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ORIGINAL ARTICLE

Predictive factors of hospitalization in adults with pediatric-onset SCI: a longitudinal analysis

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Study design: Longitudinal survey.
Objectives: To investigate the prevalence and rate of hospitalization among adults with pediatric-onset spinal cord injury (SCI) and explore medical and behavioral factors associated with hospitalization.
Methods: This study included 368 adults who sustained a SCI prior to age 19 and were enrolled in an ongoing longitudinal study investigating the outcomes of pediatric-onset SCI. Participants were interviewed on an approximately annual basis using a study-specific questionnaire and standardized outcome measures: Satisfaction with Life Scale; Short-Form 12 Health Survey; Alcohol Use Disorders Identification Test; Patient Health Questionnaire-9 Depression Scale; and Craig Handicap Assessment and Recording Technique.
Results: Overall, 61% of participants self-reported at least one hospitalization across all time points; average length of hospitalization was 14.8 days (±23.3). Individuals who were ethnic minorities as well as those with high cervical-level SCI were more likely to be hospitalized. Those who were unemployed and those with health-care coverage were more likely to be hospitalized and have longer hospitalization stays. The risk of hospitalization was higher with occurrence of pressure ulcers, urinary tract infections, pneumonia, pain and a chronic medical condition. Smoking cigarettes increased the risk of hospitalization, whereas those who engaged in exercise and were active in the community had lower odds of hospitalization.
Conclusion: Both medical and lifestyle factors have an important role in predicting hospitalization. An increased understanding of the risk and protective factors associated with hospitalization should assist clinicians in developing strategies and prevention efforts to minimize secondary health complications and foster healthy lifestyle behaviors.
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INTRODUCTION

Despite advancements in health care, people with spinal cord injury (SCI) are more likely to experience medical complications and resultant hospitalization than the general population. For instance, individuals with SCI are 2.4 times more likely to be hospitalized than the general population,[1,2] and the length of hospitalization ranges from 4 to 17 days.[1,3–5] In addition to direct costs, hospitalization creates both personal and familial strain, leads to reduced work or school days, and hinders independence and community integration.[1,3] Yet, many hospital readmissions are avoidable with prevention or proper management of secondary health conditions.[3,6]

There are a number of reasons that people with SCI are at greater risk of hospitalization, including multiple medical complications associated with SCI such as urinary tract infections (UTIs), pressure ulcers, pain, respiratory infection, cardiovascular disease, osteoporosis and depression.[6–9] The most frequent reasons for hospitalizations are UTIs,[2,9] respiratory problems[1,3,9] and pressure ulcers,[1,9] with pressure ulcers requiring longer hospitalizations.[1,3,4] Greater risk of hospitalization is associated with low FIM scores,[2] delayed rehabilitation,[3] neurological impairment,[5] duration of injury,[2] reduced community integration[2] and type of health coverage.[1,5] Data are somewhat inconclusive on whether ethnic minorities are at greater[5] or reduced[1] risk of hospitalization. Finally, psychological factors such as anxiety and depression are also positively correlated with hospitalization frequency.[10]

Hospitalization rates for persons with SCI also change as time progresses after injury. The rate is highest in the first year following injury, decreases quickly within years 2–7[5] and then declines slowly[1,2] before increasing again later in life.[2] However, many of the studies assessing the secondary health conditions associated with SCI and the resultant hospitalization are either cross-sectional in nature or longitudinal over a short follow-up period. In addition, much of the research on hospitalization in individuals with SCI involves those injured as adults. Individuals with pediatric-onset SCI face a number of unique complications, including scoliosis and relatively long life spans, during which they are more likely to develop complications such as cardiovascular disorders or overuse syndromes such as shoulder pain.[11] The pediatric nature of their injury also means that they will live with these complications for a longer time. Given these issues, information on hospitalization trends in the pediatric-onset SCI population is critically needed.

The purpose of the current study is to identify predictive and protective factors associated with hospitalization in adults with pediatric-onset SCI. This information can better inform rehabilitation

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programs to reduce the hospitalization risk as children with SCI age. It is hypothesized that hospitalization is positively correlated with higher level of neurological impairment, male sex and older age of injury. It is also hypothesized that healthy lifestyle behaviors will reduce the risk of hospitalization and that persons with less frequent hospitalization will have higher Satisfaction with Life scores.

