



ARTICLE

# Traumatic spinal cord injury in Italy 20 years later: current epidemiological trend and early predictors of rehabilitation outcome

Marco Franceschini<sup>1,2</sup> · Jacopo Bonavita<sup>3</sup> · Lorenzo Cecconi<sup>4</sup> · Salvatore Ferro<sup>5</sup> · Maria Cristina Pagliacci<sup>6</sup> · for the Italian SCI Study Group

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## Abstract

**Study design** Multicenter prospective observational study of people with acute traumatic spinal cord injury (TSCI) admitted to rehabilitation.

**Objectives** To update epidemiological characteristics of a TSCI Italian population and verify the impact of patient characteristics at admission on two outcomes: functional gain (SCIM III) and discharge destination.

**Setting** Thirty-one SCI centers for comprehensive rehabilitation in 13 Italian regions.

**Methods** All consecutive individuals admitted with acute TSCI were enrolled from October 1, 2013 to September 30, 2014; data were recorded on rehabilitation admission and discharge. Functional gain and discharge destination were identified as outcome measures and statistically analyzed with patient characteristics at admission to identify early outcome predictors.

**Results** Five hundred and ten individuals with TSCI met inclusion criteria; falls represented the most frequent etiology (45%). On admission, AIS A-B-C tetraplegia was reported in 35% of cases; AIS A-B-C paraplegia in 40%; AIS D paraplegia/tetraplegia in 25%. The majority were discharged home (72%). The mean (SD) SCIM gain was  $38 \pm 26$  points. A predictive model was found for discharge setting: individuals with fall-related injuries, severe SCI (AIS A-B-C tetraplegia), tracheal cannula or indwelling catheter on admission, were less likely to be discharged home (OR 95% CI 0.15 [0.06, 0.35]). A model with a lower predictive power was found for SCIM gain, with lower score expected for females, older age, higher severity of SCI, a longer onset of injury admission interval (OAI), and mechanical ventilation on admission.

**Conclusions** Prognostic factors in early rehabilitation are still hard to identify, making it difficult to correctly approach customized rehabilitation.

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Members of the Italian SCI Study Group Steering Committee are listed at the end of the paper.

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✉ Jacopo Bonavita  
jacopo.bonavita@gmail.com

<sup>1</sup> IRCCS San Raffaele Pisana, Rome, Italy

<sup>2</sup> San Raffaele University, Rome, Italy

<sup>3</sup> SCI Unit, Montecatone Rehabilitation Institute, Imola (BO), Italy

<sup>4</sup> Department of Statistics, Computer Science, Applications “G. Parenti”, University of Florence, Florence, Italy

<sup>5</sup> Department of Hospital Services, Emilia-Romagna Regional Health Authority, Emilia-Romagna, Italy

<sup>6</sup> SCI Unit, University Hospital Santa Maria della Misericordia, Perugia, Italy

## Introduction

Early outcome prediction after traumatic spinal cord injury (TSCI) is pivotal in the rehabilitation process, allowing clinicians to adequately inform both patients and families about prognosis, to predict rehabilitation potential, to plan rehabilitation process and to assess its efficacy. Furthermore, it is crucial to allocate resources appropriately. The sooner the endpoints are predicted, the better the rehabilitation pathway can be identified [1, 2].

The modification of epidemiological data during time may suggest to health policy-makers what is necessary to change in the organizational and clinical approach of management of spinal cord injury (SCI). Otherwise, even if the literature may provide tentative instruments of prediction of functional achievement [3], clinicians often continue to rely on intuitive assessment when defining which

functional outcome is an appropriate target for each person with TSCI.

Whatever the specific evaluation for each person, the mission of SCI rehabilitation programs is to help patients take full advantage of neurological recovery and maximize functional improvement. Being discharged home is usually a major prerequisite to benefit of regained activity and achieve full participation [4]. It is known that people with SCI are frequently discharged home after rehabilitation hospitalizations, but it is not clear which factors may facilitate or hinder this goal [5, 6]. Functional gain is also a fundamental endpoint of the rehabilitation process; however, it remains a difficult parameter to evaluate in such a heterogeneous population [7]. As a matter of fact, several aspects may have an impact on it, including individual-related conditions, severity of the initial neurological damage, time interval between injury and access to rehabilitation care, etc. In the literature, many articles and reviews suggest predictors of functional outcomes after SCI [1, 2, 7–9]. The effect of some of these parameters, such as age at trauma, revealing relevant modifications in the contemporary Italian population, is controversial [10–13]. Also, many clinical aspects, such as respiratory and bladder function at admission, trauma-associated lesions, complications arising in acute care units (ICU, NCH, etc.), are not univocal as predictors [14–16].

