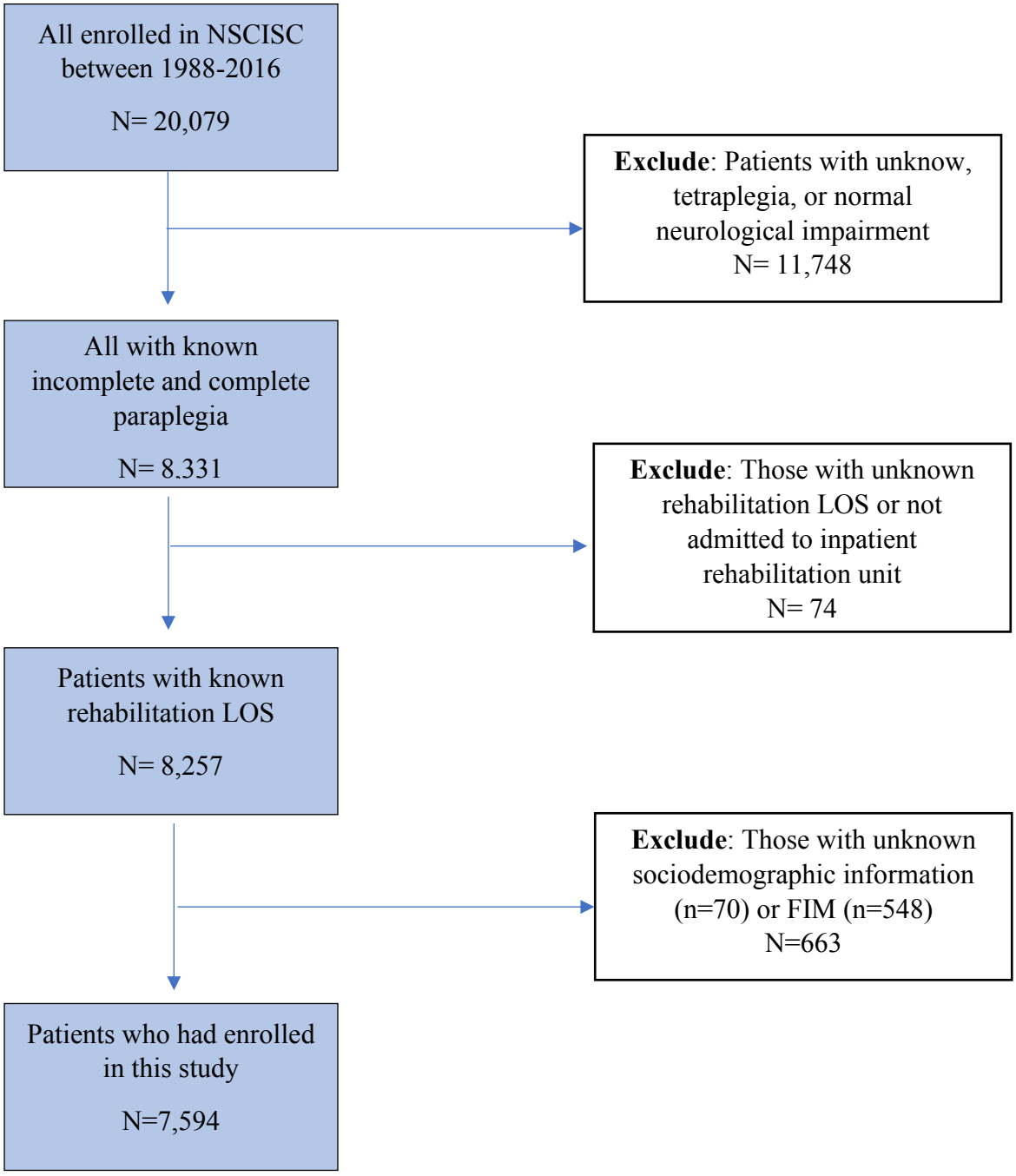


Fig 3. 2 The flowchart for inclusion and exclusion criteria using the NSCISC

Table 3. 2 Multivariable regression of log rehabilitation LOS in included and excluded SCI paraplegia groups

Variables	**Excluded N= 663**	**Included N= 7,594**
	Coeff. [95% conf. interval]	Coeff. [95% conf. interval]
Years (1988-2016)	-0.012 [-0.02, -0.01] *	-0.011 [-0.01, -0.009] *
Age (0 to 29 years = reference) 30 to 44 years 45 to 59 years 60 years or Older	 -0.016 [-0.16, 0.12] 0.104 [-0.09, 0.30] -0.067 [-0.31, 0.17]	 0.07 [0.03, 0.11] * 0.12 [0.07, 0.17] * 0.14 [0.07, 0.19] *
Race (White =reference) Black or African American Other or Multiracial Unknown	 -0.092 [-0.21, 0.03] -0.064 [-0.36, 0.23] 0.219 [0.02, 0.41] *	 -0.056 [-0.08, -0.02] * 0.133 [0.06, 0.19] * 0.234 [0.16, 0.30] *
Gender (female = reference)	-0.095 [-0.22, 0.03]	-0.051 [-0.08, -0.01] *
Marital Status (single = reference) Married Divorced, separated, or widowed	 -0.032 [-0,18, 0.12] -0.046 [-0.22, 0.12]	 -0.074 [-0.11, -0.03] -0.084 [-0.13, -0.03]

*** Significant level <0.05**

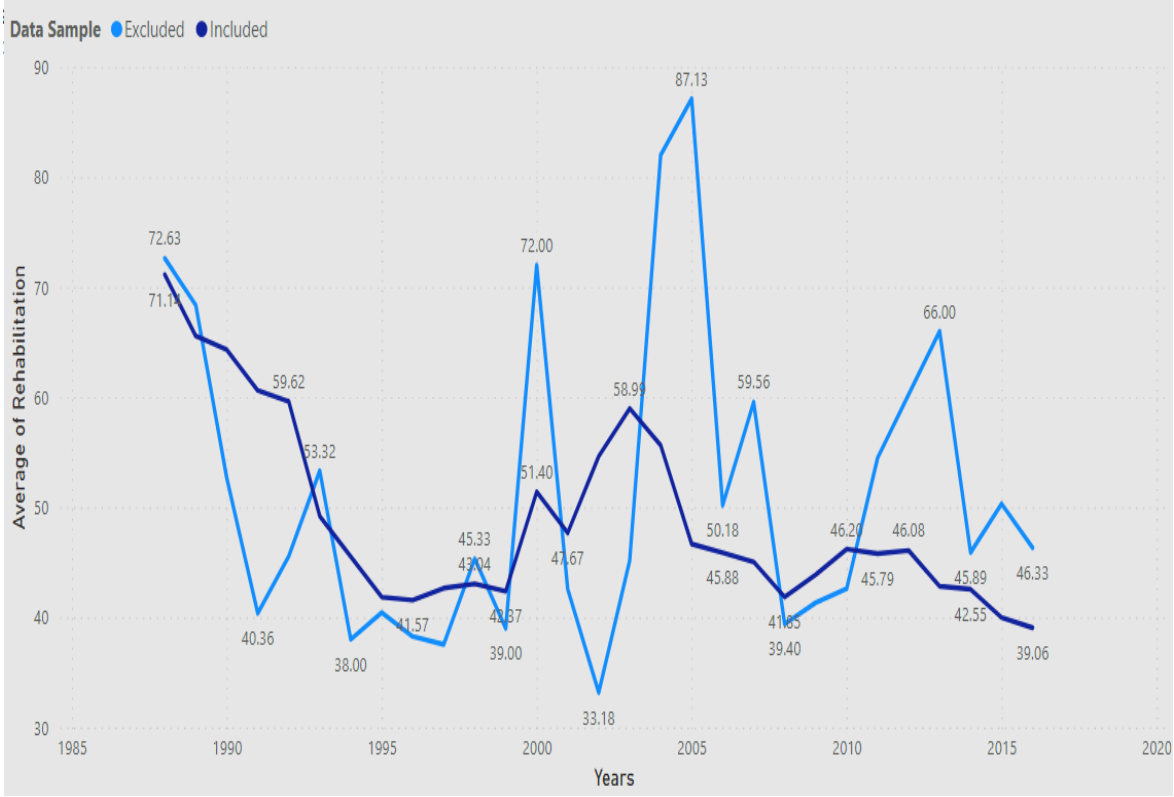


Fig 3. 3 Rehabilitation LOS in excluded and included SCI paraplegia groups between 1988-2016

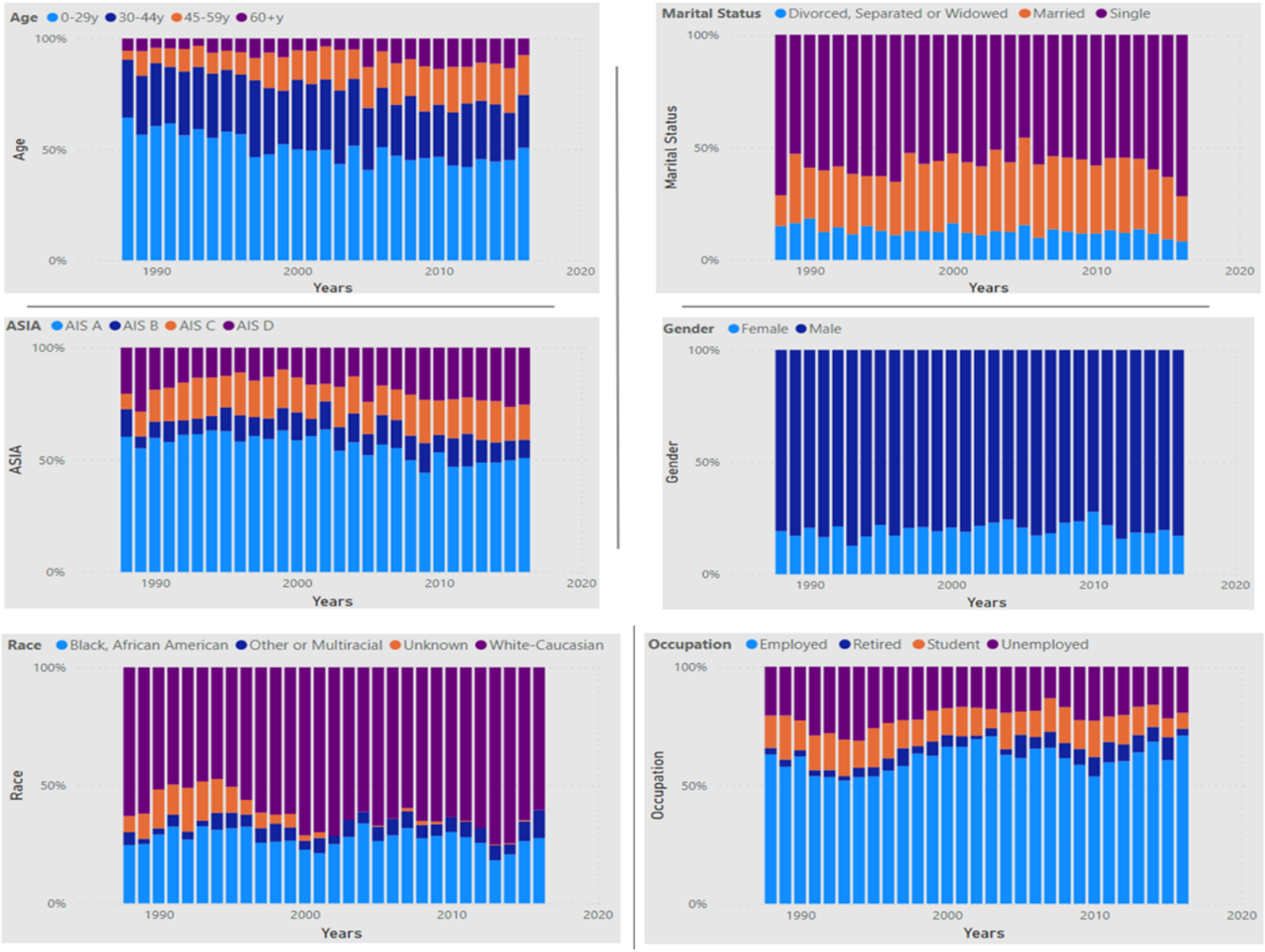


Fig 3. 4 Distribution of sociodemographic by groups of SCI paraplegia between 1988-2016

