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ARTICLE

Risk indicators of length of acute hospital stay after traumatic spinal cord injury in South Africa: a prospective, population-based study

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Abstract

Study design Population-based cohort study.

Objectives To determine non-modifiable and modifiable risk indicators of acute length of hospital stay (LOHS) after traumatic spinal cord injury (TSCI).

Setting Government-funded hospitals within the City of Cape Town, South Africa.

Methods Newly injured survivors of TSCI during a 1 year period were prospectively included. Non-modifiable (e.g., demographic factors and clinical characteristics) and modifiable risk indicators (e.g., clinical processes, timing of surgery, secondary complications) of prolonged LOHS (31 days) were determined using univariate and multivariable logistic regression analyses.

Results Of the total population-based cohort of 145 individuals, 139 (96%) had valid LOHS data and were included in the analyses. Significant univariate non-modifiable risk indicators of LOHS were age, complete injury and vertebral injury, whereas modifiable risk indicators were delayed spinal surgery (>72 h) and the occurrence of any secondary complications, as well as specifically pressure ulcers, pneumonia and urinary tract infection. In the final multivariable model showing good fit and acceptable discrimination (AUC = 0.86), older age (OR: 1.04, 95% CI: 1.00–1.07), vertebral injury (OR: 3.18, 95% CI: 1.07–9.44), pneumonia (OR: 8.40, 95% CI: 2.76–25.55) and pressure ulcers (OR: 7.16, 95% CI: 2.54–20.22) remained significant independent factors. Only injury completeness was insignificant in the final model.

Conclusions Our findings shed light on the need of developing prevention programs for secondary complications to improve the quality and efficiency of acute SCI care in South Africa.

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Introduction

There is a growing interest in improving quality and efficiency of healthcare following a spinal cord injury (SCI) in today's healthcare climate. Specialised and comprehensive acute SCI care has shown to be of particular importance for survival, prevention of secondary complications (e.g., pressure ulcers, respiratory and digestive problems) and neurological recovery [1, 2]. Length of hospital stay (LOHS) has frequently been used as an indicator of efficiency in acute SCI care [3–5] because of its direct consequence on optimising patients' recovery and utilisation of scarce healthcare resources. More specifically, prolonged LOHS not only occupies medical resources but could also lead to social restrictions in and increased financial burden on the patient [6]. In order to decrease the cost of SCI care and direct the allocation of appropriate resources for more vulnerable groups, it is vital to identify

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factors associated with acute LOHS following SCI in different contexts.

Previous studies have found that appropriate emergency management, including early transfer logistics to trauma unit [7], spinal surgery [3, 8] and admission to specialist units to be associated with shorter LOHS after SCI. The LOHS has shown to be longer for those suffering from tetraplegia compared to paraplegia, complete compared to incomplete injury, as well as for those with accompanying injuries and more severe functional impairment at the time of admission [4, 5, 9]. Furthermore, personal factors, such as educational level and self-efficacy, have been found to influence LOHS [4, 10]. However, a large discrepancy exists in the literature regarding predictors of acute LOHS after SCI [6], which likely reflect differences in healthcare practices and available resources.

SCI care has recently been established in South Africa in order to manage the high burden imposed by the high incidence of SCI in this context [11]. However, to date, only one specialized public-funded SCI unit exists in South Africa which causes a delay in the chain of early emergency management (e.g., diagnostics and acute treatment at a SCI unit) which in turn have shown to be accompanied by a high mortality rate and occurrence of secondary complications [12–14]. Majority of previous studies that have identified risk indicators of LOHS after SCI have been undertaken in developed countries [3–5, 9], with only few studies investigating the acute care phase in terms of the assessment of healthcare processes such as the influence of appropriate emergency care and timing of spinal surgery [6, 15]. It is therefore essential to determine risk indicators of acute LOHS in the South African context.

This study sought to explore risk indicators of acute LOHS after TSCI in the City of Cape Town, South Africa. More specifically, we aimed to determine non-modifiable (e.g., demographic factors and clinical characteristics) and modifiable (e.g., secondary complications) risk indicators of acute LOHS.

Methods

Design

This was a prospective, population-based cohort study which included newly injured survivors of TSCI for a one-year period (from September 2013 to September 2014) in a defined catchment area, i.e., the City of Cape Town Metropolitan area. We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during the course of this research. In particular, ethical permission was granted by the University of the Western Cape's Senate Research Committee (registration number:13/4/27) and permission to conduct this study at the specialized hospital was provided by the Chief Executive Officer. All participants in this study provided written informed consent.