About 20 years ago, the GISEM study, a prospective observational study that included 32 Italian SCI centers, collected socio-demographic and clinical data at admission and discharge from rehabilitation, and described the Italian situation at the time. A high incidence of traumatic SCI after transport accidents (53%) was one of the most peculiar aspects of the study. The outcome was evaluated with AIS improvement, bladder autonomy, and discharge home [17].

In the last two decades, the epidemiology of TSCI has deeply changed all over the western world. Italy, in particular, which has one of the oldest populations in the world, experienced a profound modification [18–21]. There has been a substantial increase of the average age at trauma and of cervical lesions, thus certainly resulting in greater fragility and complexity of patients accessing SCI rehabilitation departments. On the other hand, the increase of incomplete injuries has raised new challenges and new functional and rehabilitation goals during first hospitalization, aiming at the highest level of function and participation. Even the causes of traumatic SCI have changed as relative percentage. It is therefore crucial to evaluate and update the predictors of the main outcomes, according to our reality and in the light of the new epidemiological trends.

The main objective of this 1-year multicenter prospective observational study is to verify if patient characteristics, acute neurological impairment and some acute clinical indicators may have an impact on two chosen outcomes:

functional gain, evaluated with Spinal Cord Independence Measure (SCIM III), and discharge home. The secondary objective is to update, 20 years later, the type and the weight of some early outcome predictors, in the light of the recent epidemiological trends.

## Methods

This research was approved and funded by the Italian Ministry of Health (CCM number 15756 of 17-07-2012 and “Institutional research”). A regional network for a systematic data collection was created under the supervision of Age.Na.S. (National Agency for Regional Health Services).

This prospective observational study included all consecutive persons with TSCI admitted to 31 SCI centers of 13 Italian regions, from October 1, 2013 to September 30, 2014 (Fig. 1) [21]. Data were collected by clinicians in two phases: T1 at admission and T2 at discharge. People who were still hospitalized at the end of enrollment (September 30, 2014) were assessed at discharge whatever the date.

A TSCI case was defined, for the purpose of this study, as an acquired traumatic lesion of the spinal cord or cauda equina, resulting in a complete or partial, transient or permanent loss of motor, sensory, bladder or bowel function below the level of the lesion. Exclusion criteria were: age below 16 years; time interval between event and admission to rehabilitation >12 months; nontraumatic etiology; other neurological diagnosis.

An etiological classification of the lesion was performed according to the International Spinal Cord Injury Core Data Set [22]. The International Standards for Neurological Classification of SCI was used to assess the level and completeness of the lesion [23].

A web database was created. It included a form for the collection of the following data: gender, age, origin of the patient (migration between regions: yes/no), nationality, date of the acute episode, spinal surgery (yes/no), and date of surgery, injury date, and admission date to rehabilitation setting were used to calculate onset-admission interval (OAI) and length of stay (LoS). At T1 other clinical data were collected: lesion level, completeness according to ASIA-ISCOS impairment scale (A-B-C-D), SCIM III. For the statistical analysis, level and completeness of injury were grouped as: AIS A-B-C paraplegia/AIS A-B-C tetraplegia/all D [24]. The causes of trauma (transport accidents, falls, sports, assault, or other) were grouped for the statistical analysis as follows: (1) transport accidents; (2) falls; (3) other causes (merged together). Data on breathing (mechanical or spontaneous), tracheotomy (yes/no), associated traumas (brain injury, other, or none), bladder management (indwelling catheter vs. all other solutions), complications (pressure ulcers, osteomyelitis, deep vein



**Fig. 1** Italian regions and number of centers participating in the study.

thrombosis, pulmonary embolism, respiratory complications, urological complications, heterotopic ossifications, complications of spine surgery, multiresistant infections) were also recorded. Complications were analyzed globally as absent or present (one or more). The most frequent complications (pressure ulcers, respiratory and infectious complications) were taken into consideration separately.