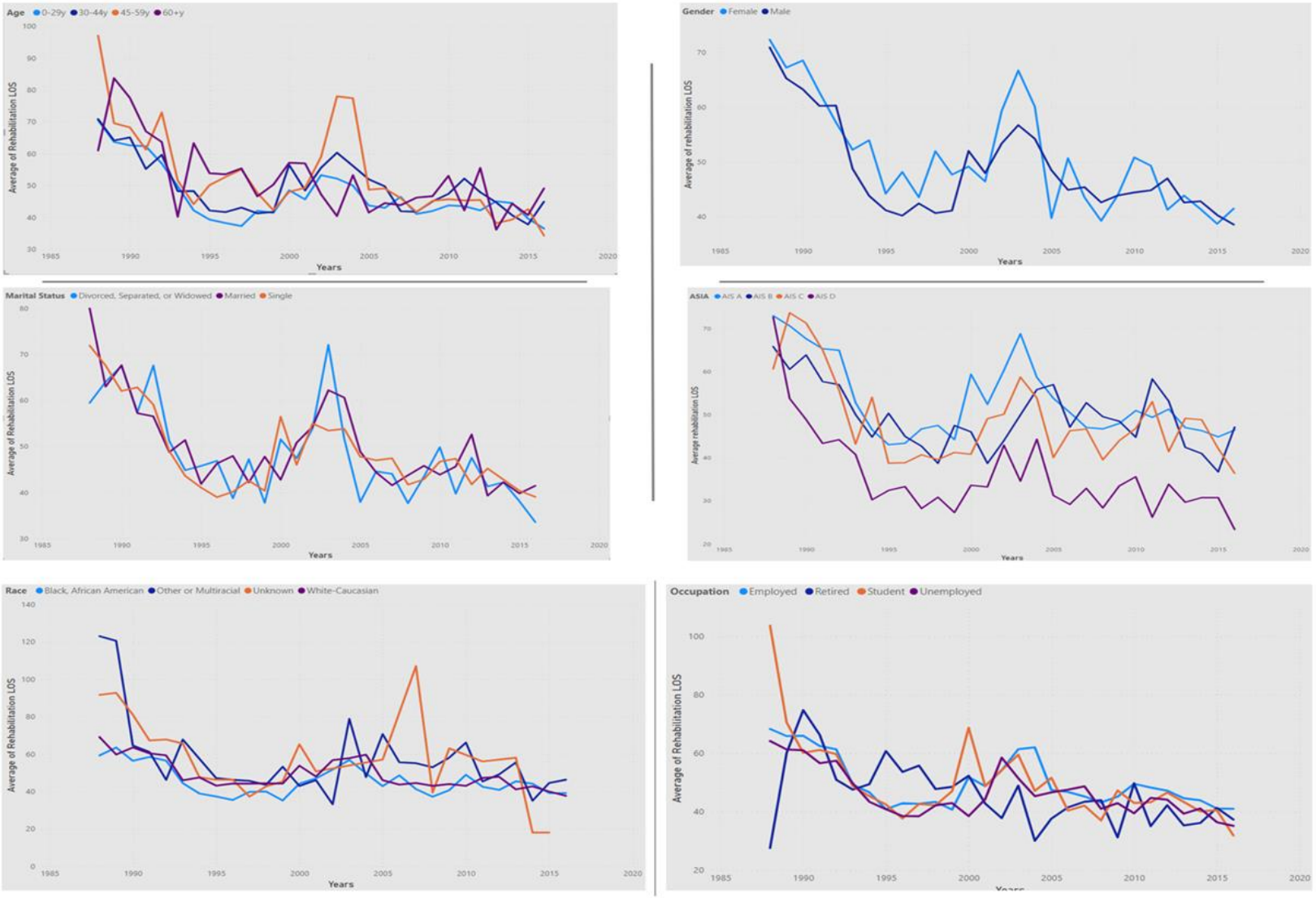


Fig 3. 5 Trends of rehabilitation LOS by sociodemographic groups of SCI paraplegia between 1988 – 2016

Table 3. 3 Sociodemographic characteristics for paraplegia SCI

Variables	Total n = 7,594
Age	
1. 0 to 29 years	3,828 (50%)
2. 30 to 44 years	2,087 (27%)
3. 45 to 59 years	1,080 (15%)
4. 60 years or Older	599 (8%)
Race	
1. White	4,734 (62%)
2. Black or African American	2,093 (28%)
3. Other or Multiracial	379 (5%)
4. Unknown	388 (5%)
Gender	
1. Male	6,090 (80%)
2. Female	1,504 (20%)
Marital status	
1. Single	4,355 (57%)
2. Married	2,260 (30%)
3. Divorced, Separated, or Widowed	979 (13%)
Occupation	
1. Employed	4,615 (61%)
2. Retired	392 (5%)
3. Students	969 (13%)
4. Unemployed	1,618 (21%)
ASIA Impairment Scale	
1. AIS A	4,253 (56%)
2. AIS B	756 (10%)
3. AIS C	1,206 (16%)
4. AIS D	1,379 (18%)
Functional Independence Score (FIM)	
Mean	31.74
Standard Deviation (SD)	11.48

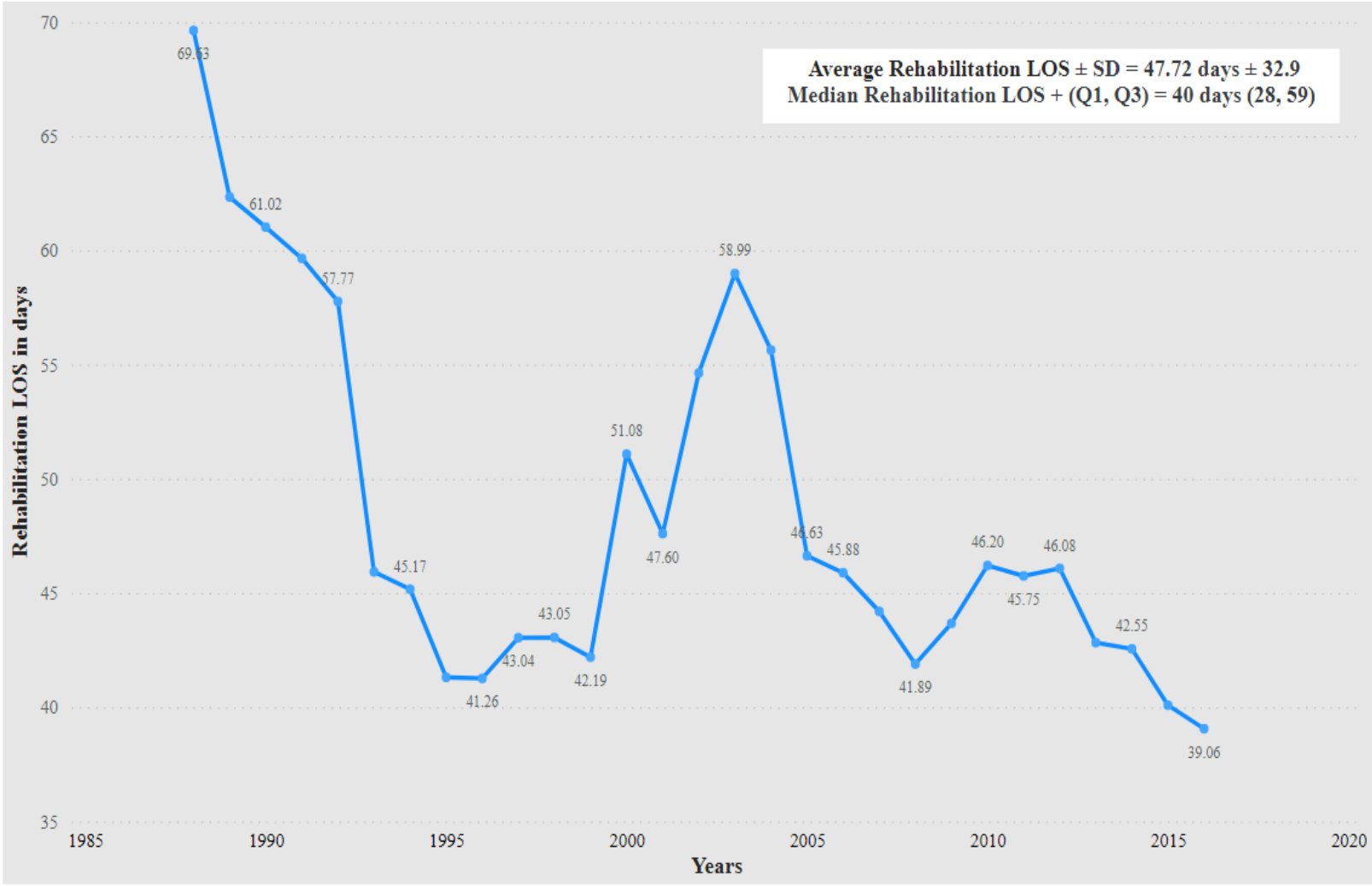


Fig 3. 6 Trends of rehabilitation LOS in SCI paraplegia between 1988 and 2016

Table 3. 4 Multivariate regression of log rehabilitation LOS with and without log transformation in SCI paraplegia

Variables **N= 7,594**	**Rehabilitation LOS** Coeff. [95% conf. interval]	**Log Rehabilitation LOS** Coeff. [95% conf. interval]
Years (1988-2016)	-0.716 [-0.809, -0.623] *	-0.014 [-0.016, -0.013] *
FIM at rehabilitation admission	-0.715 [-0.779, -0.651] *	-0.018 [-0.019, -0.017] *
Age (0 to 29 years = reference)		
30 to 44 years	3.927 [1.971, 5.882] *	0.066 [0.029, 0.103] *
45 to 59 years	9.042 [6.471, 11.612] *	0.158 [0.110, 0.205] *
60 or Older	14.075 [10.08, 16.071] *	0.241 [0.168, 0.315] *
Gender (female = reference)	-1.274 [-3.071, 0.521]	-0.026 [-0.062, 0.004]
Race (white =reference)		
Black / African American	-1.274 [-3.427, 0.036]	-0.026 [-0.059, 0.003]
Other & multiracial	5.718 [2.461, 8.977] *	0.106 [0.047, 0.165] *
Unknown	8.489 [5.126, 11.852] *	0.179 [0.118, 0.240] *
ASIA Impairment Scale (A = reference)		
AIS B	-2.761 [-5.173, -0.349] *	-0.051 [-0.095, -0.006] *
AIS C	-3.458 [-5.467, -1.448] *	-0.063 [-0.106, -0.031] *
AIS D	-12.657 [-14.648, -10.66] *	-0.361 [-0.412, -0.339] *
Marital Status (single = reference)		
Married	-4.012 [-6.074, -1.949] *	-0.085 [-0.123, -0.046] *
Divorced, separated, or widowed	-3.231 [-5.728, -0.733] *	-0.070 [-0.115, -0.024] *
Occupation (Employed = reference)		
Retired	-11.293 [-15.644, -6.943] *	-0.165 [-0.244, -0.087] *
Student	0.169 [-2.203, 2.542]	0.006 [-0.036, 0.049]
Unemployed	-2.741 [-4.629, -0.852] *	-0.042 [-0.077, -0.008] *

*** Significant Level <0.05**

Table 3. 5 Multivariable regression of rehabilitation LOS and log rehabilitation LOS with interaction between years*FIMs

Variables N= 7,594	**Rehabilitation LOS**	**Log Rehabilitation LOS**
	Coeff. [95% conf. interval]	Coeff. [95% conf. interval]
Years (1988-2016)	-0.390 [-0.64, -0.13] *	0.002 [-0.002, 0.006]
FIMs at rehabilitation admission	-0.582 [-0.69, -0.46] *	-0.0108 [-0.012, -0.008] *
Yeas*FIMs	-0.010 [-0.01, -0.002] *	-0.0005 [-0.001, -0.000] *
Age (0 to 29 years = reference) 30 to 44 years 45 to 59 years 60 or Older	 3.953 [1.99, 5.91] * 9.104 [6.53, 11.67] * 14.027 [10.03, 18.02] *	 0.067 [0.03, 0.10] * 0.162 [0.11, 0.21] * 0.23 [0.16, 0.31] *
Gender (female = reference**)**	-1.26 [-3.06, 0.52]	0.02 [-0.05, 0.006]
Race (white =reference) Black / African American Other & multiracial Unknown	 - 1.801 [-3.53, -0.06] * 5.625 [2.36, 8.88] * 8.670 [5.30, 12.03] *	 - 0.031 [-0.06, -0.001] * 0.103 [0.04, 0.16] * 0.188 [0.12, 0.24] *
ASIA Impairment Scale (A = reference) AIS B AIS C AIS D	 -2.715 [-5.12, -0.31] * -3.425 [-5.43, -1.41] * -12.561 [-14.55, -10.57] *	 - 0.048 [-0.09, -0.005] * - 0.062 [-0.09, -0.02] * - 0.356 [-0.39, -0.32] *
Marital Status (single = reference) Married Divorced, separated, or widowed	 -3.994 [-6.05, -1.93] * -3.176 [-5.67, -0.67] *	 - 0.082 [-0.12, -0.04] * - 0.067 [-0.11, -0.02] *
Occupation (Employed = reference) Retired Student Unemployed	 -11.384 [-15.73, -7.03] * 0.227 [-2.14, 2.60] -2.771 [-4.65, -0.88] *	 -0.171 [-0.25, -0.09] * 0.009 [-0.03, 0.05] - 0.044 [-0.07, -0.01] *

*** Significant level <0.05.**

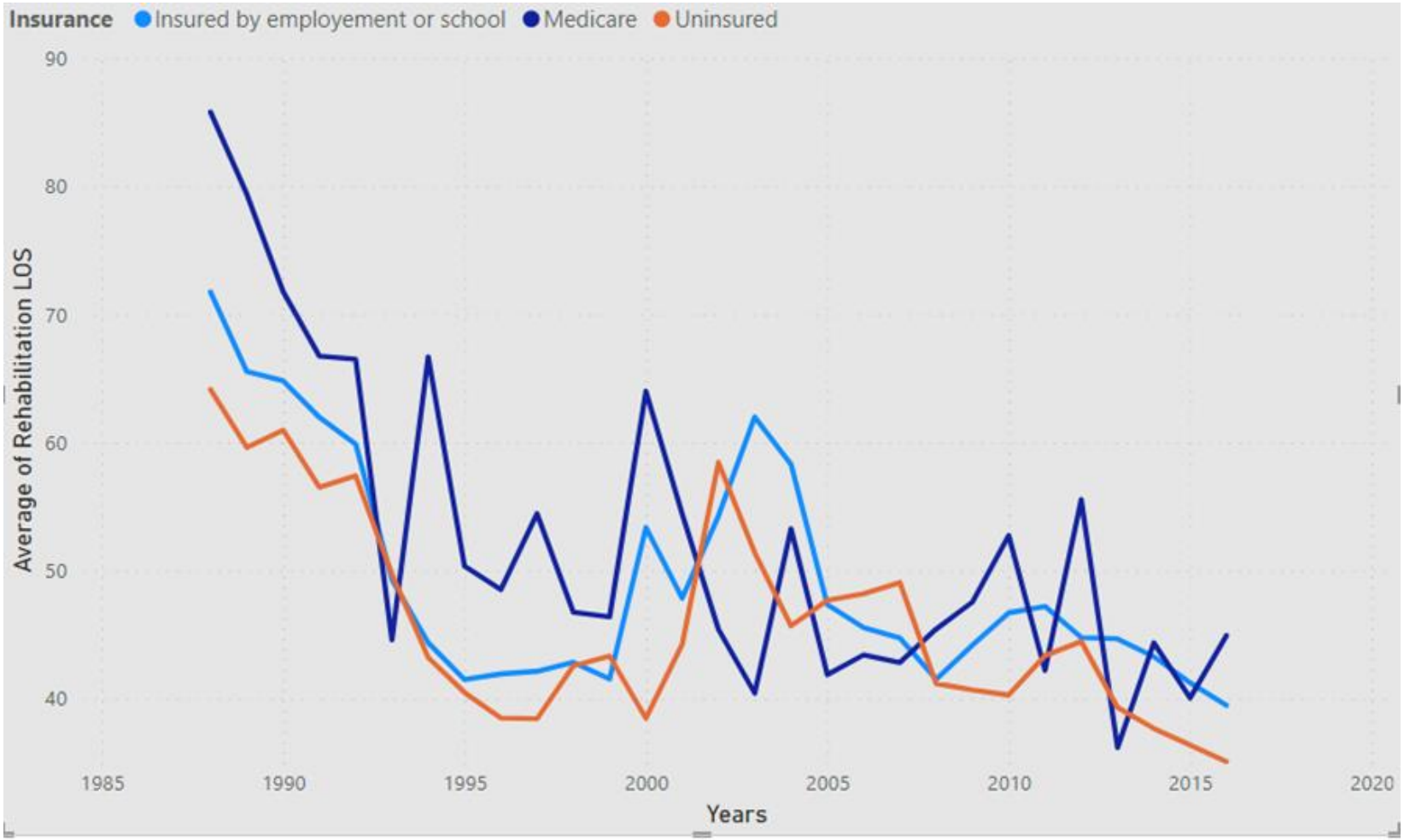


Fig 3. 7 Trends of rehabilitation LOS by insurance status between 1988-2016.