Setting and all-case detection

The City of Cape Town population was estimated at 3.86 million at the end of 2013. The public-funded healthcare system consumes about 13.5% of the country's gross domestic product and it renders services to approximately 80% of its citizens [16]. Persons with suspected/confirmed TSCIs are managed at the designed tertiary level hospital (Groote Schuur Hospital) which is the only specialised acute SCI unit in the Western Cape Province of South Africa. Since the specialised unit has a limited capacity, patients with TSCI are often managed at the other tertiary level hospital (Tygerberg Hospital), which provides general orthopaedic and/or neurosurgery care and not comprehensive acute care. These two hospitals do also receive referrals from three other secondary level hospitals that do not have the organisational capacity to manage acute SCIs.

Population and sampling

The source population for this cohort study was all persons with newly-acquired TSCI in the City of Cape Town Metropolitan area, South Africa, who were managed at the designated tertiary level hospitals. The eligibility criteria were the same as in the previously published incidence study [11] which were: (1) age of ≥18 years; (2) confirmed acute TSCI or cauda equina lesion by means of computerised evidence and/or clinical evaluation; (3) evidence of neurological fallout according to the American Spinal Injury Association (ASIA) impairment scale after seven days; (4) reside legitimately in the City of Cape Town; and (5) provision of informed consent to participate in the study. The only exception for inclusion in this study compared to the incidence paper was that participants needed to be alive at the end of acute management.

Data collection instruments

Dependent variable

Acute LOHS was defined as the number of days admitted to the acute SCI unit or general ward at the other tertiary hospital. This excluded days spent at other intermediate hospitals. Acute LOHS was dichotomised as standard LOHS (≤31 days) or prolonged LOHS (>31 days). This 1-month cut point was chosen since specialised acute care typically ranges from 2.5–5 weeks according to international literature

[6] and similar LOHS has also been reported for survivors of TSCI in this region [17].

Participants' characteristics—non-modifiable factors

Demographic, event characteristics and neurological classification (according to ASIA impairment scale) were collected on admission using the International SCI Basic Core Data Set [18]. Specific non-modifiable variables included in the analysis were: (1) sex (male v. female); (2) age as continuous variable; (3) associated injury (yes v. no); (4) level of injury (tetraplegia v. paraplegia); (5) completeness of injury (complete v. incomplete); and 6) vertebral injury (yes v. no).

Modifiable risk indicators

These variables included the development of modifiable secondary medical complications, namely pressure ulcers, pulmonary complication (atelectasis and pneumonia), urinary tract infections, deep vein thrombosis, autonomic dysreflexia, pulmonary embolism, postural hypotension, spasticity, neuropathic/spinal cord pain and other. Further, certain healthcare practices such as number of intermediate hospitalisations and time to spinal surgery were included. Time to surgery was deemed delayed if it exceeded 72 h [8, 19]. The selected medical complications were screened weekly by the medical team for the duration of acute hospitalisation. Information was gathered on a standardised list capturing the presence of respective complications and degree/severity, if available. The neurologists and specialised nurse were responsible for registering each complication on a standardised list after weekly ward meetings. The presence of complications was based on the operational definition (see Supplementary file) followed by the hospital [12]. Importantly, the prevalence of each risk factor was based on its occurrence within the first 31 days of acute hospitalisation.

Data analysis

Participant characteristics, according to the International Basic Core Data Set, were described as means (standard deviations), medians (25th and 75th percentiles) and number (percentages). Concerning the identification of risk indicators for acute LOHS, all potential risk factors were entered one at a time in unadjusted univariate logistic regression models (See Table 3). Due to the rather small sample size, as well as the low occurrence of the outcome; prolonged LOHS (> 31 days, $n = 51$), five degrees of freedom worth of predictors were allowed. Because of this, only the most significant and plausible risk indicators were selected for further inclusion in the multivariable logistic regression analyses. After consideration and analysis of adequate cases per exposure category, the following factors were included: age as continuous variable, injury completeness and vertebral injuries as non-modifiable risk indicators, and pressure ulcers and pneumonia as modifiable risk indicators. Prior to multivariable analyses, measures of association, i.e., Chi-Square tests, and correlations were computed to assess for collinearity among potential risk factors. Risk indicators were all entered into one multivariable logistic regression model, with a backward selection procedure being followed. The statistical significance level was set at $P \leq 0.05$ in the final multivariable analysis. The final predicted model was tested for goodness-of-fit using Hosmer and Lemeshow post-estimation test—a good fit should produce a P-value larger than 0.05. Following this, a sensitivity analysis was carried out using the *estat* command in STATA where the default cut point of .5 (weighing sensitivity and specificity equally) was chosen. Lastly, a receiver-operating curve, i.e., area under the curve (AUC), was computed based on the final model using the *lroc* command. Data analyses were carried out in STATA version 13 (STATA Corp, Texas, USA) and all tests were two-sided.

