Int J Public Health (2011) 56:341–352
DOI 10.1007/s00038-010-0222-8

ORIGINAL ARTICLE

Functioning and disability in people living with spinal cord injury in high- and low-resourced countries: a comparative analysis of 14 countries

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Received: 9 June 2010 / Revised: 28 October 2010 / Accepted: 16 November 2010 / Published online: 17 December 2010

Abstract
Objectives We examined whether persons with spinal cord injury (SCI) from countries with differential resources and resource distribution differ in the level and structure of functioning and disability.
Methods We analysed cross-sectional data of 1,048 persons with SCI from 14 countries based on the International Classification of Functioning, Disability and Health (ICF). We used penalized logistic regression to identify ICF categories distinguishing lower- and higher-resourced countries. Hierarchical linear models were employed to predict the number of problems in functioning. The association structure of ICF categories was compared between higher- and lower-resourced countries using graphical models.
Results A total of 96 ICF categories separated lower- and higher-resourced countries. Differences were not univocal. Lower resources and unequal distribution were predictive of more functional problems in persons with higher age or tetraplegia. In the graphical models, few associations between ICF categories persisted across countries.
Conclusion Higher-resourced countries do not score higher in all ICF categories. Countries' economic resources and their distribution are significant predictors of disability in vulnerable groups such as tetraplegics and the elderly. Functioning is multi-dimensional and structures of association suggest that country-specific pathways towards disability exist.

Keywords Functioning · Disability · Economic resources · Environmental factors · Gross domestic product · Gini coefficient

Electronic supplementary material The online version of this article (doi:10.1007/s00038-010-0222-8) contains supplementary material, which is available to authorized users.

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Introduction

The complexity of human functioning and disability (Bickenbach et al. 1999; WHO 2001) in relation to various environments poses major challenges to scientific understanding and public health interventions. In spinal cord injury (SCI), functioning ranges from the human organism to activity and participation in society (Biering-Sorensen et al. 2006). According to the World Health Organization's (WHO) International Classification of Functioning, Disability, and Health (ICF), differential functioning levels result from the interaction between health condition, and personal and environmental factors (WHO 2001). At the country level, economic resources and their distribution set the scene for individual functioning (Albrecht and Bury 2001; Badley 2008). This may relate to inequalities in population levels of functioning between countries with differential economic resources and resource distribution.

While this has been relatively well demonstrated for mortality (Wilkinson and Pickett 2008; Woolf et al. 2010) and subjective health of the general population (Pei and Rodriguez 2006; McGrail et al. 2009), no evidence exists with regard to functional outcome. In SCI, it seems obvious that "paraplegia of like clinical severity can be fatal in one environment and not in another" (Allotey et al. 2003). Yet the existing evidence is weak and sometimes conflicting (Allotey et al. 2003; Dijkers et al. 2002).

The objective of this research was to examine whether functioning levels of persons with SCI and association structures of ICF categories differ between higher- and lower-resourced countries and between countries with more and less equal resource distribution.

The specific aims of the study were: (1) to identify problems in functioning that separate higher- and lower-resourced countries; (2) to test the influence of individual, environmental and macro-economic variables on the level of functioning and disability; (3) to examine differential association structures of functioning and environmental factors between higher- and lower-resourced countries; and (4) to identify association structures, which stay stable across countries.

Methods

Design

A secondary analysis was performed on observational cross-sectional data collected in the context of the ICF Core Sets development project for SCI. ICF Core Sets are lists of ICF categories essential to persons with particular health conditions and/or in particular rehabilitation contexts (Biering-Sorensen et al. 2006).

The original study was approved by the ethical commissions of the participating countries and performed according to the principles of the Declaration of Helsinki.

Sample

From June 2006 to January 2008, trained health professionals from 16 study centres in 14 countries collected data of 1,048 adults with SCI due to an injury or disease with an acute onset. Using the research network of the WHO ICF Research Branch of the German WHO Collaborating Centre (DIMDI), the sample was purposefully constructed to represent all WHO regions as well as different phases of SCI rehabilitation (Kirchberger et al. 2010). WHO regions were represented as follows: Southeast Asia with 30.2% (Thailand, India, Vietnam and Malaysia), Europe with 14.1% (Denmark, Germany and Switzerland), Western Pacific with 15.3% (New Zealand and Australia), Eastern Mediterranean with 14.9% (Israel), the Americas with 19.2% (USA, Canada and Brazil) and Africa with 6.4% of the data (South Africa). Of the participants, 46.7% were assessed during primary rehabilitation (early post-acute situation) and 53.3% after the completion of primary rehabilitation (long-term situation).