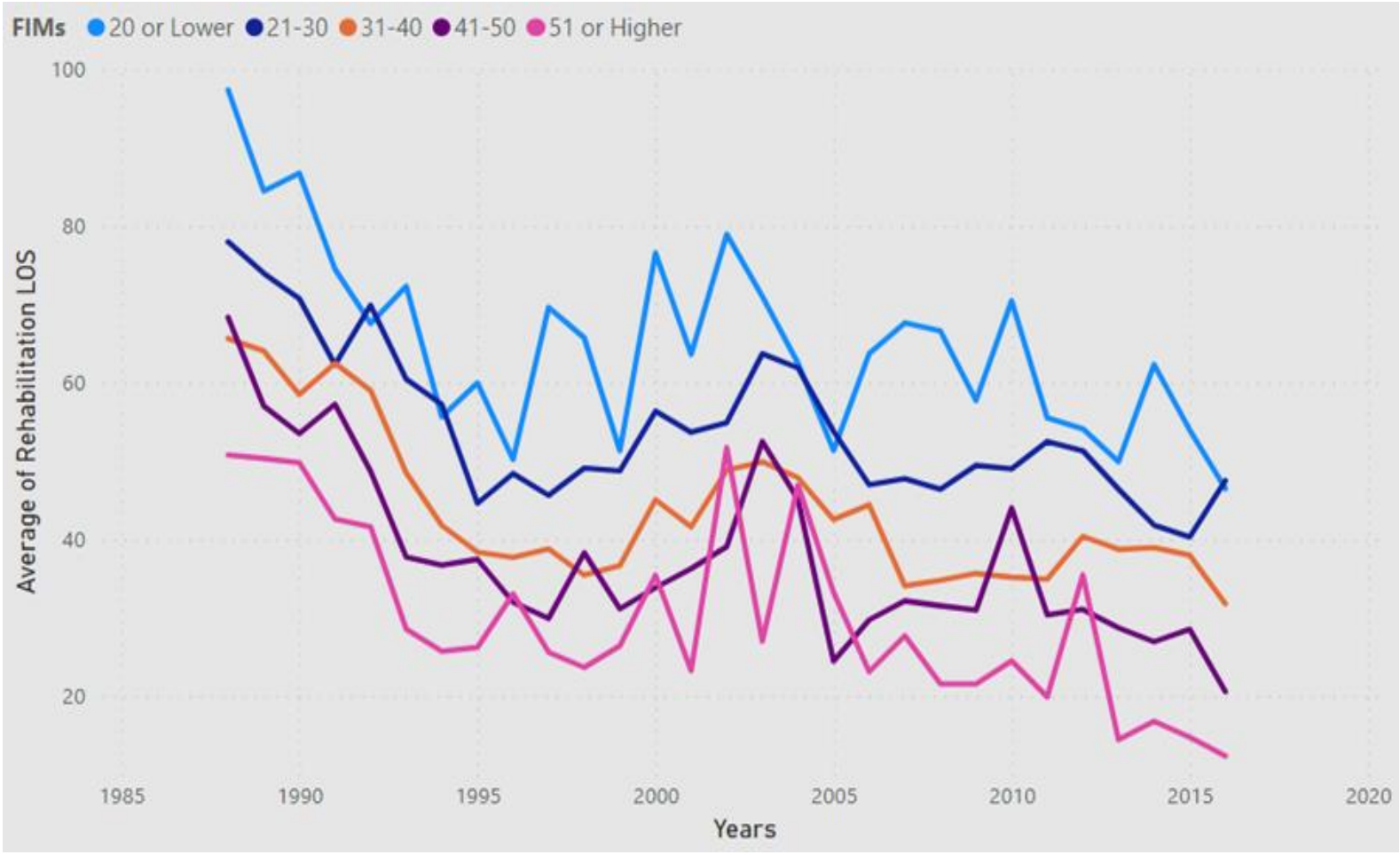


Fig 3. 8 Distribution of FIMs by rehabilitation LOS between 1988-2016

Table 3. 6 The coefficient estimates of years on rehabilitation LOS when control variables were added to the model.

Controls	1	2	3	4	5	6	7	8
	None	Col.1 & ASIA	Col.2 & age	Col.3 & gender	Col.4 & race	Col.5 & marital	Col.6 & occupation	Col.7 & FIM
None	-0.011	-0.009	-0.011	-0.011	-0.009	-0.009	-0.009	-0.015
ASIA		✓	✓	✓	✓	✓	✓	✓
Age			✓	✓	✓	✓	✓	✓
Gender				✓	✓	✓	✓	✓
Race					✓	✓	✓	✓
Marital						✓	✓	✓
Occupation							✓	✓
FIM								✓

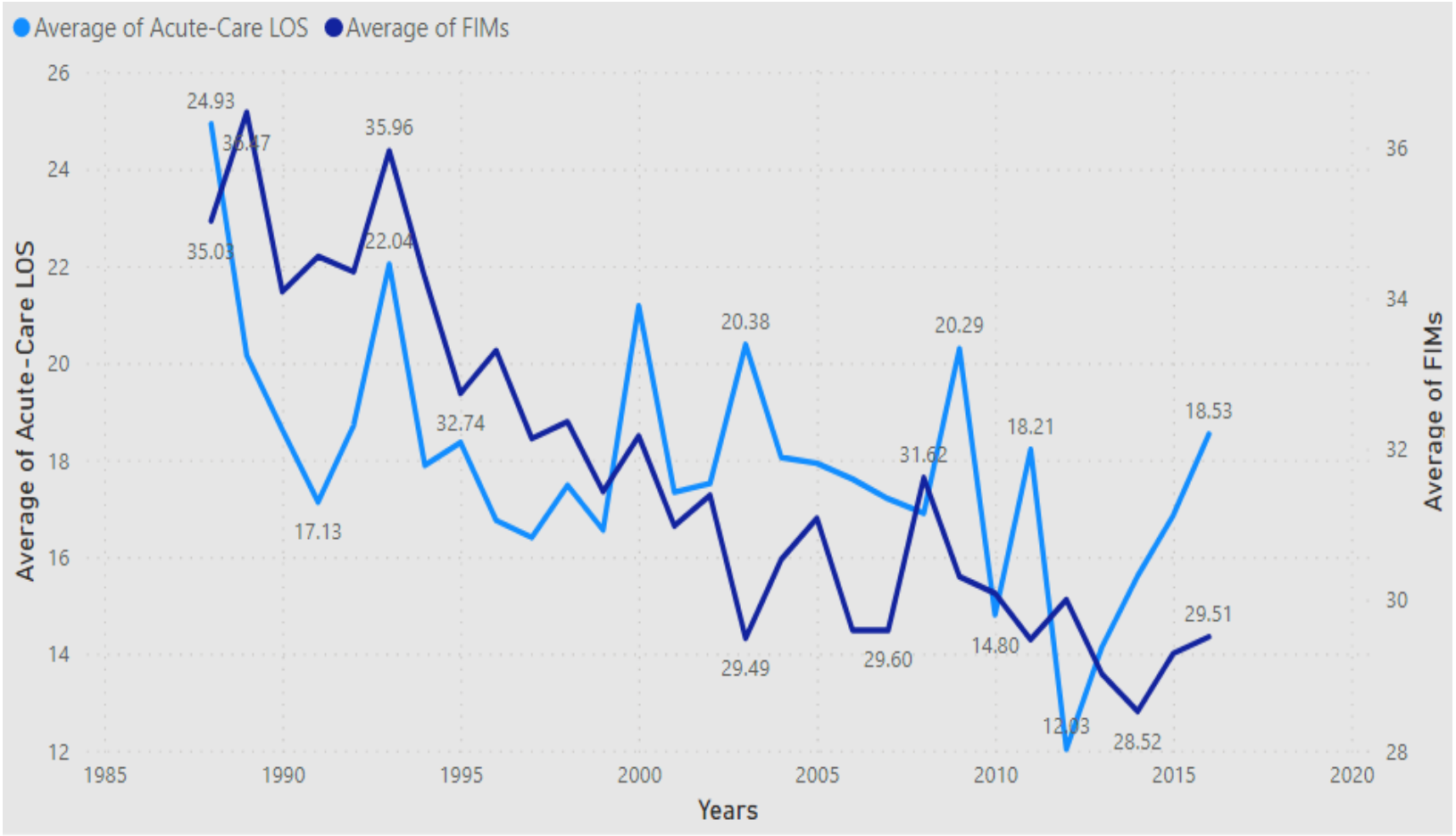


Fig 3. 9 Trends of FIM score at inpatient rehabilitation admission and acute-care LOS from 1988 to 2016

Table 3. 7 Trends of FIM score at inpatient rehabilitation admission between 1988

Variables N= 7,594	**FIM score** Coeff. [95% conf. interval]
Years (1988-2016)	-0.271 [-0.303, -0.239] *
Age (0 to 29 years = reference) 30 to 44 years 45 to 59 years 60 or Older	 -0.681 [-1.359, -0.0025] * -1.739 [-2.630, -0.848] * -3.667 [-5.051, -2.283] *
Gender (female = reference)	2.570 [1.949, 3.191] *
Race (white =reference) Black / African American Other & multiracial Unknown	 1.988 [1.388, 2.588] * -1.202 [-2.333, -0.071] * -3.640 [-4.804, -2.476] *
ASIA Impairment Scale (A = reference) AIS B AIS C AIS D	 1.116 [0.279, 1.953] * 3.438 [2.744, 4.131] * 8.008 [7.341, 8.675] *
Marital Status (single = reference) Married Divorced, separated, or widowed	 0.062 [-0.653, 0.778] 0.250 [-0.615, 1.117]
Occupation (Employed = reference) Retired Student Unemployed	 -1.510 [-3.020, -0.000] * -0.547 [-1.371, 0.276] 0.575 [-0.079, 1.231]

CHAPTER 4: HEALTH OUTCOMES IN INDIVIDUALS WITH SPINAL CORD INJURY PAPAPLEGIA ONE YEAR AFTER INPATIENT REHABILITATION DISCHARGE

4.1 INTRODUCTION

Spinal cord injury (SCI) often causes intense motor and sensory impairments that are associated with functional limitations, poor quality of life and lower participation in daily activities (Marino et al., 1999; Piatt et al., 2016; Wollaars et al., 2007). Individuals with SCI need intensive and early rehabilitation interventions to improve health and functional outcomes at hospital's discharge (Herzer, 2016; Scivoletto, 2005). The key objectives of rehabilitation in SCI are reducing disabilities, improving quality of life, preventing secondary complications, lowering rehospitalization occurrences and maximizing independence in daily activities (Cahow, 2012; DeJong, 2013; New, 2005; Yarkony, 1987). Moreover, research found that an earlier time to rehabilitation was associated with a higher functional outcome at discharge (Herzer, 2016).

However, rehabilitation length of stay (LOS) has remarkedly declined last decades (Eastwood, 1999; Morrison, 1999; Wilkinson, 2022). Eastwood et al (1999) found that rehabilitation LOS declined from 74.1 days in 1990 to 60.8 days in 1997.

In paraplegia, research found LOS decreased by 33.6 between 1991 and 1995 (Morrison, 1999). The decline of LOS leads to a public concern about its impact on patients' health outcomes. Thus, it is essential to identity the trends of rehabilitation LOS and explore its influences on health outcomes of those with SCI.

Several studies have examined the association between rehabilitation LOS and patients' functional and psychological outcomes. For example, Eastwood et al, observed that shorter LOS was associated positively with functional outcomes, social supports, and discharge to home (Eastwood, 1999). However, another study found individuals with paraplegia had significantly lower score at post-discharge in four FIM scores (feeding, grooming, bathing, and upper body dressing) and only one score (ambulation) had no change when rehabilitation LOS was declined between 1991 and 1995 (Morrison, 1999). Also, studies found longer rehabilitation LOS was associated with better FIM score at discharge (Kao, 2022). Moreover, decreased rehabilitation LOS was associated with increased the need for bowel management assistance after discharge (Wilkinson, 2022).