MATERIALS AND METHODS

Participants and procedure

Participants for the current study were drawn from an ongoing project examining the long-term outcomes of adults with pediatric-onset SCI. All participants had previously received care at one of three US hospitals within a single-specialty hospital system. Participants were identified and recruited from the Shriners Hospital for Children SCI database. To be eligible for inclusion, participants met the following criteria: (1) at least 19 years of age, (2) sustained SCI before 19 years of age, (3) no significant brain injury, (4) English-speaking and (5) participated in at least two study interviews. Of the 477 participants who had consented to participate, 368 met the inclusion criteria for the current study.

For individuals enrolled in the study, telephone interviews were conducted by trained research assistants on an approximately annual basis between 1996 and 2014, and they had completed an average of 5.4 interviews (±3.2; median = 5; range 2–15) for a total of 1959 interviews. This study was approved

Table 1 Participant demographic and injury characteristics at baseline and as a function of hospitalization

Characteristics	*Baseline (M ± s.d. or* n*)*	*Hospitalization (M ± s.d. or* n *(%))*		χ^2 *Significance test*
	Total (N = *368)*	*No* (n = *142)*	*Yes* (n = *226)*	
Age (years)	26.7 ± 3.6	31.0 ± 5.4[a]	31.4 ± 5.5[a]	
Duration	12.3 ± 5.2	16.6 ± 6.4[a]	17.1 ± 6.3[a]	
Age of injury (years)				$\chi^2(3) = 0.36$; $P = 0.949$
0–8	45	18 (40.0)	27 (60.0)	
9–12	31	13 (41.9)	18 (58.1)	
13–15	125	49 (39.2)	76 (60.8)	
16–18	167	62 (37.1)	105 (62.9)	
Sex				$\chi^2(1) = 0.08$; $P = 0.784$
Male	239	91 (38.1)	148 (61.9)	
Female	139	51 (39.5)	78 (60.5)	
Ethnicity				$\chi^2(3) = 9.35$; $P = 0.025$
Caucasian	317	128 (40.4)	189 (59.6)	
African American	22	3 (13.6)	19 (86.4)	
Hispanic/Latino	19	5 (26.3)	14 (73.7)	
Other/unknown	10	6 (60.0)	4 (40.0)	
Etiology				$\chi^2(4) = 7.35$; $P = 0.118$
Vehicular/pedestrian	176	78 (44.3)	98 (55.7)	
Violence	28	10 (35.7)	18 (64.3)	
Fall/flying object	25	5 (20.0)	20 (80.0)	
Sports	99	35 (35.4)	64 (64.6)	
Medical/surgical	32	10 (31.2)	22 (68.8)	
Other/unknown	8	4 (50.0)	4 (50.0)	
Impairment group				$\chi^2(3) = 15.79$; $P = 0.001$
C1–C4 ABC	54	10 (18.5)	44 (81.5)	
C5–C8 ABC	137	48 (35.0)	89 (65.0)	
T1–S5 ABC	143	68 (47.6)	75 (52.4)	
AIS D	34	16 (47.1)	18 (52.9)	
Employment				$\chi^2(2) = 8.15$; $P = 0.017$
Unemployed	156	49 (31.4)	107 (68.6)	
Employed	178	82 (46.1)	96 (53.9)	
Student	34	11 (32.4)	23 (67.6)	
Health insurance[b]				$\chi^2(2) = 7.86$; $P = 0.020$
No coverage	19	12 (63.2)	7 (36.8)	
Government subsidized	146	48 (32.9)	98 (67.1)	
Private (HMO/PPO)	183	78 (42.6)	105 (57.4)	

Abbreviations: AIS, American Spinal Injury Association Impairment Scale. HMO, Health Maintenance Organization; PPO, Preferred Provider Organization.
[a]Means (and s.d.) reported are based on age and duration of injury at point of hospitalization.
[b]Health Insurance information missing for 20 participants at baseline.

by the institutional review board, and all applicable institutional and governmental regulations concerning the ethical use of human participants were followed during the course of this research.