Measurement

The functional problems of the participants were assessed using a Case Record Form (CRF) [see Electronic Appendix] comprising 264 ICF second-level categories (Fig. 1). Information on the ICF components body functions and

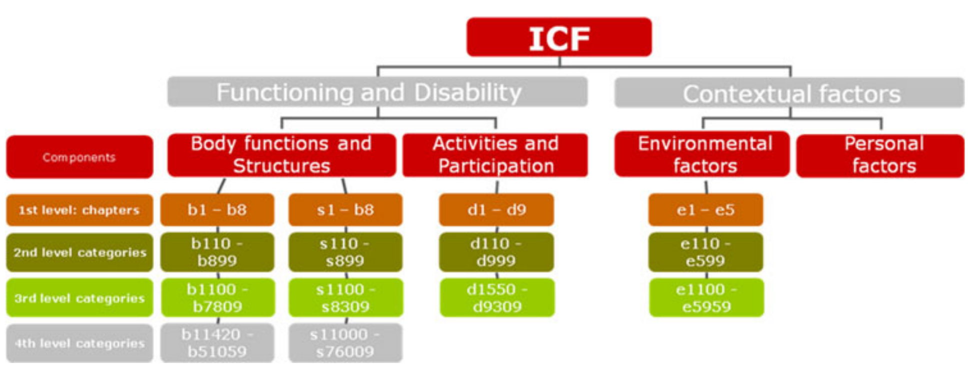

Fig. 1 Structure of the International Classification of Functioning, Disability and Health (ICF)

body structures, e.g. problems with urination or skin structures, was based on the health professionals' assessment; information on the ICF component activities and participation, e.g. problems with toileting or remunerative employment, was reported both by professionals and study participants. The assessment of environmental factors, e.g. design and construction of buildings for public use, support of the family or health policy, was rated by the participants as barrier, facilitator, both or none. The presence of a problem was binary coded for functioning. Each environmental factor was re-coded into two dummy variables: a facilitator and a barrier variable.

We examined injury-related and demographic variables: level of SCI (para- vs. tetraplegia), completeness of injury (complete vs. incomplete), time since injury, situation (early post-acute vs. long term), years of formal education, gender and current age.

With regard to macro-economic variables, per capita gross domestic products (GDP) and Gini coefficients for 2007 were obtained from World Bank data (The World Bank 2008). The Gini coefficient is a measure of inequality in resource distribution ranging from 0 (complete economic equality) to 1 (complete inequality).

For particular analyses, dummy variables were constructed for GDP and Gini coefficients. A graphical cutoff criterion was used for determining the cutoff point regarding GDP (Fig. 2). For the Gini coefficients, the sample was divided into more equal and less equal countries by median split, since no obvious cutoff could be derived from the distribution of the data (Fig. 2).

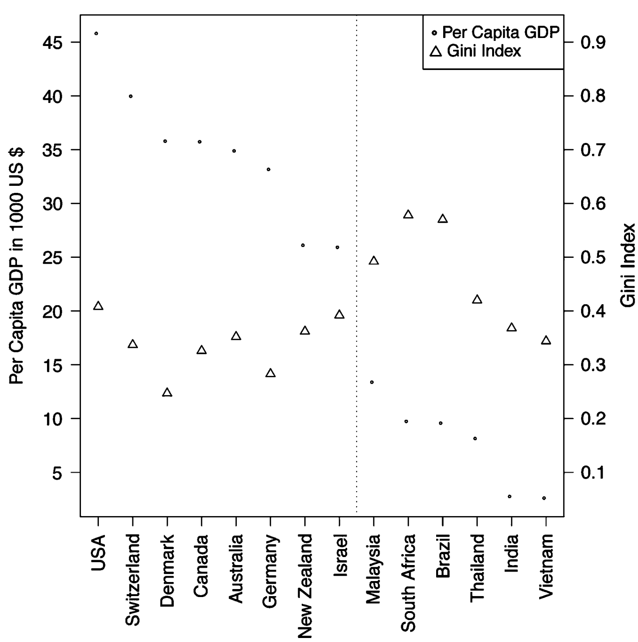

Fig. 2 Per capita gross domestic product (GDP) and Gini coefficients (2007) of the studied countries. World Bank 2008