At T2, the following data were evaluated: mortality, changes in the neurological (AIS A-B-C-D-E) and functional status (SCIM III), LoS, and discharge destination.

The main outcomes considered were: discharge destination (home or other destination) and functional gain (SCIM gain = SCIM score at discharge – SCIM score at admission) (dependent variables).

All social, personal, anamnestic, and clinical indicators considered were used as result indicators (independent variables).

### Statistical analysis

Categorical variables were calculated as frequencies and percentages for the whole sample. Standard descriptive statistics were used to summarize data, with respect to demographic and clinical characteristics.

First, a univariate analysis was performed to assess the ability of each feature to predict an outcome. Second, a multivariate analysis was performed, including all variables of interest, to evaluate the added value of a

combination of predictors and to account for confounding and multicollinearity.

For each outcome, a model selection was applied to determine the best multivariate model among all possible linear models, using three different information criteria, such as AIC (Akaike Information Criterion), BIC (the Bayesian version of AIC), and BICg (an extended version of BIC). The model selection was performed using the R library “bestglm” [25]. Model performance was evaluated by area under the ROC curve (AUC) in the binary model for discharge destination and by  $R^2$  in the linear model for SCIM gain.

Statistical analyses were performed using STATA version 12.1 (StataCorp. 2011. Stata Statistical software: Release 12. College Station, TX: StataCorp LP) and R v3.3.2 (R Foundation for Statistical Computing, Vienna, Austria). All tests were two sided, and an alpha level of 0.05 was set for statistical significance.

### Results

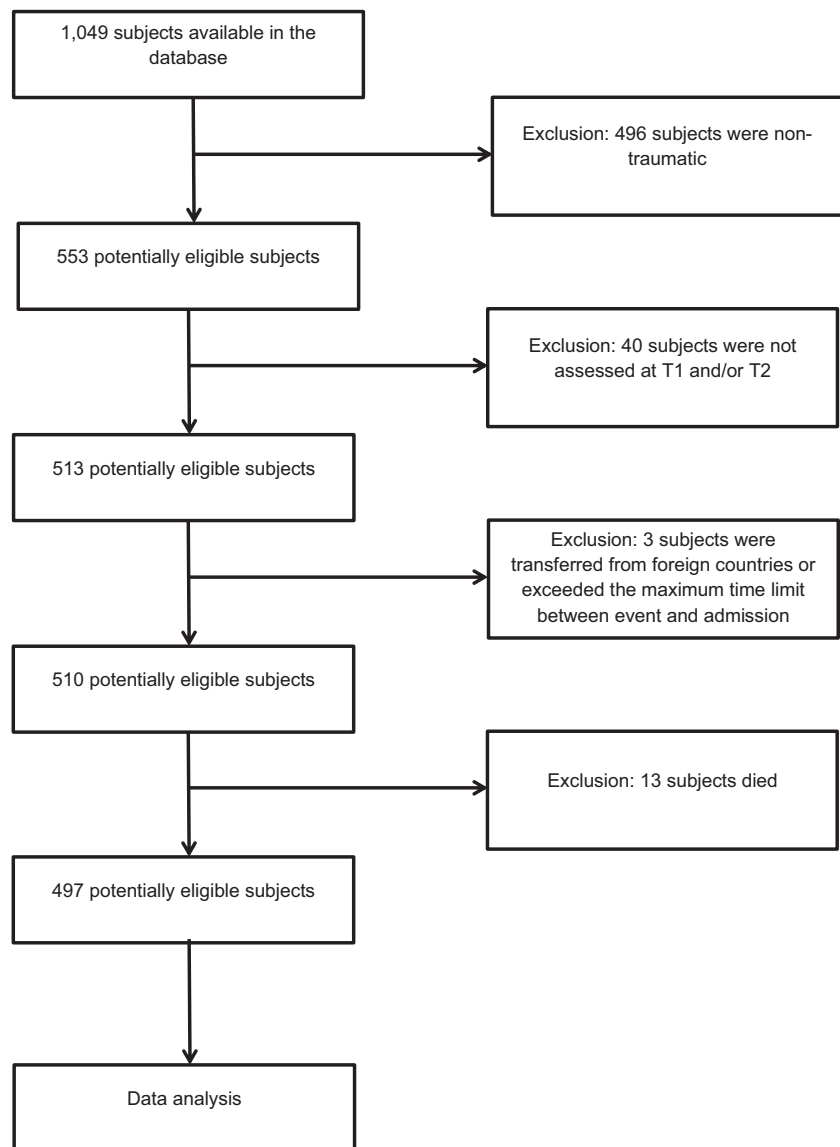
Out of the 1049 people enrolled at admission to SCI inpatient rehabilitation, 510 individuals met the inclusion criteria and were included in the analysis. The remaining were excluded for the following reasons: nontraumatic SCI (496); incomplete records (40 = 17 missing data at T1 + 23 missing data at T2); transferred from foreign countries; exceeding the maximum time limit between event and admission. This article is therefore based on a sample of 497 patients (Fig. 2).