Measures

A structured questionnaire designed for this study was used to collect demographic data and information on medical complications experienced within the previous year. Hospitalization was assessed by the presence of at least one self-reported overnight hospitalization within the year and the total number of days spent in the hospital. The severity of injury was categorized based on the American Spinal Injury Association Impairment Scale (AIS) utilizing the International Standards for Neurological Classification of Spinal Cord Injury.[12]

Perceived health-related quality of life was measured using the SF-12v2 Health Survey (SF-12v2).[13] Lifestyle and behavioral factors were assessed using a variety of standardized measures along with self-report of behavior gathered during the interview. All standardized measures utilized in the current study have previously been used with SCI populations and shown to be reliable and valid in this population. The Craig Handicap Assessment and Recording Technique (CHART)[14] was used to assess community participation, independence and activity level in a variety of domains. Lifestyle factors, including exercise, smoking and drinking behaviors, were assessed by self-report as well as the Alcohol Use Disorders Identification Test (AUDIT-C).[15] The AUDIT-C is a brief screener to identify excessive and hazardous drinking. Emotional well-being was measured via the Satisfaction with Life Scale[16] and the Patient Health Questionnaire-9.[17]

Table 2 Average length of hospitalization among individuals hospitalized at least once in the past year ($N = 479$)

Characteristics	*Mean days (± s.d.)*	*Significance test*
Overall	14.8 ± 23.3	
Age (years)		$\chi^2(3) = 8.79$; $P = 0.032$
⩽29	13.2 ± 22.2	
30–34	15.3 ± 26.1	
35–39	17.1 ± 22.5	
⩾40	15.5 ± 20.3	
Duration (years)		$\chi^2(3) = 5.06$; $P = 0.168$
2–9	17.1 ± 24.3	
10–15	14.3 ± 27.9	
16–20	12.6 ± 16.5	
⩾21	16.9 ± 22.4	
Sex		$z = -1.15$; $P = 0.249$
Male	16.0 ± 25.7	
Female	12.2 ± 17.1	
Ethnicity		$\chi^2(3) = 1.98$; $P = 0.576$
Caucasian	14.7 ± 23.2	
African American	15.6 ± 18.7	
Hispanic/Latino	14.0 ± 25.2	
Other/unknown	19.1 ± 30.9	
Etiology		$\chi^2(5) = 5.13$; $P = 0.400$
Vehicular/pedestrian	13.6 ± 20.5	
Violence	13.6 ± 22.9	
Fall/flying object	14.3 ± 16.8	
Sports	16.4 ± 30.0	
Medical/surgical	15.8 ± 22.5	
Other/unknown	17.0 ± 13.3	
Impairment group		$\chi^2(3) = 3.35$; $P = 0.340$
C1–C4 ABC	14.8 ± 20.7	
C5–C8 ABC	14.3 ± 26.1	
T1–S5 ABC	15.3 ± 21.5	
AIS D	15.5 ± 22.9	
Employment status		$\chi^2(2) = 22.65$; $P < 0.001$
Unemployed	18.5 ± 26.5	
Employed	9.5 ± 16.6	
Student	12.3 ± 20.4	
Insurance		$\chi^2(2) = 9.72$; $P = 0.008$
No coverage	9.1 ± 10.9	
Government subsidized	16.2 ± 21.3	
Private (HMO/PPO)	12.7 ± 26.6	

Abbreviations: AIS, American Spinal Injury Association Impairment Scale. HMO, Health Maintenance Organization; PPO, Preferred Provider Organization.

Data analysis

Descriptive statistics were used to summarize demographic variables and injury characteristics at the initial interview and at the point of hospitalization. Nonparametric Mann–Whitney (2-group comparisons) and Kruskal–Wallis (>2-group comparisons) tests were used to examine the differences in number of days hospitalized by demographic and injury characteristics. A series of generalized estimating equations, with a logit link function and an autoregressive AR(1) correlation structure, were used to identify the variables most strongly associated with the risk of hospitalization. In Model 1, we examined the risk of hospitalization as a function of time-varying health factors and lifestyle behaviors, while adjusting only for significant demographic characteristics. Model 2 examined both the between-subject (absolute average for person) and within-subject (relative to previous levels or history) effects of health and behavior after adjusting for demographic control variables. Thus, Model 2 allowed us to disentangle within- and between-subject effects on hospitalization over time. Finally, the effect of hospitalization on the continuous outcome measurements of life satisfaction and depression symptoms was explored using linear mixed modeling with maximum likelihood estimation. Statistical significance was based on a two-tailed alpha level of 0.05. Analyses were carried out using SPSS version 22.[18]