Data analyses

To evaluate the ICF categories' capacity to differentiate between higher- and lower-resourced countries, penalized logistic regression was carried out with all ICF categories as independent variables and the economic setting (higher- vs. lower-resourced countries) as dependent variable. Optimal penalization was evaluated using cross-validation (Hastie et al. 2003).

To test the influence of individual and macro-economic variables on levels of functioning and disability, hierarchical regression models were calculated. We performed separate analyses for four dependent variables: number of problems in body function, problems in body structure, health professional-reported problems in activity and participation, and patient-reported problems in activity and participation. Predictors comprised injury-related variables, demographics, perceptions of environmental facilitators and barriers summated and ordered according to ICF chapter, per capita GDP and Gini coefficients of the countries in question. Additionally, GDP was multiplied by Gini coefficient, resulting in an interaction term. Higher values of this interaction term indicate higher GDP, which is more unequally distributed.

Our seven principal hypotheses were as follows. H1: We expected more problems in body functions, activity and participation in lower-resourced countries, in countries with less equal resource distribution, and in countries in which a relatively high GDP was distributed unequally. H2–H3: Regarding vulnerable groups, we hypothesized that the functioning of persons with tetraplegia would be generally worse than of those with paraplegia, but worst for those tetraplegics living in the lower-resourced countries and in countries with less equal resource distribution. We thus constructed additional interaction terms for tetraplegia $\times$ GDP as well as tetraplegia $\times$ Gini coefficient. Persons with tetraplegia from lower-resourced countries were assigned a value of one, while all other participants were assigned a zero. Similarly, we assigned a value of one to all tetraplegics from less equal countries. H4: We hypothesized that unequal resource distribution would particularly affect the elderly. We thus included an interaction term of Gini coefficient $\times$ age: The older a patient and the greater the income inequality in his or her country, the higher was the value of this interaction term. H5: We expected opposite effects for the number of problems in body structures, since we assumed this to be mainly related to diagnostic procedures and technology. H6: Environmental barriers were hypothesized to increase and facilitators to decrease burden of disability. H7: years of formal education were expected to decrease the burden of disability. A random intercept was calculated for each country.

To analyse association structures of ICF categories, we used probabilistic graphical models. As much as 48 ICF categories were excluded from the analysis due to lack of variance.

A graphical model is the visual representation of a network of variables (Friedman 2004). Here, nodes represent ICF categories. Edges between two nodes stand for conditional dependency between two ICF categories, i.e. an association between two ICF categories is not explained away when taking the other variables (here: $264 - 48 - 2 = 214$ ICF categories, and control variables) into account. An algorithm (Strobl et al. 2009) based on least average shrinkage and selection operator (LASSO) regression (Tibshirani 1996) was used to identify the stable associations of each ICF category to all the remaining ICF categories. Each ICF category was entered as dependent variable in a LASSO regression on all other ICF categories and following control variables: years of formal education, age, sex, level and completeness of SCI and rehabilitation situation. Each LASSO regression selects a set of the best explanatory variables while additionally considering parsimony of the model. The latter is achieved by including a penalty term that increases the mean-squared error of the model with increasing number of variables. Each LASSO regression was repeated for 100 bootstrap samples to enhance the accuracy and validity of the final model selection (Breimann 1996). A bootstrap sample is a subset of the data randomly drawn with replacement (Efron and Tibshirani 1993). The final graphical model includes only those edges found in all of the bootstrap samples. A test for significant differences of the association structures of the graphs for higher- and lower-resourced countries has been proposed by Mansmann et al. (2010). We employed a multiple testing strategy following the ICF's hierarchical structure (Fig. 2). At first, the null hypothesis that both graphs are equal is tested. If rejected, substructures of the graphs are zoomed in. Differences in the four ICF components: body functions, body structures, activity and participation, and environmental factors are tested. Again, if these differences are significant, the testing continues on the next lower ICF level. The procedure continues down to the individual second level ICF categories, unless a null hypothesis cannot be rejected. The complete test and examples of substructures of the graph are provided in the electronic appendix.