Thirteen individuals (3%) died during the rehabilitation treatment period. The cause of death was not reported. The features of this group were: etiology (transport accidents: seven; falls: four, assault: two); the median (IQR) time from admission to death was 74 days (37–163 days). The median (IQR) age at injury was 71 years (69–77 years); 11 (85%) suffered from tetraplegia and 2 (15%) from paraplegia; the most frequently reported complications during hospitalization were respiratory (11), pressure ulcers (10), spine instability (5), multiresistant infections (5), pulmonary embolism (1), and urological infections (2).

The descriptive analysis of the characteristics of surviving population at admission is shown in Table 1.

Male-to-female ratio was 4:1; mean age for all causes was 50 years (SD = 20 years); falls were the most frequent etiology (45%), followed by transport accidents (40%). A large number of SCIs were associated with multitrauma (42%) and traumatic brain injury (21%).

Only 25% of the population did not receive spinal surgery after trauma; 23% of the population received rehabilitation treatment in centers outside their area of residence. The median (IQR) OAI was 16 days (11–34 days).

**Fig. 2** Flow of participants through the study.

As concerns the severity of the lesion, 35% presented tetraplegia (AIS A-B-C) and 40% paraplegia (AIS A-B-C) at admission. The remaining group (25%) included AIS D paraplegia or tetraplegia. At admission, AIS A was found in 173 patients, AIS B in 78, AIS C in 122, and AIS D in 104 (Table 2). Fifty-four patients needed mechanical ventilation at admission (11%). At T1, the great majority had an indwelling urethral catheter and the main complications were respiratory (34%) and pressure ulcers (30%).

LoS, neurological improvement, discharge setting, and SCIM gain were considered as rehabilitation outcomes. The median (IQR) LoS was 135 days (79–190 days). The neurological improvement is shown in Table 2: AIS condition was not reported at admission or discharge for 18 individuals, whose improvement was not possible to evaluate. The percentage of people reporting a worst AIS condition at discharge is negligible; out of 173 AIS A complete lesions

at admission, 13 (8%) converted to B; 9 (5%) to C; and only 2 (1%) to D (Table 2).

The majority of patients (72%) were discharged home; a significant number of those not returning home were transferred to a nonspecific rehabilitation facility (15%).

The mean SCIM gain, calculated as the difference between SCIM at discharge ( $57 \pm 29$ ) and SCIM at admission ( $18 \pm 16$ ), was  $38 (\pm 26)$  points.

The predictive factors for outcome that were reported at admission were investigated with univariate analysis. A longer LoS was directly and significantly correlated with discharge home (Table 3). Moreover, discharge home was inversely significantly related to age, with the mean age of the individuals not discharged home exceeding by 9 years those discharged home. An inverse significant correlation was found between discharge home and severity of the lesion, with discharge home three times less frequent in the