RESULTS

Demographic and injury characteristics for all participants at initial interview and as a function of hospitalization are shown in Table 1. Overall, 226 (61.4%) individuals were hospitalized at least once during the study period for a total of 479 hospitalizations. For individuals who reported at least one hospitalization, mean age at the time of hospitalization was 31.4 years (±5.5) and average number of hospitalizations was 3.5 (±2.7). Individuals with C1–C4 injuries reported the highest frequency (81.5%) of hospitalization. A larger percentage of hospitalization occurred among persons who were unemployed (68.6%) or were covered by Medicaid or Medicare (67.1%). Although a majority of hospitalizations occurred among Caucasians (83.6%), a higher percentage of ethnic minorities were hospitalized (African American 86.4%; Hispanic or Latino 73.7%) compared with Caucasians (59.6%). Mean length of hospitalization by demographic and injury characteristics is shown in Table 2. Overall, mean length of hospitalization was 14.8 days (±23.4; median = 6; range = 1–240). Length of hospitalization was significantly longer for those who were older, single, unemployed and covered by subsidized health care (Medicaid/Medicare).

Generalized estimating equation analyses were used to examine the longitudinal risk of hospitalization as a function of health and lifestyle variables, while adjusting for race and neurological level. The first set of models revealed that the occurrence of a chronic medical condition, pneumonia, pressure ulcers, UTI, activity-interfering pain, kidney

Table 3 Odds of hospitalization as a function of health factors and lifestyle behaviors

	Model 1[a]	*Model 2*[a]	
		Within-person effects	*Between-person effects*
	OR (95% CI)	*OR (95% CI)*	*OR (95% CI)*
Health-related issues			
Chronic medical condition	2.09 (1.58–2.76)***	1.60 (1.18–2.18)**	1.65 (1.18–2.31)**
Pressure ulcer	2.44 (1.87–3.18)***	2.23 (1.66–2.99)***	1.25 (0.88–1.77)
Urinary tract infections	2.16 (1.62–2.87)***	2.06 (1.53–2.78)***	1.26 (0.58–2.73)
Pneumonia/respiratory failure	4.95 (2.86–8.56)***	4.67 (2.44–8.92)***	1.28 (0.79–2.06)
Bladder accidents	1.00 (0.78–1.28)	0.95 (0.72–1.26)	1.13 (0.78–1.63)
Bowel accidents	1.45 (1.06–1.98)*	1.41 (0.98–2.04)	1.05 (0.73–1.53)
Pain	1.33 (1.06–1.68)*	1.14 (0.88–1.47)	1.74 (1.20–2.53)**
Kidney/bladder stones	2.98 (2.18–4.08)***	2.76 (1.88–4.05)***	1.11 (0.75–1.63)
Muscle spasms	1.55 (1.18–2.05)**	1.66 (1.18–2.34)**	0.91 (0.59–1.39)
Autonomic dysreflexia	1.13 (0.85–1.50)	0.90 (0.65–1.25)	1.55 (0.98–2.43)
Perception of overall health			
Physical health	0.97 (0.95–0.98)***	0.98 (0.97–1.00)*	0.94 (0.92–0.96)***
Emotional health	0.98 (0.96–0.99)***	0.99 (0.97–1.01)	0.96 (0.94–0.98)***
Lifestyle and community behaviors			
Community participation (CHART)[b]			
Physical independence	0.42 (0.26–0.68)***	0.65 (0.36–1.16)	0.29 (0.12–0.72)**
Cognitive independence	0.08 (0.02–0.41)**	0.26 (0.03–2.12)	0.01 (0.01–0.07)***
Mobility	0.47 (0.28–0.78)**	0.99 (0.48–2.01)	0.31 (0.17–0.55)***
Occupation	0.81 (0.66–0.98)*	1.08 (0.85–1.37)	0.56 (0.41–0.79)***
Social integration	0.56 (0.37–0.87)**	0.82 (0.45–1.52)	0.31 (0.13–0.73)**
Economic self-sufficiency	0.77 (0.68–0.87)***	0.95 (0.79–1.14)	0.65 (0.53–0.80)***
Smoking	1.38 (1.04–1.82)*	0.98 (0.72–1.34)	1.72 (1.22–2.41)**
Exercise	0.71 (0.55–0.92)**	0.76 (0.57–1.00)	0.75 (0.44–1.28)
Alcohol use	0.75 (0.56–0.98)*	0.72 (0.52–1.00)*	1.08 (0.64–1.83)
Marijuana use	1.35 (0.94–1.94)	1.21 (0.77–1.93)	1.16 (0.77–1.74)