Data analyses were performed with Stata 11 (hierarchical models) (Rabe-Hesketh and Skrondal 2008) and R 2.9.0 (R Development Core Team 2009). Missing values were replaced using the AMELIA imputation technique (King et al. 2001) such that a variable has a similar distribution after imputation as before.

Results

Descriptive statistics for the total study population are shown in Table 1.

ICF categories that separate higher- and lower-resourced countries

In total, we identified a list of 96 categories that significantly distinguish between higher- and lower-resourced countries (see Table 2). In some categories such as blood pressure, fine hand use and school education problems are more prevalent in higher-resourced countries. For other categories, such as involuntary movement functions, eating, complex economic transactions and religion, more problems are reported in lower-resourced countries. More barriers and fewer facilitators in services, systems and policies are perceived by participants living in lower-resourced countries.

Influence of individual and macro-economic variables on the burden of disability

The results of the hierarchical regression models are shown in Table 3. More problems in body function are reported for persons with tetraplegia and older persons living in less equal countries, although higher age is generally associated with a smaller number of problems. The same holds true for persons who perceive more barriers in products and technology, in the natural environment as well as in attitudes. The number of problems in body structures significantly increases with time since onset of injury. It is also higher for tetraplegics and for persons who perceive more facilitators in social relations. Finally, more barriers in products and technology, as well as in the natural environment, also seem to increase the number of problems in body structures. Conversely, the number of problems in body structures decreases with perceived facilitators in nature and in tetraplegics living in less equal countries.

More patient-reported problems in activity and participation can be found in persons with tetraplegia, particularly in those living in lower-resourced countries, in persons who report more barriers in products and technology as well as attitudes, and in older people living in less equal countries. It decreases with the country's Gini coefficient, with years of formal education, age and time since onset of injury.

There are more health professional-reported problems in activity and participation in tetraplegics, particularly in those living in lower-resourced and less equal countries and persons with SCI in the long-term situation. The same holds true for those who perceive more facilitators in social

Table 1 Demographic and injury-related variables across countries

Variable	All	Low resourced	High resourced	Equal	Unequal	Valid N (all)
Age; mean (SD)	42.2 (15)	37.9 (12.6)	45.0 (15.8)	44.2 (15.9)	40.6 (14)	1,029
Sex: female (%)	22.5	22.8	22.3	23.80	21.5	1,048
Years of formal education; mean (SD)	12.1 (4.5)	9.7 (4.3)	13.6 (3.9)	13.6 (4.4)	11.1 (4.2)	982
Time since injury (years); mean (SD)	6.2 (9.9)	4.5 (6.8)	7.5 (11.4)	7.5 (11.3)	5.3 (8.5)	1,029
Marital status: married (%)	45.5	46.4	45	43.8	46.9	1,043
Paid employment (%)	43.4	46.8	41.1	42.1	44.5	1,048
SCI level: tetraplegia (%)	45.3	37.2	50.9	47.9	43.3	1,048
Completeness of injury: complete (%)	52.2	55.6	49.9	47.8	55.0	929
Situation: early post-acute (%)	46.7	44	48.5	46.4	46.9	1,048