**Table 1** Descriptive analysis of the TSCI population at admission.

		<i>N</i> = 497
Gender	M	402 (80.9%)
	F	95 (19.1%)
Age (years)	Mean (SD)	50 (20)
	Median (min, max)	50 (16, 89)
Nationality	Italian	433 (87.1%)
	Other	64 (12.9%)
Etiology	Fall	223 (44.9%)
	Transport	201 (40.4%)
	Sports	23 (4.6%)
	Assault	26 (5.2%)
	Other	24 (4.8%)
Associated trauma	No	187 (37.6%)
	Brain injury	103 (20.7%)
	Multi	207 (41.6%)
Surgery	No	120 (24.1%)
	Yes	377 (75.9%)
Migration	No	384 (77.3%)
	Yes	113 (22.7%)
Onset-admission interval (days)	Mean (SD)	25.7 (25.1)
	Median (min, max)	16 (1, 287)
Severity of SCI	All D	106 (21.3%)
	Para A-B-C	199 (40.0%)
	Tetra A-B-C	176 (35.4%)
	Missing	16 (3.2%)
Breathing	Spontaneous	443 (89.1%)
	Mechanical	54 (10.9%)
Tracheal cannula	No	396 (79.7%)
	Yes	101 (20.3%)
Micturition	Spontaneous	55 (11.1%)
	Intermittent catheterization	16 (3.2%)
	Indwelling catheterization	426 (85.7%)
Complications	Respiratory	171 (34.4%)
	Pressure ulcers	151 (30.4%)
	Infections	66 (13.3%)
	Urological	53 (10.7%)
	Deep vein thrombosis	38 (7.6%)
	Other (osteomyelitis, heterotopic ossifications, complications of spine surgery)	45 (9.1%)
Length of stay (days)	Mean (SD)	139 (77)
	Median (min, max)	135 (4, 387)
Destination	Back to acute ward	16 (3.2%)
	Another hospital	17 (3.4%)
	Day hospital	24 (4.8%)
	Rehabilitation (non SCI-dedicated)	75 (15.1%)

**Table 1** (continued)

		<i>N</i> = 497
	AMA (against medical advice)	5 (1.0%)
	Supportive housing	4 (0.8%)
	Home	356 (71.6%)
SCIM at admission	Mean (SD)	18 (16)
	Median (min, max)	14 (0, 96)
SCIM at discharge	Mean (SD)	57 (29)
	Median (min, max)	63 (0, 100)

**Table 2** AIS modification: AIS at admission (T1) vs. AIS at discharge (T2).

	AIS at admission (T1)					AIS at discharge (T2)				
	A	B	C	D	E	A	B	C	D	E
A	173	149	13	9	2					
B	78	2	44	21	10	1				
C	122		1	54	65	2				
D	104				97	7				
E	2					2				
Total	479	151	58	84	174	12				

AIS A-B-C paraplegia group and six times less frequent in the AIS A-B-C tetraplegia group in respect of AIS D group. Discharge home was also four times less frequent in patients with mechanical ventilation or tracheal device and 50% less frequent in patients with respiratory complications or pressure ulcers at admission.

SCIM gain (Table 4) showed a weakly significant inverse correlation with LoS. A worst SCIM gain was significantly correlated with older age, etiology (lower score registered for victims of fall), female gender (9-point lower gain), longer OAI, associated trauma, but no brain trauma. Moreover, it was highly significantly correlated with the severity of the lesion (AIS A-B-C tetraplegia has 20-point lower gain, while AIS A-B-C paraplegia group has 8-point lower gain than all AIS D), mechanical ventilation (20-point lower gain) and complications (11-point lower gain for pressure ulcers and 8-point lower gain for respiratory complications).

The multivariate analysis designs a model with a good predictive power (80% AUC, Area under ROC Curve) (Fig. 3) for the discharge home outcome (Table 3): individuals with fall-related SCI, severe SCI (AIS A-B-C tetraplegia: eight times less likely; AIS A-B-C paraplegia: four times less likely than all AIS D), tracheal cannula (four times less likely) or indwelling catheter (six times less likely) at admission are less likely to be discharged home.