The aim of this research is to examine the effect rehabilitation length of stay on functional and psychological outcomes in individuals with paraplegia between 2000 and 2015 in the United States. The individuals' health outcomes comprise functional independence score (FIM), rehospitalization, and Craig Handicap Assessment and Reporting Technique (CHART) quality of life, and satisfaction with life score (SWLS). We evaluate patients' outcomes after one-year of discharge in patients' annual anniversary follow-up. We hypothesis that health outcomes were getting worse between 2000 and 2015 after one year of inpatient rehabilitation discharge when rehabilitation LOS continued to decline.

4.2 CONCEPTUAL FRAMEWORK: INTERNATIONAL CLASSIFICATION OF FUNCTIONING, DISABILITY, AND HEALTH (ICF).

The International Classification of Functioning, Disability, and Health (ICF) is WHO framework for measuring health and disability at both individual and population level (World Health Organization, 2001). The ICF framework was approved for use by the World Health Assembly in 2001 (World Health Organization, 2001), Several studies have used this model to assess and evaluate rehabilitation care outcomes (AlHuthaifi, 2017; van Leeuwen, 2012). For the purpose of our research, we used the ICF framework to construct the study's objective and justify selected factors (see **Fig.4.1**). The ICF framework implies patients' functioning ability as a dynamic interaction between their health conditions, personal factors, and environmental factors (World Health Organization, 2001). The framework components include three outcome dimensions (**body structures and functions, activities, participation)** that are thought to be affected by health conditions and personal & environmental factors.

For the study's objectives, we applied the outcome dimensions to evaluate health and functional outcomes of individuals with paraplegia SCI that includes: FIM scores, CHART quality of life, life satisfaction and rehospitalization. For body structure and function dimensions, we used CHART physical independence score and FIM score. In activities dimension, we applied CHART mobility and occupation score. While for participation, we included CHART social integration score, SWLF and rehospitalization occurrence.

The control factors included level of severity injury that defined by AIS impairment scale (AIS A, B, C, and D), environmental factors (i.e., rehabilitation LOS) and personal factors. Several studies used LOS as a predictor factor to measure patients' outcomes (Abdul-Sattar, 2014; AlHuthaifi, 2017). For our analysis, we used rehabilitation LOS as the main explanatory variable along with severity of injury and personal factors such as age, gender, race, occupation, and marital status.

4.3 METHODS

4.3.1 Data source and study sample

We used the National Spinal Cord Injury Statistics Center (NSCISC) dataset between 2000 and 2015 in the United States, which is the same database that was used in chapter 2. Our analysis used the latest version of de-identified data that are freely available for the public. The health outcomes were obtained during the 1st annual anniversary of follow-up after discharge from inpatient rehabilitation care. Since the health outcome variables were included into the database after 1994, we chose a different study's cohort (2000-2015) than the cohort used for chapter 2 (1988-2016). In our model, we included patients' injury characteristics and sociodemographic information. For the study's objective, we included only patients with traumatic complete or incomplete paraplegia. We excluded responses that are unknown, declined, interview not done, respondent does not know or where under 18 years old (see **Fig 4.2**). These missing responses represented about 30% of the study's sample.

4.3.2 Outcome variable

The main outcomes of this research were patients' functional and psychological health outcomes at first follow-up visit after inpatient rehabilitation discharge including Functional Independence Score (FIM), rehospitalization, and Craige Handicap Assessment and Reporting Technique (CHART), and satisfaction with life score (SWLS). These outcomes are routinely collected at follow-up times and provided in the data.

FIM scores represent the functional status of patients and grade the independence level of motor function. We used the total FIM scores ranging from 13 to 91 where the lower score indicates lower functional performance, and higher score indicates higher functional performance ((Granger & Hamilton, 1993).

CHART is a widely used questionnaire to provide a simple and objective measure of the degree handicaps after initial rehabilitation (Hall, 1998). We used the total scores of four CHART outcomes: total physical independence, total mobility, total occupation, and total social integration scores. The highest total CHART score is 100 and indicates no handicap in individual's ability. There were some cases in which the total CHART score exceeded 100. These cases were coded as 100. Even though CHART produced scores theoretically ranging from 0-100 that could be quantitatively analyzed, these data exhibited a large proportion of scores of 100. Therefore, we coded CHART as a dichotomous variable. For the analysis, we categorized each CHART outcomes into two groups: individuals without handicaps (score = 100) and individuals with some degree of handicaps (score < 100).

Rehospitalization represented the event where patients were re-hospitalized at least once in the 12 months following inpatient rehabilitation. The rehospitalization were sorted into two groups; individuals who had not been re-hospitalized and individuals who had been re-hospitalized at least once.

Life satisfaction measured the concept of life satisfaction based on the participant's responses to survey questions (Diener, 1985). We used the total SWLF that ranged from 5 to 35; where higher score means more life satisfaction.

4.3.3 Independent variables

The independent variables were rehabilitation LOS, patients' sociodemographic variables at the hospital admission (age, gender, race, year of injury, occupation, marital status), and severity of injury as defined by the American Spinal Injury Association (ASIA) Impairment Scale (AIS A, B, C, and D). The years' boundary started from 1 when years was 2000 to 16 when years was 2015. Similar to chapter 3, age group comprised four categories: 0-29 years old, 30-44 years old, 45-59 years old, and 60 or older. The study had two gender groups: males and females. There were three race group in this study including White, Black or African American and other or multiracial. Also, there were four groups in occupation groups: employed, retired, student and unemployed group. Moreover, the sample involved three marital statuses: single, married and separated, widowed or divorced.

4.3.4 Statistical analysis

The descriptive statistic was used to summarize individuals' characteristics and functional health outcomes. For categorical variables, we used frequency counts and percentages. For continuous variables, we used means with standard deviation if they were normally distributed per the Kolmogorov-Smirnov test, and median with 1st and 3rd quartiles if they were not normally distributed.

To evaluate the effect of rehabilitation LOS on one-year post-discharge health outcomes, after adjusting for individuals' sociodemographic characteristics, we conducted multivariable regression models. For instance, we performed multivariable logistics regression for CHART and rehospitalization and multivariate linear regression for SWLF. For logistics regression, the reference groups were not having handicap for CHART score and had not been re-hospitalized for rehospitalization. Since FIM score is heavily skewed to the left and all transformation methods (natural logarithm, square root, and exponentiate transformation) did not satisfy normality assumptions, we conducted multivariable quantile regression to the median.

All tests were 2-sided with a significance level set to 0.05. Statistical analyses were performed in Stata/IC 15 (StataCorp, 2017).

4.4 RESULTS

4.4.1 Sociodemographic Characteristics:

The characteristics of sociodemographic variables are presented in **Table 4.1**. Across all health outcomes, the majority of the sample were males (79%), mostly white (70%), and predominantly between 0 to 29 years old (45%). Also, single individuals

represented the majority of the sample (54%) and employed were the highest (65%). Individuals with complete AIS A made up 53%.

4.4.2 Rehabilitation LOS:

The trend of rehabilitation LOS was plotted in the graph (see **Fig 4.3**). Between the period of 2000 and 2015, the rehabilitation LOS has declined by approximately 1% in each additional year **(Table 4.2**). Individuals with complete AIS A, older age, unemployed, married and with lower FIM score had longer rehabilitation LOS.

4.4.3 CHART Scores

The majority of sample were reported as having some degree of handicap in all CHART groups (**Table 4.1**). For each additional year, the odds of having some degree of handicap in physical independence in first year follow-up after inpatient rehabilitation discharge increased by 3% (**Table 4.3**). However, we did not find significant associations between years and other CHART scores (mobility, occupation, and social integration). For an additional day increase of rehabilitation LOS, the estimated odds of having handicap in physical independence and mobility increased by 1%, while no significant results were found in occupation and social integration. The trends of individuals with some degree of handicap in CHART score by rehabilitation LOS from 2000 to 2016 are presented in **Fig 4.4**. The trends showed a decrease in rehabilitation LOS and somewhat increase of all CHART handicap groups. Notable, the large drop in 2015 is a result of the small sample size.

Also, the finding showed significant difference across sociodemographic characteristics of individuals with SCI paraplegia. Across all CHART groups, the odds of having some degree of handicap for 30 to 44 years, 45 to 59 years, and 60 or older were higher than 0 to 29 years (see **Table 4.3**). Also, the odd of having some degree of handicap for Black and other or multiracial were higher compared to white groups in all CHART scores, except in social integration where no significant difference was found between other or multiracial and white groups. Moreover, the odd of having some degree of handicap for male compared to female was estimated to decreased by 25% in physical independence and mobility and increased by 30% in occupation, while no differences were found between gender groups in social integration.

Individuals with incomplete AIS C and D had lower odds of having handicaps in physical independence, mobility, and occupation compared to complete AIS A, but no significant differences were shown in social integration. Compared to single groups, married groups experienced lower odds of having handicap in occupation and social integration, while divorced, separated, or widowed were having higher odds of handicap in physical independence. Moreover, the study found that the odd of having some degree of handicap for unemployed and retired increased in all CHART groups when compared to employed groups except for physical independence where there was no difference between retired and employed groups. Also, students had lower odds of having some degree of handicap in physical independence, mobility and social integration when compared to employed (see **Table 4.3**).

4.4.4 Functional Independence Measure (FIM)

At the median quantile (50^{th}), an additional year was associated with a decline of median FIMs by an estimated 0.22 scores (**Table 4.4**). Also, the median FIMs decreased by 0.05 when rehabilitation LOS increase by one day. The trends of FIM scores and rehabilitation LOS from 2000 to 2016 is presented in **Fig 4.5**

Compared to 0 to 29 years old, at the median quantile, individual age 30 to 44 years, 45 to 59 years, and 60 or older had lower FIM scores by 2.89, 5.09 and 8.65 scores, respectively. Also, Black, or African American, and other or multiracial groups had lower FIM score by 1.54 and 3.16 score when compared to white groups. Compared to complete AIS A, individuals with incomplete AIS B, C, D experienced higher FIM scores by 1.66, 6.81 and 11.41 scores, respectively. Moreover, males had higher FIM score compared to females by 1.85 scores. Also, unemployed had lower FIM scores by 1.86 compared to employed. However, there were no significant differences between marital status groups.

4.4.5 Satisfaction with Life Scale (SWLF)

The study found that one additional year was associated with 0.22 increase of SWLF scores (**Table 4.4**). Also, the SWLS decreased by 0.01 score when rehabilitation LOS increased by one day. The trend of SWLF score and rehabilitation LOS from 2000 to 2016 is presented in **Fig 4.6.**

Compared to individual age 0 to 29 years, life satisfaction for individual age 30 to 44 years, 45 to 59 years, and 60 or older decreased by 2.89, 3.54 and 2.23 scores, respectively. Also, Black individuals had lower life satisfaction than white by 1.54.

Moreover, life satisfaction for incomplete AIS C and D increased by 1.13 and 2.21 when compared to complete AIS A. Married groups experienced a higher life satisfaction score equaled 1.62 than single groups. Also, the life satisfaction for unemployed decreased by 1.91 compared to employed. However, there was no statistical difference in life satisfaction between gender groups.

4.4.6 Rehospitalization

In each additional year, the odds of being re-hospitalized at least once in the past 12 months increased by 2% (**Table 4.3**). Also, the odds of rehospitalization increased by 1% when rehabilitation LOS increased by one day. The trends of rehospitalization occurrence by rehabilitation LOS from 2000 to 2016 is presented in **Fig 4.7**

The odds of rehospitalization for 45-59 years and 60 or older were 1.36 and 1.66 times higher than the odds of 0-29 years. Also, the odds of rehospitalization for males were 23% lower than the odds for females. Compared to complete AIS A, the odds of rehospitalization decreased for incomplete AIS B, C, and D by 39%, 33% and 55%, respectively. The odds of rehospitalization for divorced, separated, or widowed were 1.45 higher than the odds for single groups. Moreover, the odds of rehospitalization for unemployed were 1.47 times the odds for employed. However, there was no statistical difference of rehospitalization across race groups.

4.5 DISCUSSION

From 2000 to 2015, we observed a trend of lower FIM scores, higher rehospitalization occurrence, and higher degree of physical independence handicaps in

individuals with SCI paraplegia after one year of inpatient rehabilitation discharge. There was no significant change in CHART occupation, mobility, and social integration scores. Despite the trend in poor health outcomes, individuals showed a positive trend in life satisfaction scores. Consistently, previous research found similar results. For instance, research found patients experienced higher rehospitalization rates and decreased of overall FIM score over time (DeVivo, 2007). Also, Kogos, DeVivo, & Richards (2004) did not find differences in CHART scores between 1995 and 1999 (Kogos, 2004).

Most measures of functional health outcomes showed negative association with longer rehabilitation LOS. Our finding shown that longer rehabilitation LOS was associated with lower FIM scores and SWLF scores. Also, people with longer rehabilitation LOS had some degree of handicap on physical independence, mobility, and occupation abilities. Moreover, longer rehabilitation LOS was associated with occurrence of rehospitalization events. Previous studies found comparable results that longer rehabilitation LOS was associated with lower FIM scores and lower mobility scores (DeVivo, 2007; Whiteneck, 2012). In contrast, studies found shorter rehabilitation LOS was associated with rehospitalization occurrences (DeJong, 2013; Eastwood, 1999). Not necessarily longer rehabilitation LOS makes post-discharge health outcome worse; it is merely because individuals with longer rehabilitation LOS had severe injury, critical medical complications and discharged from acute care with low functional health outcomes (Catharine Craven, 2017). Since rehabilitation LOS was not randomly assigned, it just reflected the severity of injury and the general functional status. Thus, it is not surprising that that longer rehabilitation LOS was associated with worse health outcomes after one year of inpatient rehabilitation discharge. In other words,

rehabilitation LOS was only an indicator of severity of injury and the general functional status. We also performed additional analysis to control the effect of functional status (FIMs) at different period of time: at admission of inpatient rehabilitation care, at discharge from inpatient rehabilitation care and the difference between admission and discharge from rehabilitation care. Still, rehabilitation LOS was significantly associated with worse health outcomes and the main results did not largely change. In brief, controlling for functional status may not be enough to detect the effect of the actual health condition of individual and other predictors (i.e., medical complications, pressure ulcer, bowel management) should be evaluated.