Variable	Australia	Brazil	Canada	Denmark	Germany	India	Israel
Age; mean (SD)	38.3 (14.6)	36.5 (10.6)	43.9 (15.1)	49.8 (15.9)	41.5 (17.3)	32.5 (9.3)	45.6 (15.8)
Sex: female (%)	18.8	21.4	23.8	28.2	27.8	20	17.9
Years of formal education; mean (SD)	14 (2.2)	10.4 (5.9)	14.3 (2.9)	13.9 (5.2)	13.3 (3.5)	11.1 (3.7)	12 (3.8)
Time since injury (years); mean (SD)	2.9 (4.1)	7.5 (7)	9.1 (13.6)	9.2 (13.8)	9.8 (12.7)	2 (3.5)	5.5 (9.5)
Marital status: married (%)	38.5	38.1	25.3	50	22.2	58.8	56.4
Paid employment (%)	45	47.6	31.3	42.3	50	48.8	34.6
SCI level: tetraplegia (%)	73.8	28.6	52.5	35.9	55.6	28.8	39.1
Completeness of injury: complete (%)	54	71.4	50.7	20.4	52.9	80	47.3
Situation: early post-acute (%)	53.8	14.3	50	47.4	38.9	50	52.6
Setting[a]	High resourced/equal	Low resourced/unequal	High resourced/equal	High resourced/equal	High resourced/equal	Low resourced/equal	High resourced/unequal

Variable	Malaysia	New Zealand	South Africa	Switzerland	Thailand	USA	Vietnam
Age; mean (SD)	37 (12.6)	43.8 (14.7)	36.7 (12)	54.9 (17)	44.1 (13.9)	42.7 (13.2)	38.7 (13.1)
Sex (%)	19.2	22.5	25.4	21.2	23.8	26.6	26.9
Years of formal education; mean (SD)	11 (3.1)	15.1 (5)	10.4 (3.8)	13.6 (3.4)	7.1 (4.0)	14.2 (2.5)	7.5 (4.2)
Time since injury (years); mean (SD)	6.2 (8.7)	7.5 (10.9)	6.9 (9.1)	15.1 (13.1)	3.1 (5.8)	6.9 (10.9)	3.0 (3.7)
Marital status: married (%)	38.5	40	14.9	48.1	51.3	51.9	67.9
Paid employment (%)	61.5	42.5	38.8	40.4	35	55.7	48.7
SCI level: tetraplegia (%)	34.6	48.8	44.8	50	58.8	65.8	24.4
Completeness of injury: complete (%)	55.1	59	48.5	65.4	46.3	49.4	7.1
Situation: early post-acute (%)	50	50	38.8	25	50	50.6	46.2
Setting[a]	Low resourced/unequal	High resourced/equal	Low resourced/unequal	High resourced/equal	Low resourced/unequal	High resourced/unequal	Low resourced/equal

Multi-centre study 2006–2008: International Classification of Functioning, Disability and Health (ICF) Core Sets for Spinal Cord Injury (SCI)

SD standard deviation

[a] Graphical cutoff point of per capita gross domestic product (GDP) leads to a dichotomy of higher- and lower-resourced countries; median split of Gini coefficient (median = 0.368, min. = 0.247, max. = 0.578) leads to a dichotomy of equal and unequal countries

Table 2 Set of International Classification of Functioning, Disability and Health (ICF) categories distinguishing well between higher- and lower-resourced countries according to penalized logistic regression with cross-validation (higher values for functional problems, environmental facilitators or barriers in the lower-resourced setting are printed in italic)