**Table 3** Univariate and multivariate analysis of “discharge home” outcome.

		Univariate			Model selection		
		OR	CI 95%	<i>p</i> value	OR	CI 95%	<i>p</i> value
Gender	M	Ref.					
	F	0.74	(0.46, 1.20)	0.220			
Age	Mean	0.98	(0.97, 0.99)	<0.001	0.986	(0.973, 0.999)	0.047
Nationality	IT	Ref.					
	No	1.42	(0.76, 2.66)	0.277			
Migration	No	Ref.					
	Yes	1.28	(0.79, 2.08)	0.321			
Hospitalization	(mean)	1.003	(1.000, 1.006)	0.030	1.012	(1.008, 1.016)	<0.001
Tetraplegia + AIS	All D	Ref.			Ref.		
	Para A-B-C	0.35	(0.17, 0.72)	0.004	0.28	(0.12, 0.66)	0.004
	Tetra A-B-C	0.14	(0.07, 0.29)	<0.001	0.17	(0.07, 0.39)	<0.001
Onset-admission interval (days)	Mean	0.998	(0.991, 1.006)	0.681			
Surgery	No	Ref.					
	Yes	0.84	(0.53, 1.34)	0.471			
Associated trauma	No	Ref.					
	Brain injury	0.82	(0.49, 1.38)	0.464			
	Multi	1.31	(0.83, 2.05)	0.241			
Breathing	Spontaneous	Ref.					
	Mechanical	0.23	(0.13, 0.42)	<0.001			
Tracheal cannula	No	Ref.			Ref.		
	Yes	0.27	(0.17, 0.43)	<0.001	0.35	(0.19, 0.65)	0.001
Bladder	Spontaneous/ intermittent catheterization	Ref.			Ref.		
	Indwelling catheterization	0.13	(0.05, 0.37)	0.001	0.25	(0.06, 0.97)	0.045
Etiology	Fall	Ref.			Ref.		
	Transport	1.46	(0.96, 2.23)	0.079	1.45	(0.83, 2.54)	0.193
	Other	2.52	(1.28, 4.97)	0.007	2.73	(1.18, 6.32)	0.019
Pressure ulcers	No	Ref.					
	Yes	0.52	(0.34, 0.78)	0.002			
Respiratory complications	No	Ref.					
	Yes	0.41	(0.27, 0.61)	<0.001			
Infection	No	Ref.					
	Yes	0.62	(0.36, 1.07)	0.088			
SCIM at admission	Mean	1.06	(1.04, 1.08)	<0.001	1.031	(1.003, 1.059)	0.028

As regards SCIM gain (Table 4), a lower score is expected for females, older age at admission (3-point lower score/10 years of age), severity of SCI (AIS A-B-C tetraplegia: 23 points and AIS A-B-C paraplegia: 14 points lower than all AIS D), a longer OAI (1-point lower score/week), mechanical ventilation at admission (14-point lower score); the model shows a lower predictive power (only 25% of the variance is explained).

## Discussion

The study allowed us to detect some descriptive aspects that differ from data obtained by a previous comparable prospective, rehabilitation-based study (GISEM study), carried out 20 years earlier [17], drawing an epidemiological trend in agreement with the recent literature from other countries [18, 26]. We then tried to identify

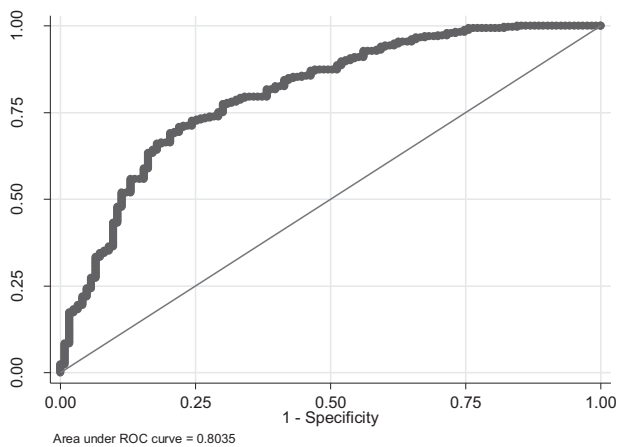
**Table 4** Univariate and multivariate analysis of “SCIM gain” outcome.