Individuals' health outcomes varied across the sociodemographic variables. Old, unemployed, and with complete AIS A had lower FIM score, higher rehospitalization rate, lower SWLF score, and higher degree of handicap in physical independence, mobility, occupation, and social integration handicap. Similarly, previous studies found significant variations of health outcome across sociodemographic groups. For instance, DeJong et al. (2013) suggested that rehospitalization rates associated with being women, younger age, with server level of injury, and being unemployed or retired (DeJong, 2013). Also, Backus et al. (2013) found older age with server level of injury were more likely to have lower FIM, mobility and occupation scores (Backus, 2013). Our finding showed that Black individuals had worse health outcomes including lower FIM score, lower SWLF score, and higher degree of handicap in physical independence, mobility, occupation, and social integration handicap when compared to white group. However, there was no difference between racial groups in rehospitalization rate.

Our finding showed distinguished differences between gender groups. For instance, males had higher FIM scores, lower rehospitalization rate, better physical independence and mobility scores when compared to female. Females had better outcome only in occupation scores when compared to males. Both gender groups were not statistically different in social integration and life satisfaction. Married individuals showed better life satisfaction and lower social integration and occupation handicap when compared to single. While divorced, separated, or widowed had higher rehospitalization rate and lower degree of handicap in physical independence scores.

4.6 LIMITATION

This study has several limitations. First, we used individuals' responses of CHART and SWLF questionnaires and hence, it is possible that individuals overestimated or underestimated the types, elements, or duration of the services and instruments. Second, NSCISC database missed potentially useful variables such as hospital characteristics and insurance status between 2000 and 2015, which are essential information to understand the variation of individuals' health outcomes.

Evaluating the variation of treatment time and intensity would help to understand health outcomes, and rehabilitation efficiency. Whiteneck et al. (2011) found inpatient treatment time varied across patients with SCI after controlling for rehabilitation LOS (Whiteneck, 2011). Also, studies found significant variations in treatment time of physical therapy, occupational therapy, therapeutic recreation, and speech-language pathology across SCI patients' injury characteristics (Brougham, 2011; Foy, 2011; Gassaway, 2011; Taylor-Schroeder, 2011). Research suggested that more and intensive

time on physical therapy was associated with higher functional scores, and lower rehospitalization rates (DeJong, 2013; Teeter, 2012).

4.7 CONCLUSION

The first-year post-discharge health and functional outcomes became worse or did not improve among individuals with paraplegia over the years from 2000 to 2015. Individuals with paraplegia experienced negative trends of FIM score, positive trends of physical independence handicap and higher rehospitalization rates. Our analysis found large variations of health outcomes across individuals characteristics. Old, unemployed, and with complete paraplegia had lower FIM score, higher rehospitalization rate, lower SWLF score, and higher degree of handicap in physical independence, mobility, occupation, and social integration handicap. Also, our results suggested that longer rehabilitation LOS was associated with higher degree of handicap of physical independence and mobility, lower FIM scores, lower SWLF and higher rate of rehospitalization. Future research should evaluate the types and intensities of rehabilitation care to assure rehabilitation efficiency and quality of care. Since this study had limited information about the insurance status of individuals, future research needs to evaluate the association between rehabilitation LOS and insurance status of individuals.

The finding of this study can be beneficial to healthcare physicians and practitioners to develop intervention to improve the overall health outcomes of individuals with paraplegia SCI with sustaining rehabilitation efficiency. Also, this study can help healthcare research and administrators to evaluate healthcare efficiency with caution to health outcomes. This study found that individuals post-discharge health

outcomes became worse or did not improve, which may indicate cost-shifting from cost saving in rehabilitation care by mainly reducing LOS to cost spending in rehospitalization occurrences and treating preventive health issues. Moreover, this study examined the sociodemographic disparities that are associated with health outcomes, which can benefit healthcare professionals to design strategies and interventions to identify the needs and demands of underserved populations.

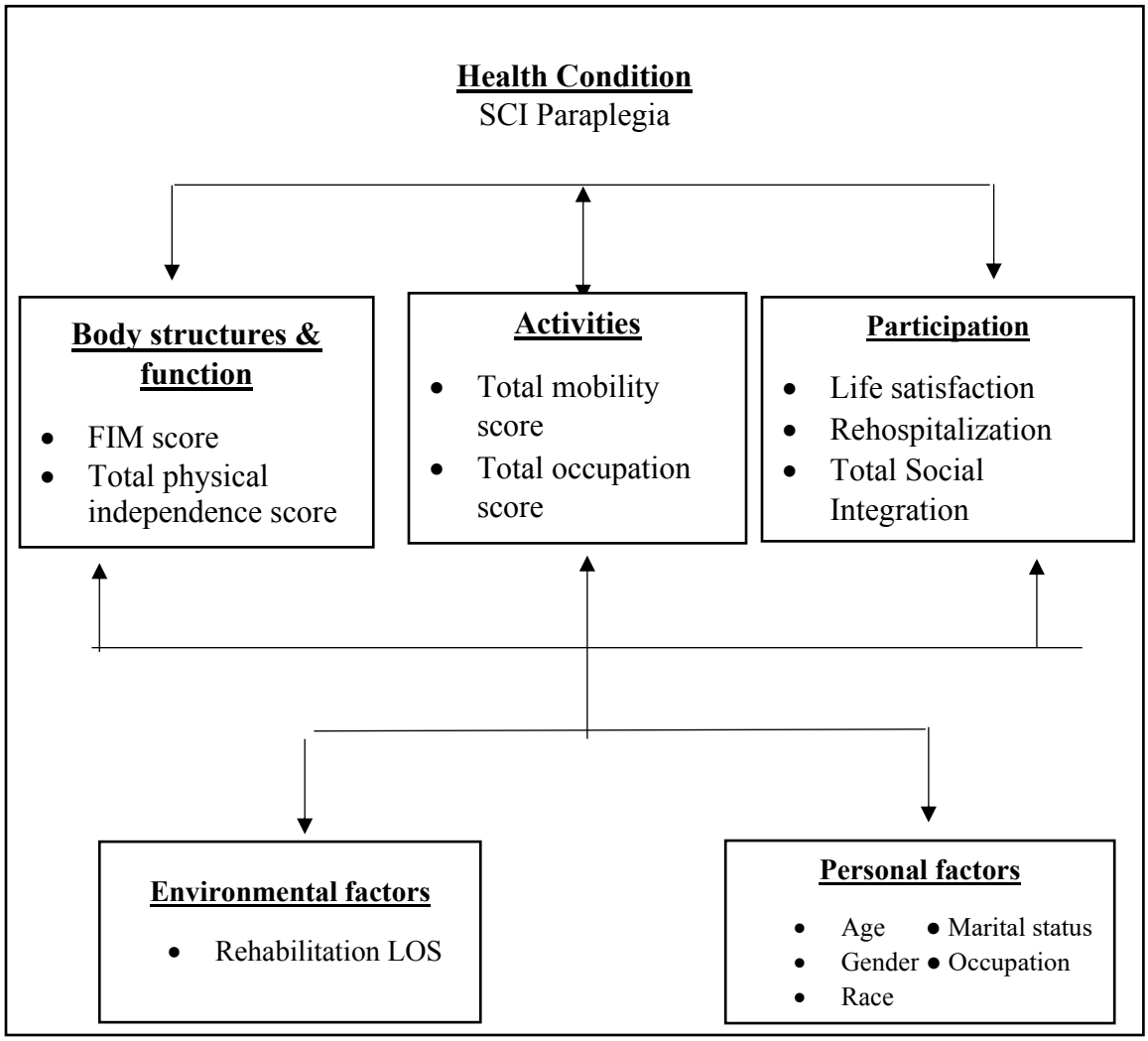
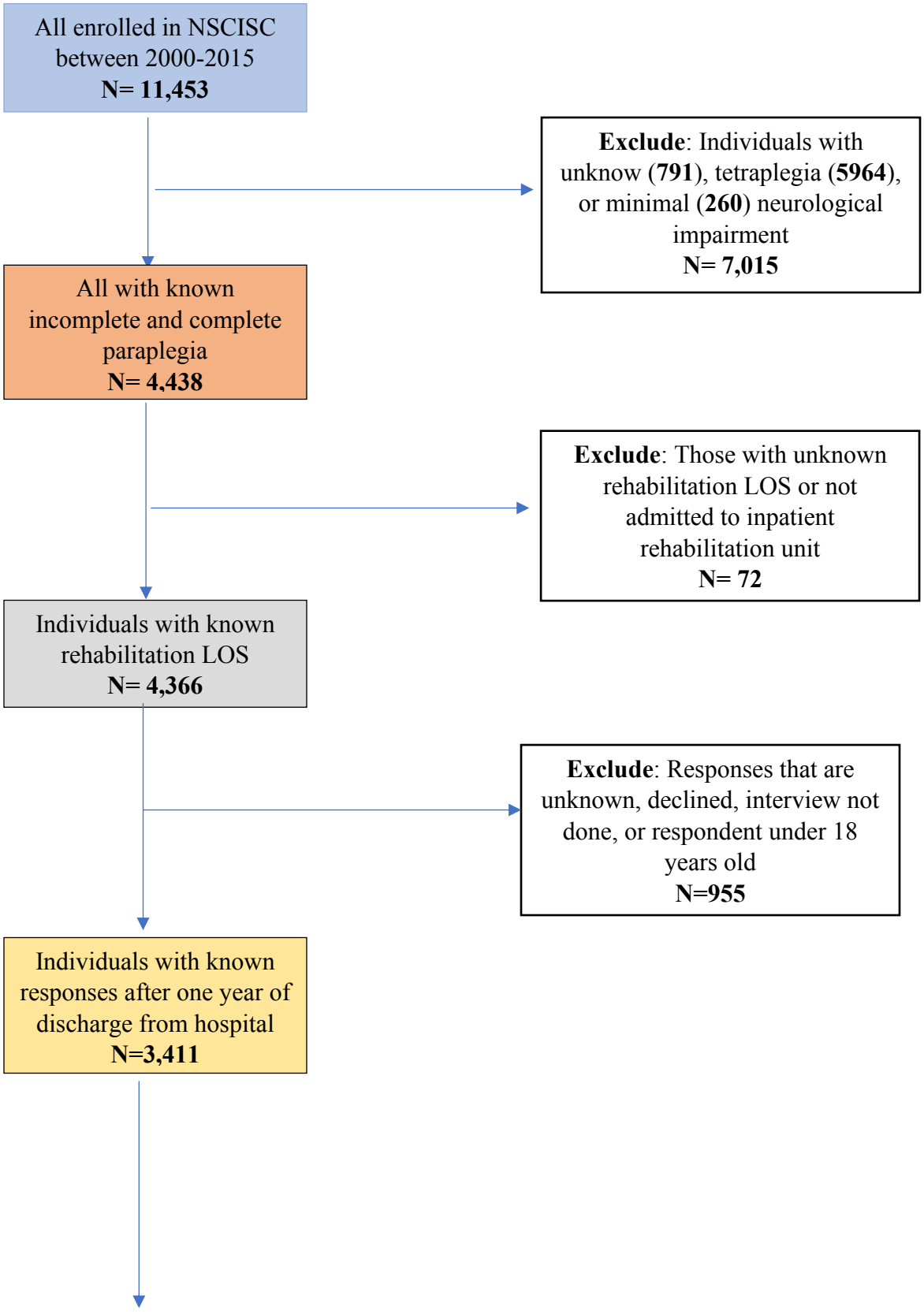


Fig 4. 1 The International Classification of Functioning, Disability, and Health (ICF)


All enrolled in NSCISC between 2000-2015
N= 11,453
Exclude: Individuals with unknow (791), tetraplegia (5964), or minimal (260) neurological impairment
N= 7,015
All with known incomplete and complete paraplegia
N= 4,438
Exclude: Those with unknown rehabilitation LOS or not admitted to inpatient rehabilitation unit
N= 72
Individuals with known rehabilitation LOS
N= 4,366
Exclude: Responses that are unknown, declined, interview not done, or respondent under 18 years old
N=955
Individuals with known responses after one year of discharge from hospital
N=3,411

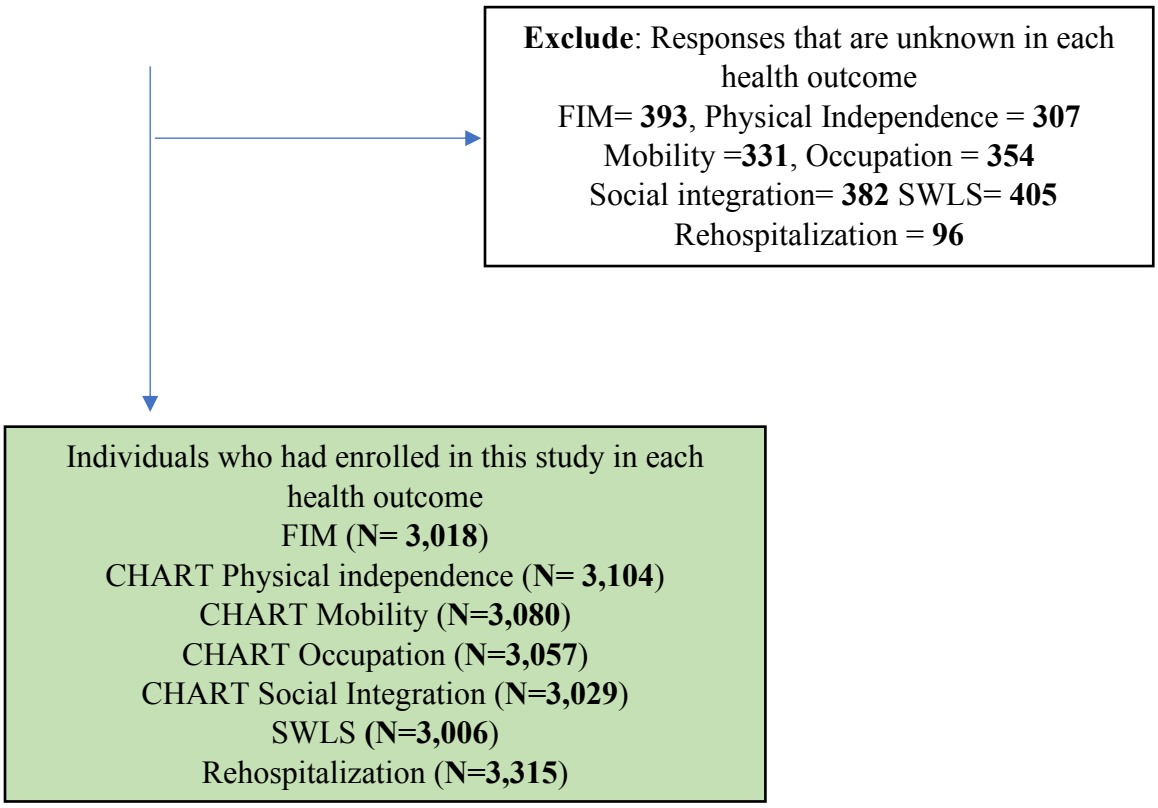


Fig 4. 2 The flowchart of inclusive and exclusive criteria using the NSCISC database.