Results

Participant characteristics

The total incidence cohort consisted of 145 individuals of which 139 had valid acute LOHS data, as presented in Table 1. The sample consisted mainly of males (85%), and the mean age of injury onset was 34 years. Assault was found to be the leading cause of injury, causing 60% of TSCIs, followed by transport-related injuries (26%) and falls (12%). The mean and median length of acute care were 37 [SD: 37] and 24 [range: 3–245)] days, respectively. Majority (63%) of the survivors of TSCI had a standard LOHS (≤ 31 days) whereas 37% had a prolonged LOHS.

Description of modifiable risk indicators

In terms of secondary medical complications as modifiable factors, the development of pressure ulcers during the first 31 days of acute hospitalisation was most common, at 30%, followed by pneumonia (23%) and urinary tract infections (17%). Overall, more than half of those enrolled in this study had at least one secondary complication. Concerning other modifiable factors, 85% had intermediate hospitalisations and 79% had to wait more than 72 h for spinal surgery (Table 2).

Non-modifiable and modifiable risk indicators of acute LOHS

As seen in Table 3, univariate logistic regression analyses indicated that older age, as well as those with complete

Table 1 Participants' characteristics according to the International Core Data Set ($n = 139$)

Variables		
Gender (*n*; %)		
Male	118	85
Female	21	15
Mean age at injury, years (mean; sd)	34	14
Median age at injury, years (median; IQR)	30	23–41
Aetiology (*n*; %)		
Sport	1	1
Assault	83	60
Transport	35	26
Falls	17	12
Other	3	2
Neurological category		
C1-C4 AIS A (complete; *n*, %)	11	8
C1-C4 AIS B, C, D (incomplete; *n*, %)	25	18
C5-C8 AIS A (complete; *n*, %)	9	6
C5-C8 AIS B, C, D (incomplete; *n*, %)	28	20
T1-S5 AIS A (complete; *n*, %)	33	24
T1-S5 AIS B, C, D (incomplete; *n*, %)	33	24
Level of injury (*n*; %)		
Tetraplegia	73	53
Paraplegia	66	47
Completeness on injury (*n*; %)		
Complete	53	38
Incomplete	86	62
Associated injuries (*n*; %)		
Yes	81	58
No	68	42
Vertebral injuries (*n*; %)		
Yes	100	72
No	39	28
Spinal surgery (*n*; %)		
Yes	71	51
No	68	49
Time to spinal surgery, days (mean; sd)	9.93	9.50
Time to spinal surgery (median; range)	7	0–45
Acute LOHS, days (mean(sd); median (IQR))	37 (37)	24 (16–37)
Acute LOHS (*n*; %)		
≤31 days	88	63
>31 days	51	37

AIS American Spinal Injury Association Impairment Scale, *LOHS* length of hospital stay, *SD* standard deviation, *IQR* interquartile range, *associated injuries/vertebral injuries/spinal surgery* the definitions of these terms were taken from the International SCI Core Data Set [18]

injuries and vertebral injuries were significantly more likely to have a longer acute hospitalisation. The univariate analysis on modifiable risk indicators revealed that those who have undergone spinal surgery more than 72 h following injury had a greater risk of staying longer in hospital than those who received surgery within 72 h. Furthermore, those who developed pressure ulcers or pneumonia during their acute hospital stay have shown to be at great risk of having a prolonged LOHS.

Table 2 Description of modifiable factors (medical complications, intermediate hospitalisations, and time to surgery) in the study sample ($n = 139$)

Complications and other modifiable factors	
Pressure ulcers	42 (30)
Pneumonia	33 (24)
Urinary tract infection	24 (17)
Autonomic dysreflexia	2 (1)
Deep vein thrombosis	8 (6)
Pulmonary embolism	1 (1)
Postural hypotension	2 (1)
Neuropathic pain	8 (6)
Spasticity	4 (3)
Total patients with at least one complication	71 (51)
Patients with 1 complication	36 (26)
Patients with 2 complications	23 (17)
Patients with ≥3 complications	12 (9)
Intermediate hospitalisations	
Yes	118 (85)
No	21 (15)
*Time to surgery**	
<72 h	15 (21)
≥72 h	56 (79)