ICF	Label	Direction of effect[a]	*p* value*
b134	Sleep functions	High > low	<0.01
b210	Seeing functions	High > low	<0.01
b265	Touch functions	High > low	<0.01
b280	Sensation of pain	High > low	<0.01
b420	Blood pressure functions	High > low	<0.01
b440	Respiration functions	High > low	<0.01
b445	*Respiratory muscle functions*	*Low > high*	*<0.01*
b450	*Additional respiratory functions*	*Low > high*	*<0.01*
b455	Exercise tolerance functions	High > low	<0.01
b535	Sensations associated with the digestive system	High > low	<0.01
b630	*Sensations associated with urinary functions*	*Low > high*	*<0.01*
b715	Stability of joint functions	High > low	<0.01
b755	*Involuntary movement reaction functions*	*Low > high*	*<0.01*
b765	*Involuntary movement functions*	*Low > high*	*<0.01*
b770	Gait pattern functions	High > low	<0.01
b780	*Sensations related to muscles and movement functions*	*Low > high*	*0.14*
b840	*Sensation related to the skin*	*Low > high*	*0.56*
s130	*Structure of meninges*	*Low > high*	*<0.01*
s140	*Structure of sympathetic nervous system*	*Low > high*	*0.32*
s150	*Structure of parasympathetic nervous system*	*Low > high*	*0.25*
s610	Structure of urinary system	High > low	<0.01
s710	Structure of head nd neck region	High > low	<0.01
s730	Structure of upper extremity	High > low	<0.01
s740	Structure of pelvic region	High > low	<0.01
s750	Structure of lower extremity	High > low	<0.01
s760	*Structure of trunk*	*Low > high*	*0.02*
d120	Other purposeful sensing	High > low	<0.01
d240	Handling stress and other psychological demands	High > low	<0.01
d410	Changing basic body position	High > low	<0.01
d440	Fine hand use	High > low	<0.01
d470	Using transportation	High > low	<0.01
d480	*Riding animals for transportation*	*Low > high*	*<0.01*
d510	*Washing oneself*	*Low > high*	*<0.01*
d560	*Drinking*	*Low > high*	*<0.01*
d570	*Looking after one's health*	*Low > high*	*<0.01*
d640	Doing housework	High > low	<0.01
d650	Caring for household objects	High > low	<0.01
d730	Relating with strangers	High > low	<0.01
d770	Intimate relationships	High > low	<0.01
d820	School education	High > low	0.325
d840	*Apprenticeship (work preparation)*	*Low > high*	*<0.01*
d865	*Complex economic transactions*	*Low > high*	*<0.01*
d870	*Economic self-sufficiency*	*Low > high*	*<0.01*
d930	*Religion and spirituality*	*Low > high*	*<0.01*
e110.barrier	Products or substances for personal consumption	High > low	<0.01
e115.barrier	*Products and technology for personal use in daily living*	*Low > high*	*0.23*
e115.facilitator	Products and technology for personal use in daily living	High > low	<0.01
e120.facilitator	Products and technology for personal indoor and outdoor mobility and transportation	High > low	<0.01
e135.facilitator	Products and technology for employment	High > low	<0.01
e140.barrier	Products and technology for culture, recreation and sport	High > low	<0.01
e140.facilitator	Products and technology for culture, recreation and sport	High > low	<0.01

Table 2 continued

ICF	Label	Direction of effect[a]	p value*
e145.facilitator	*Products and technology for the practice of religion and spirituality*	*Low > high*	*<0.01*
e150.barrier	*Design, construction and building products and technology of buildings for public use*	*Low > high*	*0.02*
e150.facilitator	Design, construction and building products and technology of buildings for public use	High > low	<0.01
e155.facilitator	*Design, construction and building products and technology of buildings for private use*	*Low > high*	*<0.01*
e165.barrier	Assets	High > low	0.017
e210.barrier	Physical geography	High > low	<0.01
e215.facilitator	Population	High > low	<0.01
e220.barrier	*Flora and fauna*	*Low > high*	*0.16*
e225.barrier	Climate	High > low	<0.01
e225.facilitator	Climate	High > low	<0.01
e235.barrier	*Human-caused events*	*Low > high*	*<0.01*
e240.barrier	*Light*	*Low > high*	*<0.01*
e245.facilitator	Time-related changes	High > low	<0.01
e260.facilitator	Air quality	High > low	<0.01
e320.barrier	*Friends*	*Low > high*	*<0.01*
e325.facilitator	*Acquaintances, peers, colleagues, neighbours and community members*	*Low > high*	*<0.01*
e335.barrier	*People in subordinate positions*	*Low > high*	*<0.01*
e350.facilitator	Domesticated animals	High > low	<0.01
e360.facilitator	Other professionals	High > low	<0.01
e410.barrier	Individual attitudes of immediate family members	High > low	<0.01
e420.facilitator	Individual attitudes of friends	High > low	<0.01
e425.facilitator	*Individual attitudes of acquaintances, peers, colleagues, neighbours and community members*	*Low > high*	*0.43*
e445.barrier	*Individual attitudes of strangers*	*Low > high*	*0.01*
e445.facilitator	*Individual attitudes of strangers*	*Low > high*	*0.84*
e450.facilitator	*Individual attitudes of health professionals*	*Low > high*	*0.24*
e455.barrier	*Individual attitudes of health-related professionals*	*Low > high*	*0.69*
e455.facilitator	*Individual attitudes of health-related professionals*	*Low > high*	*0.05*
e465.facilitator	*Social norms, practices and ideologies*	*Low > high*	*0.01*
e510.facilitator	Services, systems and policies for the production of consumer goods	High > low	<0.01
e515.barrier	*Architecture and construction services, systems and policies*	*Low > high*	*<0.01*
e520.facilitator	Open space planning services, systems and policies	High > low	<0.01
e525.facilitator	Housing services, systems and policies	High > low	<0.01
e530.barrier	*Utilities services, systems and policies*	*Low > high*	*<0.01*
e535.barrier	*Communication services, systems and policies*	*Low > high*	*<0.01*
e540.facilitator	Transportation services, systems and policies	High > low	*<0.01*
e545.barrier	*Civil protection services, systems and policies*	*Low > high*	*<0.01*
e550.facilitator	Legal services, systems and policies	High > low	*<0.01*
e555.barrier	*Associations and organizational services, systems and policies*	*Low > high*	*<0.01*
e555.facilitator	Associations and organizational services, systems and policies	High > low	*<0.01*
e560.facilitator	*Media services, systems and policies*	*Low > high*	*0.11*
e565.facilitator	*Economic services, systems and policies*	*Low > high*	*0.05*
e570.facilitator	Social security services, systems and policies	High > low	*<0.01*
e580.facilitator	*Health services, systems and policies*	*Low > high*	*<0.01*
e590.barrier	*Labour and employment services, systems and policies*	*Low > high*	*<0.01*
e590.facilitator	Labour and employment services, systems and policies	High > low	*<0.01*