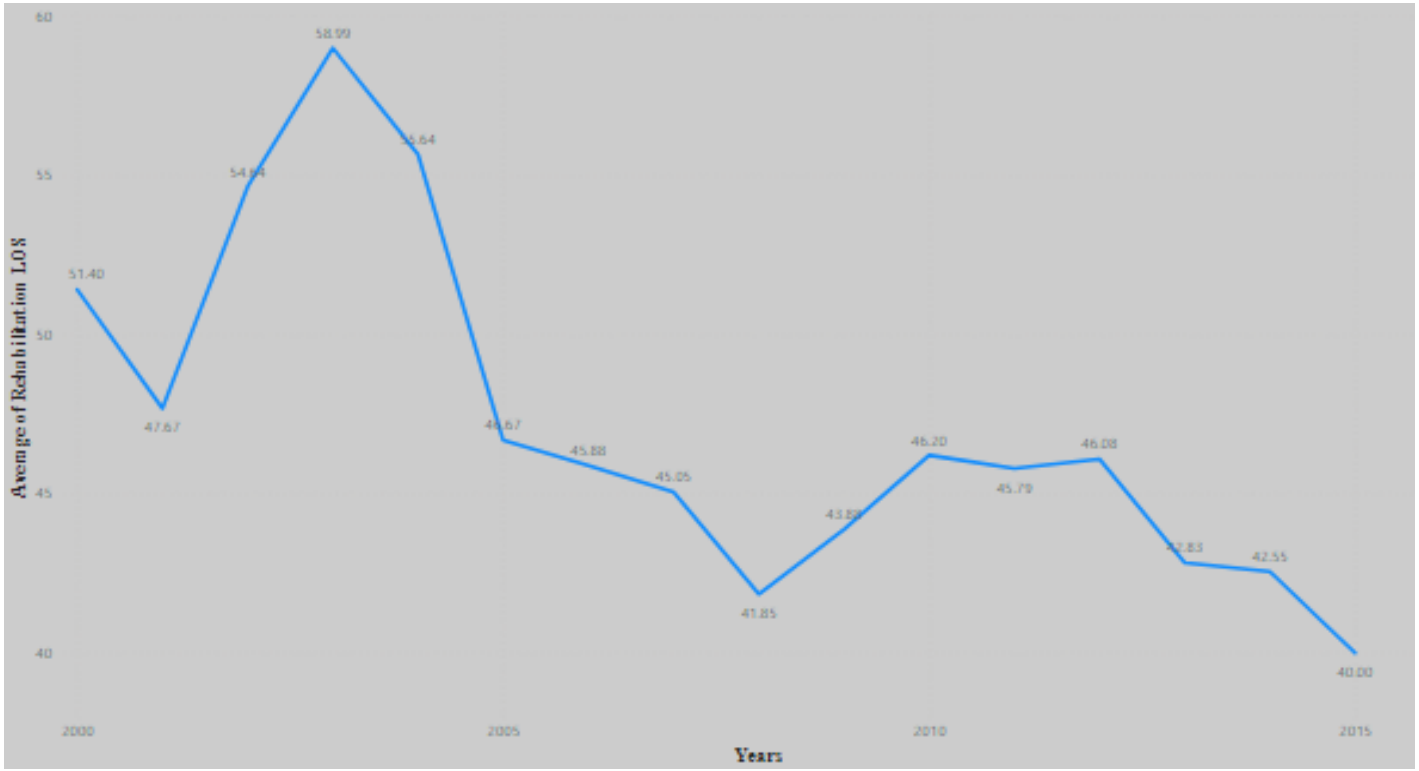


Fig 4. 3 The trends of rehabilitation LOS between 2000 and 2015.

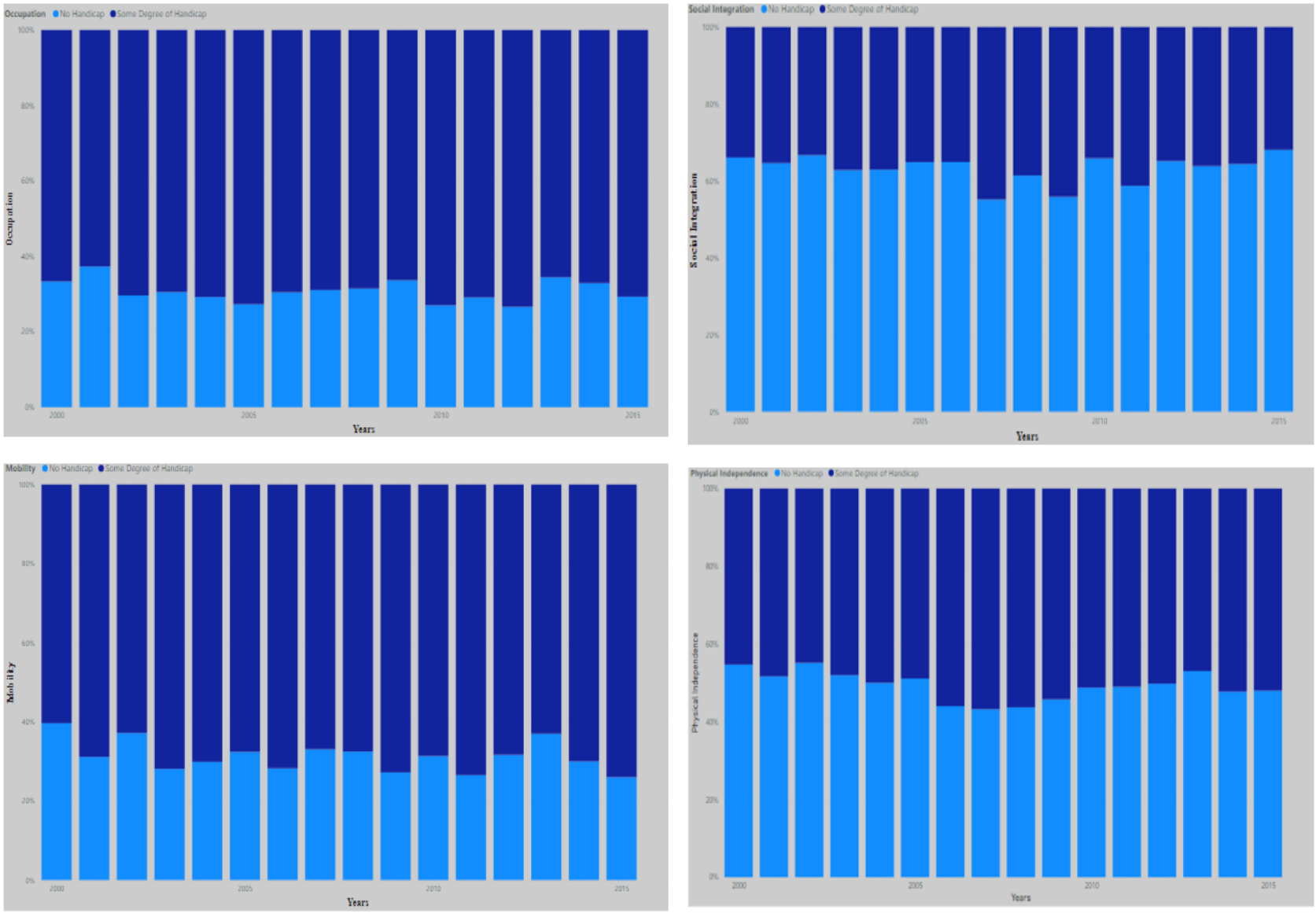


Fig 4. 4 Distribution of CHART scores from 2000 to 2015

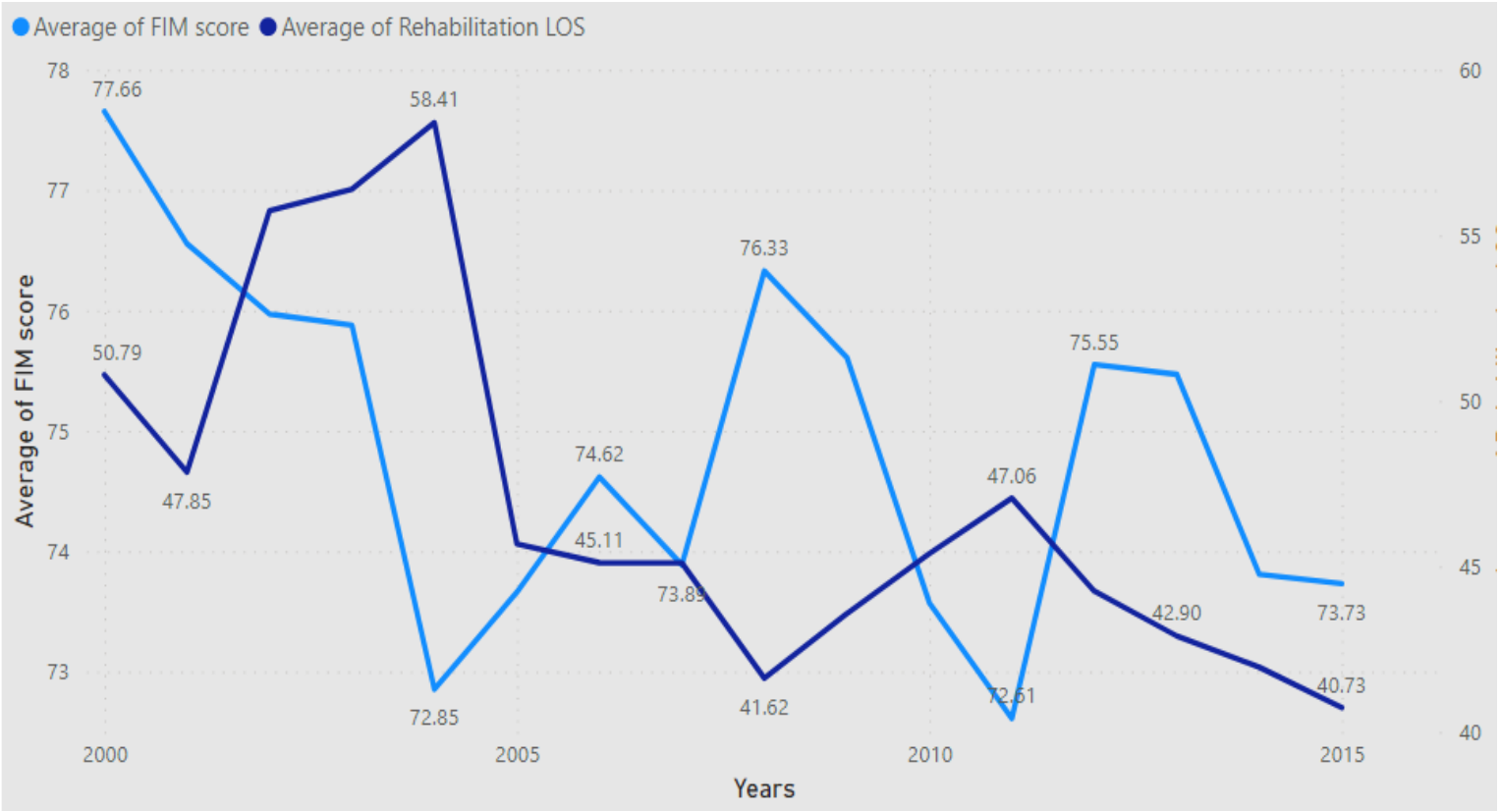


Fig 4. 5 Trends of FIMs and rehabilitation LOS in SCI paraplegia between 2000-2015

NOTE: The change in trends of rehabilitation LOS is a result of different sample size that were included for each health outcomes.