Abbreviations: CHART, Craig Handicap Assessment and Recording Technique; CI, confidence interval; OR, odds ratio.
[a]Adjusted for neurological level and ethnicity.
[b]Chart subscale scores were natural log transformed to reduce the influence of extreme scores.
***$P \leqslant 0.001$; **$P \leqslant 0.01$; *$P \leqslant 0.05$.

stones and spasticity significantly increased the odds of hospitalization. Greater perceived general physical and emotional health was associated with significantly decreased odds of hospitalization. Individuals with greater physical and cognitive independence, community mobility, occupational/vocational involvement, social integration and economic self-sufficiency were less likely to be hospitalized. Somewhat surprisingly, alcohol use was associated with decreased odds of hospitalization; however, as would be expected, smoking was associated with increased odds of hospitalization and those who exercised were less likely to be hospitalized (Model 1, Table 3).

The use of longitudinal models to examine risk of hospitalization provides a number of advantages, including the ability to disentangle the aggregated effect of variables that change over time to understand both the independent effects of within-person (relative to own previous levels) and between-person variations (average relative to other people). The next series of analyses explicitly modeled how medical and lifestyle factors might influence the odds of hospitalization both within and between participants by including parameters for both effects, while also adjusting for the demographic confounds (Model 2, Table 3). Both chronic medical conditions and general physical health showed significant between- and within-person effects on hospitalization, such that being higher in overall physical health and improvements in relative physical health were each related to decreased odds of hospitalization. Similarly, people with chronic medical conditions have greater odds of hospitalization, and when individuals contract a chronic medical condition risk of hospitalization is greater after diagnosis than before.

The impact of many of the SCI-related medical complications, including pressure ulcers, UTIs, pneumonia, kidney stones and spasticity, did not appear to contain between-subject variation. In other words, these conditions were associated with increased odds of hospitalization during the period that they occurred rather than before. This was not the case for activity-interfering pain, where the within-subject effect was not significant, but the between-subject effect was significant, suggesting that people with higher-than-average pain generally have higher odds of hospitalization. Likewise, after controlling for within-subject effects, individuals with superior mental health and higher-than-average community participation had significantly lower odds of hospitalization across time. In addition, those who smoke have a greater risk of hospitalization all the time. Finally, the unexpected finding of decreased odds of hospitalization with alcohol use appears to be limited to the within-subject effect, suggesting that relative to their own use, when people drink alcohol they have decreased odds of hospitalization. Notably, however, if the presence of alcohol misuse is controlled for, alcohol use is significant only for those individuals with moderate or minimal drinking habits (odds ratio = 0.80, 95% confidence interval = 0.67–0.97, $P = 0.021$), whereas abusive drinking patterns was not significantly related to

hospitalization (odds ratio = 1.47, 95% confidence interval = 0.88–2.97, $P = 0.137$).

The remaining analyses examined the relation of hospitalization to depression symptoms and life satisfaction utilizing multilevel mixed models. Consistent with our prediction, there was a negative association between hospitalization and psychosocial well-being, with hospitalization being significantly related to both decreased life satisfaction ($\beta = -1.69$, s.e. = 0.53, $P = 0.002$) and increased symptoms of depression ($\beta = 0.87$, s.e. = 0.41, $P = 0.034$).