*Time to surgery only includes those who have undergone spinal surgery ($N = 71$)

Multivariable model of risk indicators of acute LOHS

As reported in Table 4, older individuals at the time of injury, and those with vertebral injuries were at higher risk of having a prolonged acute LOHS. Furthermore, those who developed a pressure ulcer or pneumonia during their acute hospitalization were significantly more at risk of having a longer LOHS. Based on Hosmer and Lemeshow goodness-of-fit test ($P = 0.86$), the predicted probabilities were not significantly different from the observed probabilities, indicating a good fit of the final multivariable logistic regression model. Furthermore, the final model showed acceptable discrimination (AUC = 0.86).

Discussion

This study is one of the first to identify risk indicators for acute LOHS in survivors of TSCI in a developing context. While the strongest non-modifiable risk indicators of LOHS

Table 3 Univariate logistic regression analysis of non-modifiable and modifiable indicators for acute LOHS

Variables	OR [95% CI]	*p*-value
Non-modifiable		
Sex		
Male	2.04 [0.70–5.96]	0.19
Female	1.00 (ref)	
Age (continuous)	1.03 [1.00–1.05]	**0.03**
Associated Injury		
Yes	1.74 [0.85–3.57]	0.12
No	1.00 (ref)	
Level of injury		
Tetraplegia	1.93 [0.95– 3.91]	0.06
Paraplegia	1.00 (ref)	
Completeness of injury		
Complete	3.07 [1.49–6.30]	**≤0.01**
Incomplete	1.00 (ref)	
Vertebral injury		
Yes	4.50 [1.73–11.69]	**≤0.01**
No	1.0 (ref)	
Modifiable		
Intermediate hospitalization		
Yes	1.10 [0.41–2.98]	0.56
No	1.00 (ref)	
Time to surgery		
Delayed (>72 h)	2.27 [1.10–3.45]	**0.02**
Normal (≤72 h)	1.00 (ref)	
Secondary medical complication (any)		
Yes	5.52 [2.52–12.09]	**≤0.01**
No	1.00 (ref)	
Pressure ulcers		
Yes	9.55 [4.02–22.66]	**≤0.01**
No	1.00 (ref)	
Pneumonia		
Yes	11.14 [4.30–28.86]	**≤0.01**
No	1.00 (ref)	
Urinary tract infection		
Yes	2.55 [1.05–6.24]	**0.04**
No	1.00 (ref)	
Deep vein thrombosis		
Yes	3.26 [0.75–14.26]	0.12
No	1.00 (ref)	

Bold values indicate significant results

Table 4 Multivariable logistic regression model of acute LOHS risk indicators

Variable	Odds Ratio	95% CI	*P*-value
Age (continuous)	1.04	1.00–1.07	**0.03**
Vertebral injury	3.18	1.07–9.44	**0.04**
Pressure ulcer	7.16	2.54–20.22	**<0.001**
Pneumonia	8.40	2.76–25.55	**<0.001**

Bold values indicate significant independently associated factors

were older age and vertebral injury, the strongest modifiable risk indicators were pressure ulcer and pneumonia. These findings shed light on the unmet need to develop and implement prevention programs for secondary complications to improve the efficiency and quality of acute SCI care in South Africa and to take into consideration the patients age and injury characteristics in the acute care SCI management.

A major finding of the present study was the identification of pressure ulcers and pneumonia as independent risk indicators for acute LOHS which are imperative associations as these secondary complications could have a direct impact on the patient's recovery and rehabilitation which in turn could lengthen their LOHS. In line with the current result, increased acute LOHS between 11 and 25 days have been reported among TSCI patients who reported secondary complications in the acute setting [20]. Despite preventive protocols in place for TSCI management in South Africa, the occurrence of pressure ulcers and pneumonia were 30 and 23%, respectively, in the present cohort [12]. Pressure ulcers leading to enormous societal costs [21] and a decline in health-status accompanied by pain, infection, depression and ultimately death [22]. The high occurrence of pressure ulcers already in the acute care setting is therefore alarming. According to international guidelines for TSCI care, key elements in the acute care prevention of pressure ulcers are avoidance of prolong positional immobilization through repositioning schemes, daily comprehensive skin inspections, provision of adequate nutritional intake, individually prescribed wheelchair including pressure-reducing seating system and exercise regime to promote activity and prevent deconditioning [21]. Importantly, it is not possible to draw conclusion on the specific type of acute care SCI management causing the high occurrence of pressure ulcers in this cohort. However, previous findings by Pather and Mudzi (2013) showed that the most common prevention approach for pressure ulcers in specialised spinal rehabilitation centres in South Africa were passive; 98% was ordered bed rest, and their engagement in active physiotherapy interventions (e.g., physical and transfer exercise) was scarce [23]. Furthermore, as there is currently no intervention studies performed in Cape Town, South Africa we, therefore, encourage clinical trials regarding pressure ulcer prevention and treatment before suggesting possible preventative strategies specific for this context.