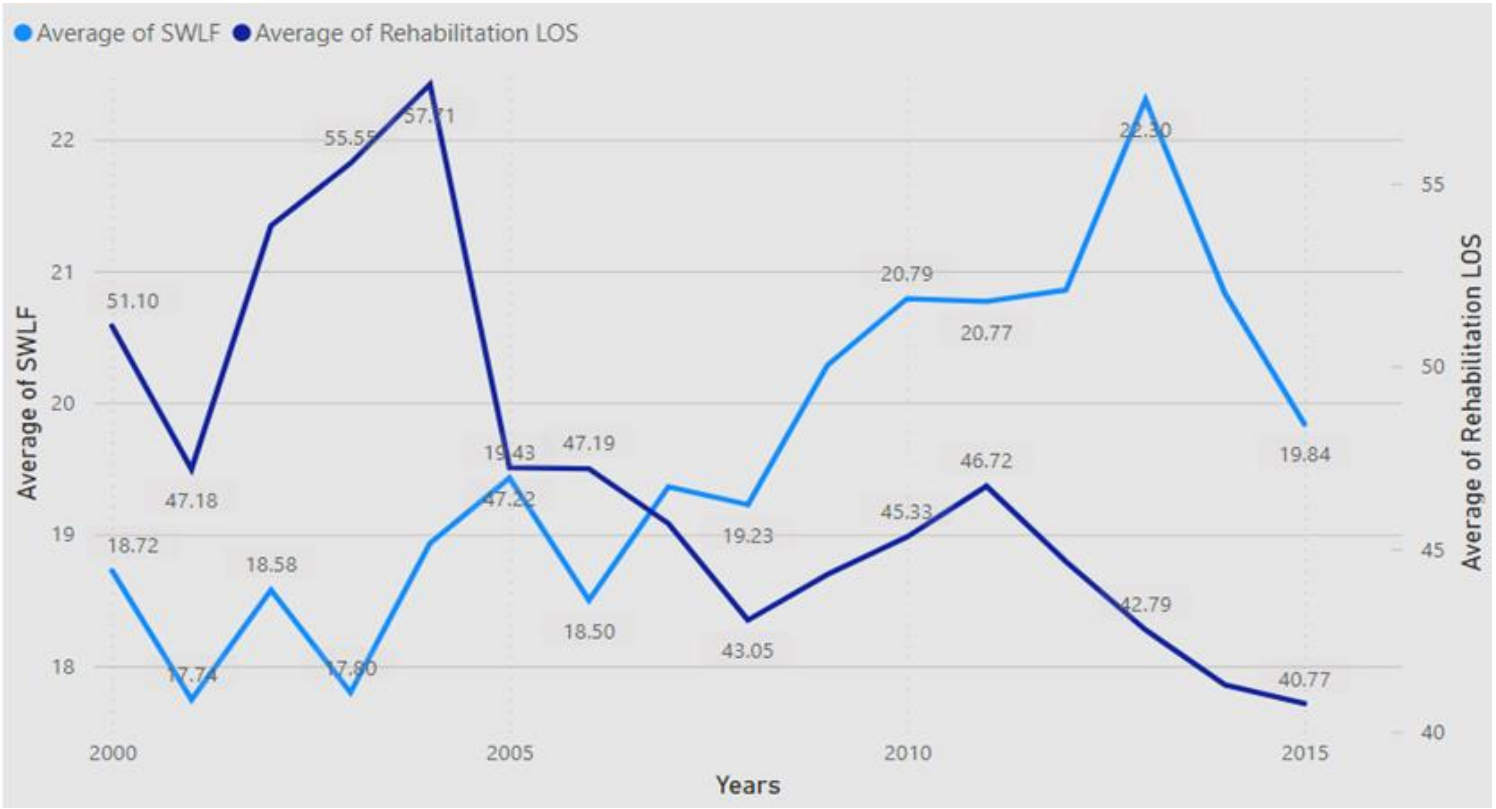


Fig 4. 6 Trends of SWLF and rehabilitation LOS in SCI paraplegia between 2000-2015.

NOTE: The change in trends of rehabilitation LOS is a result of different sample size that were included for each health outcomes.

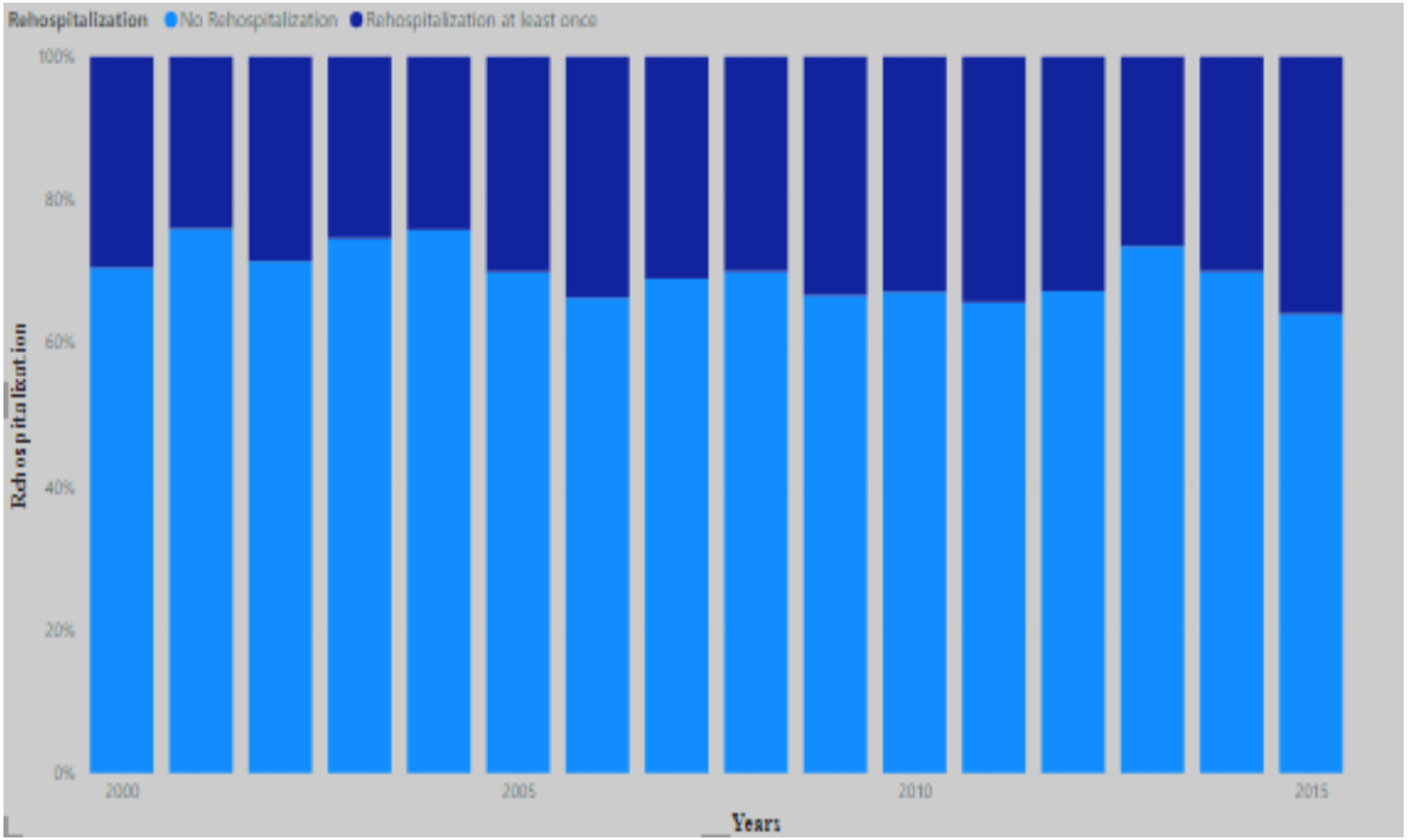


Fig 4. 7 Distribution of rehospitalization occurrence between 2000-2015

Table 4. 1 Individuals' characteristics across all health outcomes

Variables	CHART: Craig Handicap Assessment & Reporting Technique				FIM	Life Satisfaction	Rehospitalization in the last 12 months
	Physical Independence N= 3104	**Mobility** N=3.080	**Occupation** N=3,057	**Social Integration** N=3,029	N=3,018	N=3,006	N= 3,315
Yes [a]	1,581 (51%)	2,107 (68%)	2,112 (69%)	1,903 (63%)	--	--	994 (30%)
No	1,523 (49%)	937 (32%)	945 (31%)	1,126 (37%)			2,321 (70%)
Mean ± SD	--	--	--	--	74.91± 13.8	19.72± 7.71	--
Median (Q1, Q3)					79 (70, 84)	20 (14, 26)	
Age							
0 to 29 years	1,382 (45%)	1,378 (45%)	1,355 (44%)	1,356 (45%)	1,383 (46%)	1,329 (44%)	1,527 (46%)
30 to 44 years	862 (28%)	848 (28%)	851 (28%)	837 (27%)	824 (27%)	844 (28%)	911 (27%)
45 to 59 years	575 (18%)	572 (18%)	570 (19%)	560 (19%)	536 (18%)	558 (18%)	584 (18%)
60 years or older	285 (9%)	282 (9%)	281 (9%)	276 (9%)	275 (9%)	275 (9%)	293 (9%)
Race							
White	2,171 (70%)	2,151 (70%)	2,135 (70%)	2,108(70%)	2,094 (70%)	2,095 (70%)	2,313 (70%)
Black or African American	770 (25%)	768 (25%)	760 (25%)	761 (25%)	772 (25%)	752 (25%)	835 (25%)
Other or Multiracial	163 (5%)	161 (5%)	162 (5%)	160 (5%)	152 (5%)	159 (5%)	167 (5%)
Gender							
Male	2,456 (79%)	2,432 (79%)	2,418 (79%)	2,386 (79%)	2,389 (79%)	2,375 (79%)	2,611 (79%)
Female	648 (21%)	648 (21%)	639 (21%)	642 (21%)	629 (21%)	631 (21%)	704 (21%)
ASIA Impairment Scale							
AIS A	1,639 (53%)	1,632 (53%)	1,617 (53%)	1,595 (53%)	1,584 (53%)	1,587 (53%)	1,769 (53%)
AIS B	339 (11%)	338 (11%)	336 (11%)	338 (11%)	339 (11%)	329 (11%)	360 (11%)
AIS C	488 (16%)	482 (16%)	481 (16%)	477 (15%)	477 (15%)	471 (15%)	518 (16%)
AIS D	638 (20%)	628 (20%)	623 (20 %)	619 (20%)	618 (20%)	619 (20%)	668 (20%)

Marital status							
Single	1,654 (53%)	1,647 (53%)	1,623 (53%)	1,620 (53%)	1,643 (53%)	1,596 (53%)	1,808 (55%)
Married	1,062 (34%)	1,047 (34%)	1,049 (34%)	1,028 (34%)	1,003 (34%)	1,027 (34%)	1,102 (33%)
Divorced, separated, or widowed	388 (13%)	386 (13%)	385 (13%)	381 (13%)	372 (13%)	383 (13%)	405 (12%)
Occupation							
Employed	2,056 (66%)	2,034 (66%)	2,025 (66%)	1,997 (66%)	1,949 (65%)	1,995 (66%)	2,139 (65%)
Retired	172 (6%)	172 (6%)	170 (6%)	168 (6%)	166 (6%)	166 (6%)	180 (5%)
Students	337 (11%)	340 (11%)	335 (11%)	338 (11%)	371 (12%)	319 (11%)	424 (13%)
Unemployed	539 (17%)	534 (17%)	527 (17%)	528 (17%)	532 (17%)	526 (17%)	572 (17%)
Rehabilitation LOS							
Mean ± SD	46.82 ±31.2	46.95 ±31.3	46.82 ±31.3	46.60 ±30.9	46.79 ±31.2	46.89 ±31.4	47.06 ±31.4

[a] – For CHART category, (Yes) references to some degree of handicap, while (No) indicates no handicaps.
For rehospitalization variable, (Yes) represents individuals who re-hospitalized at least once in the last 12 months, while (No) references to individual who did not re-hospitalized.

Table 4. 2 Multivariable linear regression of rehabilitation LOS from 2000 to 2015

Variables	**Log Rehabilitation LOS**
	Coefficient [95% conf. interval]
Years (2000-2015)	-0.011 [-0.014, -0.006] *
Functional Independence Score (FIM)	-0.019 [-0.021, -0.018] *
Age (0 to 29 years = reference)	
30 to 44 years	0.081 [0.032, 0.131] *
45 to 59 years	0.143 [0.082, 0.204] *
60 or Older	0.206 [0.115, 0.349] *
Gender (female = reference)	-0.021 [-0.064, 0.022]
Race (white =reference)	
Black / African American	-0.022 [-0.064, 0.019]
Other & multiracial	0.108 [0.029, 0.186] *
ASIA Impairment Scale (A = reference)	
AIS B	-0.035 [-0.092, 0.021]
AIS C	-0.049 [-0.09, 0.002]
AIS D	-0.397 [-0.445, -0.349] *
Marital Status (single = reference)	
Married	-0.083 [-0.134, -0.033] *
Divorced, separated, or widowed	-0.073 [-0.135, -0.010] *
Occupation (Employed = reference)	
Retired	-0.192 [-0.288, -0.095] *
Student	-0.002 [-0.064, 0.57]
Unemployed	-0.067 [-0.11, -0.019] *