		Univariate			Model selection ( $R^2 = 27\%$ )		
		Beta	CI 95%	<i>p</i> value			
Constant					+62.0	(53.4, 70.6)	
Gender	M	Ref.			Ref.		
	F	-8.6	(-14.4, -2.82)	0.004	-8.9	(-14.1, -3.7)	0.001
Age		-0.37	(-0.49, -0.26)	<0.001	-0.22	(-0.34, -0.11)	<0.001
Nationality	IT	Ref.					
	No	1.9	(-5.0, 8.8)	0.588			
Migration	No	Ref.					
	Yes	0.72	(-4.8, 6.3)	0.799			
Hospitalization		-0.03	(-0.06, -0.001)	0.042			
Tetraplegia + AIS	All D	Ref.			Ref.		
	Para A-B-C	-8.1	(-14, -2.2)	0.007	-9.1	(-14.6, -3.5)	0.001
	Tetra A-B-C	-23.6	(-30, -18)	<0.001	-18.7	(-24.5, -12.9)	<0.001
Onset-Admission Interval		-0.17	(-0.26, -0.08)	<0.001	-0.13	(-0.21, -0.05)	0.002
Surgery	No	Ref.					
	Yes	0.75	(-4.7, 6.2)	0.785			
Associated Trauma	No	Ref.					
	Brain injury	0.3	(-6.2, 6.7)	0.932			
	Multi	5.5	(0.3, 10.7)	0.038			
Breathing	Spontaneous	Ref.			Ref.		
	Mechanical	-20.6	(-27.7, -13.5)	<0.001	-12.9	(-19.9, -5.9)	<0.001
Tracheal cannula	No	Ref.					
	Yes	-15.7	(-21.4, -10.0)	<0.001			
Bladder	Spontaneous/ intermittent catheterization	Ref.					
	Indwelling catheterization	-1.25	(-8.2, 5.7)	0.723			
Etiology	Fall	Ref.			Ref.		
	Transport	12.4	(7.5, 17.4)	<0.001	8.7	(4.1, 13.4)	<0.001
	Other	10.7	(3.9, 17.6)	0.002	6.8	(0.37, 13.2)	0.038
Pressure ulcers	No	Ref.					
	Yes	-11.5	(-16.4, -6.5)	<0.001			
Respiratory complications	No	Ref.					
	Yes	-7.9	(-12.8, -3.0)	0.002			
Infection	No	Ref.					
	Yes	-5.8	(-12.6, 1.0)	0.093			

significant early predictors of the selected outcome measures: discharge home and functional gain (SCIM gain) during rehabilitation.

The low mortality (13/510) reported during rehabilitation can be explained because the data collection excluded the high-risk immediate postevent period [27]. Although a statistical comparison between heterogeneous groups of people with SCI who survived or died during rehabilitation was not carried out, the median age of the deceased group exceeded by 20 years that of the survived group, and tetraplegia was more represented in the deceased group.

Compared with the previous study [17, 28], there was a marked change in the mean age at the time of SCI onset of the survived population (from 38.5 to 50 years). This aspect has probably implied also a change in the etiology of trauma. We observed a decrease in the proportion of transport accidents (from 54 to 41%) and an increase in the proportion of falls (from 23 to 45%), especially of low-level falls. The mechanism involved in the predominant etiology makes tetraplegia more frequent (247 patients; 50%) in respect of 40% of GISEM study, with a high frequency of AIS D lesions (71 patients; 14%). These data are consistent



**Fig. 3** ROC curve for multivariate analysis of “discharge home” outcome.

with the recent international literature concerning the average age at injury and the etiology in high-income countries [18, 27, 29].

The mean OAI is reduced (from 34 to 15 median days), possibly due to a better organization of the acute rehabilitation pathway implemented in Italy in the last two decades, with an increase of the number of specific SCI rehabilitation facilities inside trauma centers/emergency hospitals on the whole Italian territory. It is noteworthy that preventable complications, such as pressure ulcers, did not decrease (30% vs. 27% in GISEM), possibly due to the increased clinical complexity of patients with acute SCI, as suggested by the report of 34% respiratory complications on admission (12% in GISEM study), 10% ventilated patients and a higher percentage of tetraplegia.

The median LoS was similar, with 135 median days reported in the current study vs. 122 in the GISEM study. The number of people being discharged home has decreased in the last 20 years (from 82 to 72%) [28]. These data may partially be explained by the increased percentage of incomplete lesions, leading to transfers to nonspecific SCI rehabilitation centers (15%), for outpatient rehabilitation or lower intensity rehabilitation programs. A higher patient complexity and a high burden of assistance may possibly discourage families from taking their relatives home at discharge. The increase of the mean age may also result in too few or too old relatives, that cannot guarantee an ongoing commitment towards their next of kin with SCI. In our sample 46% of patients who need to maintain tracheal cannula are discharged home.

The main negative predictors of discharge home are etiology (fall-related SCI), severe SCI (with an intuitive decreasing profile from “non functional” AIS A-B-C tetraplegia to incomplete AIS D lesions), and clinical severity indicators, such as indwelling catheter and tracheal cannula,

at admission. In comparing the multivariate analysis for discharge home, only bladder management is still a predictive factor of outcome, as it was in the previous study.