DISCUSSION

In the current study, we examined hospitalization frequency and the predictors and psychosocial outcomes associated with hospitalization for adults with pediatric-onset SCI. In addition, we utilized longitudinal models to further tease apart the between-subject and within-subject effects of medical complications, lifestyle behaviors and community participation on hospitalization. This study reveals the importance of both medical and behavioral factors in determining hospitalization risk and highlights the high frequency of hospitalizations and its impact on well-being.

Consistent with previous research, these findings suggest that hospitalizations occur frequently and that ethnic minorities and individuals with more severe injuries are at the greatest risk of hospitalization.[5] However, it is worth noting that these same demographic variables did not appear to be related to the length of hospitalization. Rather, mean length of stay was significantly shorter for individuals who were younger and who were employed. The availability of insurance coverage, either through a third-party payer such as Medicaid or through private health insurance, increased both the likelihood of hospitalization and the length of hospitalization. While individuals with subsidized health insurance had the highest rate of hospitalizations and the longest lengths of stay, those without any health insurance had the shortest lengths of stay. The current finding suggestive of an association between hospitalization and employment is likely intertwined with the finding showing a relation between hospitalization and health coverage. Specifically, individuals who are unemployed are more likely to have lower incomes and as such more likely to rely on Medicaid/Medicare as an insurance provider. Likewise, lower income levels are also associated with reduced access to resources, including preventive care, which may increase the risk of secondary medical complications and hospitalizations.[4] The same conditions that increase the risk of hospitalization could in turn reduce the probability of employment.[19]

Pressure ulcers, UTIs, pneumonia, incontinence, muscle spasms and kidney stones were associated with increased odds of hospitalization. This is in line with previous studies documenting an elevated risk of hospitalization associated with secondary health conditions.[1,4,5] Pain and the added burden of another chronic medical condition apart from SCI were also important factors for predicting hospitalization risk. These findings emphasize the importance of close follow-up for individuals with SCI, and aggressive management and prevention of secondary medical conditions to not only improve health but also reduce hospitalization.

A number of lifestyle and community participation behaviors were also associated with the risk of hospitalization. In addition to expected relations between CHART Mobility and Physical Independence scores and hospitalization, engagement in meaningful activities, including recreational and self-improvement pursuits and participation in social relationships, was associated with decreased risk of hospitalization. Exercise was also significantly associated with decreased risk of hospitalization; these findings replicate the relationship established between physical fitness and post-injury hospitalization in the adult-SCI population.[5] By identifying the behavioral correlates of hospitalizations, the current study should help guide efforts to identify potentially modifiable areas of change in order to reduce hospitalization risk.

Although somewhat paradoxical, the finding that alcohol use had the opposite effect is not without precedence. Indeed, findings have been reported for both the adult-onset and pediatric-onset SCI populations indicating that nonproblematic levels of alcohol consumption may be associated with community integration and participation.[20,21] It may be the case that alcohol use, but not misuse, is an indicator that these people are just more social, have more support or are higher functioning, which is associated with better physical and emotional health. This is supported by follow-up analyses in the current study showing that abusive drinking patterns are unrelated to hospitalization risk.

Many factors can contribute to higher psychosocial well-being for persons with pediatric-onset or adult-onset SCI. In the current study, hospitalization was significantly related to both decreased life satisfaction and increased depression symptoms. Given that our results suggest that a significant percentage of individuals with pediatric-onset SCI will experience a hospitalization at some point, these findings underscore the importance of preventing hospitalizations not only to reduce costs but also to improve quality of life. It is imperative that future research identify the global risk and protective factors associated with hospitalization, as well as attend to strategies to help individuals with SCI identify their own personal risk factors that could be targeted in an effort to prevent hospitalization.

Limitations

There are several shortcomings to the methodology that are worth noting. In particular, participants included in the current study received care from a single hospital system and were mostly Caucasian. Similarly, there was some attrition in the current study and the vast majority of interviews were limited to those that could be conducted over telephone. These issues may limit the generalizability of the current results to all adults with pediatric-onset SCI. In addition, all data obtained for this study were self-reported and prone to the biases associated with self-report measures. To provide a better basis for identifying risk factors and improving long-term well-being, further studies that include a representative sample of adults with pediatric SCI and a wider array of assessment procedures that incorporate both objective and subjective measurements are warranted.

DATA ARCHIVING

There were no data to deposit.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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