Variables	CHART: Craig Handicap Assessment & Reporting Technique				Rehospitalization in the last 12 months N=3,315
	Physical independence N= 3,104	**Mobility** N=3,080	**Occupation** N=3,057	**Social Integration** N=3,029	
	OR. (95% conf. interval)	OR. (95% conf. interval)	OR. (95% conf. interval)	OR. (95% conf. interval)	OR. (95% conf. interval)
Years (2000-2015)	1.03[1.01, 1.04] *	1.02[0.99, 1.03]	0.99 [0.98, 1.02]	0.99 [0.98, 1.01]	1.02 [1.01, 1.04] *
Rehabilitation LOS	1.01 [1.00, 1.01]*	1.01[1.00, 1.01] *	1.00 [0.99, 1.01]	1.00[0.99, 1.00]	1.01 [1.00, 1.01] *
Age					
(0-29 years=reference)					
30 to 44 years	1.78[1.42, 2.22] *	1.51[1.20, 1.92] *	1.31 [1.04, 1.64] *	1.38[1.10, 1.71] *	1.23 [0.99, 1.54]
45 to 59 years	2.81[2.13, 3.68] *	1.97[1.48, 2.63] *	2.46 [1.85, 3.28] *	2.05[1.55, 2.70] *	1.36 [1.04, 1.78] *
60 years or older	4.51[2.98, 6.82] *	2.84[1.81, 4.46] *	5.67 [3.49, 9.20] *	2.23[1.46, 3.38] *	1.66 [1.12, 2.47] *
Race					
(White= reference)					
Black or African American	1.91[1.57, 2.31] *	2.33[1.88, 2.89] *	1.47 [1.20, 1.81] *	1.92[1.59, 2.31] *	0.97 [0.80, 1.17]
Other or Multiracial	2.32[1.62, 3.31] *	2.53[1.68, 3.81] *	2.02 [1.37, 2.97] *	1.26[0.88, 1.79]	0.81 [0.56, 1.16]
Gender					
(Female=reference)					
Male	0.74[0.61, 0.89] *	0.75[0.61, 0.92] *	1.31 [1.08, 1.59] *	0.85[0.71, 1.11]	0.77 [0.64, 0.92] *
ASIA					
(AIS A= reference)					
AIS B	0.83[0.64, 1.06]	0.79[0.61, 1.03]	1.02 [0.78, 1.34]	0.86[0.66, 1.11]	0.61 [0.47, 0.79] *
AIS C	0.39[0.31, 0.49] *	0.64[0.51, 0.81] *	0.81 [0.64, 1.02] *	0.95[0.76, 1.19]	0.67 [0.54, 0.84] *
AIS D	0.18[0.14, 0.22] *	0.42[0.34, 0.53] *	0.52 [0.42, 0.65] *	0.89[0.71, 1.44]	0.45 [0.36, 0.56] *

Marital Status (Single=reference)					
Married	0.92[0.74, 1.15]	0.91[0.71, 1.14]	0.49 [0.39, 0.63] *	0.29[0.22, 0.36] *	1.09 [0.88, 1.37]
Divorced, separated, or widowed	0.66[0.49, 0.22] *	1.33[0.97, 1.81]	0.83 [0.61, 1.12]	1.09[0.83, 1.44]	1.45 [1.11, 1.89] *
Occupation (Employed=reference)					
Retired	1.22[0.79, 1.91]	1.90[1.12, 3.22] *	2.63 [1.42, 4.87] *	1.12[0.71, 1.75]	1.30 [0.86, 1.97]
Students	0.70[0.53, 0.92] *	0.56[0.43, 0.73] *	0.96 [0.74, 1.27]	0.73[0.55, 0.96] *	0.95 [0.72, 1.25]
Unemployed	1.33[1.06, 1.64] *	1.84[1.43,2.36] *	1.93 [1.51, 2.48] *	1.53[1.23, 1.89] *	1.47 [1.19, 1.82] *

Table 4.3 Multivariable logistics regression of CHART scores and Rehospitalization occurrence.

*** Significant level <0.05**

Table 4. 3 Multivariable 50th quantile and linear regression of FIM score and SWLF scale

Variables	**FIM** [a]	**SWLF** [b]
	Coef. se	Coef. se
Years (2000-2015)	-0.22 (0.05) *	0.22 (0.03) *
Rehabilitation LOS	-0.05 (0.01) *	-0.01 (0.00) *
Age (0 to 29 years =reference)		
30 to 44 years	-2.08 (0.64) *	-2.89 (0.38) *
45 to 59 years	-5.08 (0.78) *	-3.54 (0.46) *
60 years or older	-8.65 (1.16) *	-2.23 (0.67) *
Race (White= reference)		
Black or African American	-1.54 (0.54) *	-1.21(0.33) *
Other or Multiracial	-3.16 (1.02) *	0.50 (0.61)
Gender (Female=reference)		
Male	1.85 (0.55) *	0.23 (0.34)
ASIA (AIS A= reference)		
AIS B	1.66 (0.72) *	0.03 (0.44)
AIS C	6.81 (0.63) *	1.13 (0.39) *
AIS D	11.41 (0.6) *	2.21 (0.38) *

Marital Status (Single=reference)		
Married		
Divorced, separated, or widowed	0.02 (0.65)	1.62 (0.38) *
	0.64 (0.81)	0.12 (0.49)
Occupation (Employed=reference)		
Retired	-1.62 (1.26)	0.11 (0.74)
Students	0.81 (0.75)	1.33 (0.50) *
Unemployed	-1.85 (0.62) *	-1.91 (0.38) *

- [a]: FIM was examined by 50th quantile regression
- [b]: SWLF was examined by linear regression
- * Significant level <0.05

CHAPTER 5: CONCLUSION

5.1 SUMMARY

Rehabilitation is an essential factor in restoring physical independence, improving functional outcomes and preventing medical complications in individuals with paraplegia SCI (Cahow, 2012; DeJong, 2013; New, 2005; Yarkony, 1987). Primarily, rehabilitation LOS is used as a proxy of intensity of rehabilitation care as well as a measure of healthcare efficiency (Agency for Healthcare Research and Quality, 2020; Whiteneck, 2011). Yet, rehabilitation is a complex long-term care that involves various phases and practices (i.e., occupational, physical, speech, therapeutic exercise), which makes assessing rehabilitation LOS challenging. Also, individuals' sociodemographic characteristics, functional status, and severity of injury play a major role in the variations of rehabilitation LOS that need to be cautiously assessed.

This dissertation focused mainly on individuals who sustain paraplegia SCI. The dissertation objectives were designed to fulfill three aims: 1) to identify the factors associated with rehabilitation LOS 2) to capture the trends of inpatient rehabilitation LOS between 1988 and 2016 in the United States, 3) to evaluate the association between rehabilitation LOS and health and functional outcomes after one year of discharge from inpatient rehabilitation from 2000 to 2016 in the United States. The dissertation aims were responded in three manuscripts.

In manuscript 1, a systematic review of existing literature was conducted to identify the factors associated with rehabilitation LOS in paraplegia populations. The systematic review used PRISMA guidelines for analysis. In this manuscript, 13 articles were included in the review. The analysis yielded 6 factors associated with rehabilitation LOS including age, gender, type of etiology, severity and level of injury, surgical interventions, and body weight. About half of reviewed articles had paraplegia samples (N=6) while other half had SCI samples and controlled for neurological level of injury (N=7). Of the six factors identified in this review, two factors showed significant influence on rehabilitation LOS: age, and severity and level of injury. Individuals with paraplegia who were older experienced longer rehabilitation LOS than younger people. Also, individuals with severe injury had longer rehabilitation LOS compared to mild or moderate injuries.

However, the rest of four factors did not show significant impact on rehabilitation LOS, except for two studies. Males had longer rehabilitation LOS than females in Degenerated Spinal Disease (DSD) while both gender groups had comparable rehabilitation LOS in other etiology groups. Also, individuals with Vascular Ischemia (VI) had longer rehabilitation LOS compared to other groups, yet the rest of etiology groups has similar rehabilitation LOS.

The majority of identified articles (N=9) had small sample sizes, or poor methodological analysis to control for confounding effects, which makes the generalization insupportable. This systematic review identified only 13 articles that evaluate factors associated with LOS rehabilitation over the last four decades. This implies a lack of research in existing literature in this area.

In manuscript 2, the Donabedian quality of care model was used to examine the trends of inpatient rehabilitation LOS in paraplegia after traumatic SCI between 1988 and 2016 in the United States. The manuscript used structure, process, and outcome dimensions of Donabedian model to construct this study. Structure included patients' characteristics and severity of SCI injury. Functional Independence Measure (FIM) score was used as a process and rehabilitation LOS represented the outcome.

The manuscript used a national SCI database to perform the analysis. The multivariable linear regression of rehabilitation LOS of patients with paraplegia SCI found that rehabilitation LOS decreased by 1.4 % on average each year from 1988 to 2016, while holding other control factors constant. Also, this study showed that individuals who had severe injury (complete AIS A), were older, being unemployed or retired, and had a lower FIM score, experienced longer rehabilitation LOS. Moreover, the trends of rehabilitation LOS depended on the scores of FIM where individuals with a lower FIM experienced slight or low decreased on rehabilitation LOS, while individuals with higher FIM scores had greater declined of rehabilitation LOS. Furthermore, the analysis revealed that FIM scores over the years 1988-2016 decreased by 0.27.

Several limitations were noted in this manuscript. First, the healthcare facilities information (i.e., size, type, location, number of beds) were not provided in the database.

Second, the study did not have enough information of insurance status of individuals, which is a major factor in rehabilitation LOS. Third, the national SCI database that was used in this study captures only an estimated 6% of all new cases, which may not be representative of individuals who treated elsewhere.

The manuscript 3 of this dissertation aimed to examine the association between rehabilitation LOS and health outcomes of individuals with paraplegia SCI after one year of inpatient rehabilitation discharge. The manuscript used the International Classification of Functioning, Disability, and Health (ICF) for constructing the research model and validating the control factors. The ICF was designed to evaluate the health and disability of individuals while accounting for health conditions, and personal and environmental factors. For health and functional dimensions in the ICF framework, this study used individuals' health outcomes (i.e., FIM scores, CHART scores, rehospitalization, SWLF) during their annual follow-up assessments after one year of discharge from inpatient rehabilitation care. The personal and environmental factors of the ICF include individuals' characteristics (i.e., age, gender, race, marital status, occupation) and rehabilitation LOS.

The manuscript 3 used the same national SCI database that was used in manuscript 2. Multivariable logistics, linear and quantile regression were used for statistical analysis. The finding of this manuscript revealed that the first-year post-discharge health and functional outcomes became worse or did not improve among individuals with paraplegia over the years from 2000 to 2015. Individuals with paraplegia experienced negative trends of FIM scores, positive trends of physical independence handicap and higher rehospitalization rates. Also, the analysis of this study found that

individuals who were older, unemployed and had complete paraplegia experienced lower FIM scores, higher rehospitalization rates, lower SWLF scores, and higher degrees of handicap in physical independence, mobility, occupation, and social integration. Moreover, the manuscript's results suggested that longer rehabilitation LOS was associated with a higher degree of handicap of physical independence and mobility, a lower FIM score, a lower SWLF and a higher rate of rehospitalization.

There were several limitations the study noted. CHART and SWLF were questionnaires responses, and it is possible that individuals overestimated or underestimated the types, duration, or elements of services. The national SCI database that used in this manuscript were missing important information, such as hospital characteristics and insurance information. Moreover, the type and intensity of rehabilitation care was not evaluated, which may explain the variation of individuals' health outcomes.

5.2 PUBLIC HEALTH IMPLICATIONS

The three manuscripts add valuable contributions to healthcare physicians and practitioners, public health professionals, and health services researchers and administrators. These manuscripts aimed to examine crucial questions that were guided by theoretical frameworks. For physicians and medical practitioners, the studies evaluated factors associated with rehabilitation LOS in individuals with paraplegia that can be beneficial to assess healthcare programs in more effective and efficient practices. Also, the finding of the manuscripts revealed that the decline of rehabilitation LOS over years depended mainly on FIM scores, which urges to develop interventions to elevate or maintain FIM score to enhance healthcare efficiency. Moreover, the manuscripts

provided a broad analysis of the health and functional outcomes after one-year of rehabilitation discharge that helped physician and medical professionals to develop assessments and interventions to improve individuals' overall health.

For healthcare administrators and researchers, the studies in this dissertation offered unique examinations of rehabilitation LOS in paraplegia SCI. This can be beneficial to develop strategies to achieve healthcare efficiency while preserving individuals' functional and health outcomes. The finding of manuscripts suggested that keeping FIM score as high as possible at rehabilitation admission can, theoretically, decrease LOS and enhance healthcare efficiency. However, the manuscripts' results showed that health outcomes after one year of rehabilitation discharge became worse or did not improve in paraplegia SCI individuals. This suggests that the short-term cost-saving of the declined rehabilitation LOS may be cost shifting due to increased need of assistance, higher rehospitalization rates and poor health outcomes. Healthcare professionals and administrators can benefit from the findings of these manuscripts to improve assessments of rehabilitation LOS and develop interventions to successfully maintain health efficiency while improving health outcomes. Moreover, the manuscripts' results found significant variations of sociodemographic factors in rehabilitation LOS that will help healthcare policymakers to assist the underserved groups. For example, unemployed groups had shorter rehabilitation LOS and poor of all health outcomes. This can help healthcare researchers to design and evaluate healthcare programs for the targeted populations.

5.3 FUTURE RESEARCH

The three manuscripts provide general evaluations of rehabilitation LOS in individuals with paraplegia SCI that help future research to be built on its finding. The systematic review finding identified only 13 studies over the last four decades, which indicates lack of research on this topic. Most of the articles included in the systematic review had small sample sizes or poor methodological analysis that urges future research to design more inclusive and methodologically appropriate research. The manuscripts showed that the trends of rehabilitation declined between 1988 and 2016. However, the type and intensity of rehabilitation care should be assessed along with rehabilitation LOS to evaluate the effectiveness of rehabilitation care.

Future research should focus on other health outcomes that were not included in the manuscripts such as medical complications, pressure sores, and bladder managements and their associations with rehabilitation LOS. Also, there is a need to evaluate the association between rehabilitation LOS and healthcare facilities charges to increase rehabilitation efficiency while maintaining the best health outcomes. The findings of the manuscript revealed that the health outcomes became worse or did not improve between 2000 and 2015. This may be a sign of cost-shifting that the saving of rehabilitation costs by reducing LOS result on spending on rehospitalization or treating preventive health issues. Therefore, future research should examine health efficiency with caution to individuals' health outcomes.

The three manuscripts had limited information about individuals' insurance status, payment methods and types of payers, which are an important information to examine

rehabilitation LOS. This information should be considered in future research when rehabilitation LOS is examined.

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