Furthermore, pneumonia is one of the most common respiratory complications to arise after a TSCI [12, 24]. In a study conducted on 261 patients, atelectasis was seen in

36%, followed by 31% suffering from pneumonia [25]. However, it was noted that injuries of the cervical spine and upper thorax gave rise to a higher chance of developing pneumonia compared to injuries involving the lower thoracic region and lumbar spine, due to the involvement of respiratory muscles [25]. There is, therefore, the need to test the use of technology in the form of machines that could assist with respiration and a better understanding of the ability to retrain the function of the respiratory musculature in the local context [25].

Older age and vertebral injury were the only non-modifiable risk indicators that were independently associated with acute LOHS. Inconsistent findings have been reported regarding the association between age and LOHS in TSCI; one previous study have shown that an association exists between age and longer LOHS [4] whereas other studies have not [3, 10]. Longer LOHS in advance age, previously also observed after stroke [26] and abdominal surgery [27], could be the result of worse functional outcome found in older survivors of TSCI [28]. Alternatively, longer LOHS in older persons could be the results of more negative psychological experience (e.g., depressed mood, less positive affect and lower self-efficacy) demonstrated in older survivors of TSCI [29]. We, therefore, propose that other personal factors not considered in our study; such as anxiety, depression acceptance of their injury, could be important to account for in further studies. Furthermore, the association between vertebral injury could reflect the unique profiles of survivors of TSCI in South Africa; where injury predominantly occur due to interpersonal violence (e.g. gunshots, stabs and blunt trauma) [11]. Such aetiology has shown to increase the risk of associated vertebral injuries [30]. TSCI survivors with an associated vertebral injury often require more complex acute care management; including spinal stabilization surgery and immobilization, which in turn could influence their recovery and rehabilitation, and ultimately leading to an extended LOHS. However, it is important to acknowledge that the causality between vertebral injuries and acute LOHS remains indecisive. Therefore, additional studies investigating the time-sensitive chain of events (e.g. acute management, spinal surgery and early rehabilitation) and their impact on efficiency of TSCI care are warranted.

Limitations of the study

Firstly, our research was limited to one region (Province) in South Africa that offers specialised care. Therefore, the conclusions made from this study may not be generalised to the greater population of South Africa. Furthermore, this study excluded persons receiving private medical care. Including those with private care could have contributed to our understanding of the influence of private v. public systems on healthcare efficiency. Based on our study findings, it is recommended that future studies include a wider range of hospitals in South Africa, persons of all ages, and those with private medical care in order to gain a more complete picture. For now, special attention should be given to developing and implementing programmes aimed at reducing the occurrence of preventable secondary medical complications, such as pressure ulcers and pneumonia.

In conclusion, the strongest modifiable risk indicators of acute LOHS were pressure ulcers and pulmonary complications, whereas older age and vertebral injuries were non-modifiable risk indicators. These findings shed light on the need of developing prevention programs for secondary complications to improve the quality and efficiency of acute SCI care in South Africa.

Data archiving

The dataset generated and analysed during the current study is available from the corresponding author on reasonable request.

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Author contributions DC: Was responsible for planning of statistical analysis, assisted with the writing of the first draft of the manuscript, and made corrections to subsequent drafts prior to submission. JP: Was responsible for fund procurement for this study, assisted with the conception of the study, and commented on the manuscript drafts. EN: Assisted with data analysis and interpretation, as well as critically reviewing the manuscript prior to submission. CH: Assisted with the conception of the study, data management, and critically reviewed the manuscript prior to submission. CJ: Chiefly responsible for the conception of the study, collected the data, planned and executed the analysis and wrote the first draft of the manuscript. He managed the overall project.

Compliance with ethical standards

Statement of ethics Ethics permission was granted by the University of the Western Cape's Senate Research Committee (registration number: 13/4/27)

Conflict of interest The authors declare that they have no conflict of interest.

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