As regards SCIM gain, a comparison with the Italian previous data is not possible because no functional outcome had been reported 20 years ago. The mean (SD) total SCIM III score reported at admission in the sample of this study ( $18 \pm 16$ ) is lower than other SCI samples reported in the literature in similar case-mix, ranging from the lowest in Israel ( $25.1 \pm 17.2$ ) to the highest in the USA (42, range 13–68) [30].

Lower score expected in the predictive model for severe SCI and mechanical ventilation at admission are consistent with reports in the literature [3, 14]. Age is also involved in the predictive model of SCIM gain at discharge: we found a significant correlation between age, AIS grade, and future functional status. Clinicians perceive that an older age is often in relation with a worse outcome, but this effect varies across the spectrum of injury severity and has to be considered in that perspective. A longer OAI is the most amendable factor in the model, suggesting a role of early management in the risk of complications, but also that early complications in complex patients are more often cause of delay in transferring patients to rehabilitation, thus hampering the rehabilitation process.

The presence of multiple trauma is significantly associated with a better SCIM gain outcome. These data could seem a contradiction at first reading, but it emerges that most of those who have a polytrauma have a post traumatic etiology and are younger. As previously said, those who are younger and have a post traumatic etiology have a better SCIM gain prognosis, thus the correlation can be explained.

### Limitations

This study’s main limitation is the possible selection bias due to losing patients who died or spread out, because of an uneven acute rehabilitation pathway or overwhelming complications. Moreover, this study cannot be considered representative of the whole Italian population, since it covers about half of it with a nonhomogeneous distribution of recruitment centers.

### Conclusions

Ageing and increasing complexity of people with SCI in a high-income country is a very challenging condition. Prognostic factors in early rehabilitation are still hard to identify, making it difficult to facilitate clinical interpretation, develop customized treatment and define the correct approach to rehabilitation programs for every single person with SCI, in the context of cost/effectiveness.



## Data availability

Data are included in the registry of 2012 CCM project according to national privacy regulations and are available by a formal request to the Emilia-Romagna Regional Health Authority.

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## Compliance with ethical standards

**Ethics statement** We certify that all applicable institutional and governmental regulations concerning the ethical use of data originally

collected for clinical purpose were followed during the course of this research.

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## Italian SCI Study Group

Salvatore Ferro<sup>7</sup> · Mariadonata Bellentani<sup>7</sup> · Marco Franceschini<sup>8</sup> · Augusto Cavina<sup>9</sup> · Jacopo Bonavita<sup>9</sup> · Maria Cristina Pagliacci<sup>10</sup> · Annibale Biggeri<sup>11</sup> · Lorenzo Cecconi<sup>11</sup> · Federico De Iure<sup>12</sup> · Giovanni Gordini<sup>12</sup> · Tiziana Redaelli<sup>13</sup> · Maria Vittoria Actis<sup>14</sup> · Giulio Del Popolo<sup>15</sup> · Giannettore Bertagnoni<sup>16</sup> · Renato Avesani<sup>17</sup> · Vincenzo Falabella<sup>18</sup>

<sup>7</sup> National Agency for Regional Health Services (Age.Na.S.), Department of Hospital Services, Emilia-Romagna Regional Health Authority, Emilia-Romagna, Italy

<sup>8</sup> Department of Neurorehabilitation, IRCCS San Raffaele Pisana, Rome, Italy

<sup>9</sup> SCI Unit, Montecatone Rehabilitation Institute, Imola (BO), Italy

<sup>10</sup> SCI Unit, Perugia Hospital, Perugia, Italy

<sup>11</sup> Department of Statistics, University of Florence, Florence, Italy

<sup>12</sup> SCI Surgery Unit and Intensive Care Unit, Maggiore Hospital, Bologna, Italy

<sup>13</sup> SCI Unit, Niguarda Hospital, Milan, Italy

<sup>14</sup> SCI Unit, Città della Salute e della Scienza Hospital, Turin, Italy

<sup>15</sup> SCI Unit, Careggi Hospital, Florence, Italy

<sup>16</sup> SCI Unit, San Bortolo Hospital, Vicenza, Italy

<sup>17</sup> Department of Neurorehabilitation, Don Calabria Hospital, Negrar, Verona, Italy

<sup>18</sup> FAIP, Italian Federation of Paraplegics and Tetraplegics Associations, Rome, Italy