Multi-centre study 2006–2008: ICF Core Sets for Spinal Cord Injury (SCI)

* *p* values were calculated with normal logistic regression; it is therefore possible that differences found with the penalized logistic regression and cross-validation show *p* values >0.05

[a] High > low = more problems in functioning, more barriers or more facilitators reported in the higher-resourced countries. Low > high = more problems in functioning, more barriers or more facilitators reported in the lower-resourced countries

Table 3 Generalized linear mixed models to predict the number of problems in functioning with variables on the country and the individual level (parameters confirming hypotheses are given in bold)

	Dependent variables			
	Number of problems in body functions	Number of problems in body structures	Number of patient-reported problems in activity and participation	Number of health professional-reported problems in activity and participation
Predictors	**B (SE)**	**B (SE)**	**B (SE)**	**B (SE)**
Intercept	1.04 (11.92)	−0.61 (7.28)	3.38*** (7.09)	1.86* (9.51)
GDP	1.23 (<0.01)	0.27 (<0.01)	−1.28 (<0.01)	−0.23 (<0.01)
Gini	0.28 (0.28)	0.59 (0.17)	−2.69*** (0.16)	−1.79* (0.22)
Years of formal education	−1.09 (.06)	1.15 (0.02)	**−2.73*** (0.03)**	**−3.93*** (0.05)**
Sex (reference: female)	−0.86 (0.51)	1.00 (0.22)	1.44 (0.31)	0.36 (0.45)
Level of SCI (reference: paraplegia)	**4.98*** (0.68)**	**6.20*** (0.29)**	**3.19*** (0.41)**	**11.05*** (0.59)**
Age	−2.26** (.08)	1.51 (0.03)	−2.07** (0.05)	−1.44 (0.07)
Time since injury	1.23 (<0.01)	**2.02** (<0.01)**	**−4.87*** (<0.01)**	**−2.68*** (0.84)**
Rehabilitation situation (reference: early post-acute situation)	−1.85* (0.54)	−1.13 (0.23)	−0.37 (0.33)	**2.62*** (0.47)**
Number of perceived facilitators in products and technology	0.27 (0.10)	0.03 (0.04)	0.07 (0.06)	0.70 (0.09)
Number of perceived facilitators in nature	−0.87 (0.11)	**−3.47*** (0.05)**	−0.73 (0.07)	−1.85*(0.10)
Number of perceived facilitators in social relations	1.59 (0.14)	2.28**(0.06)	−1.32 (0.08)	2.09** (0.12)
Number of perceived facilitators in attitudes	−1.10 (0.12)	−1.02 (0.05)	0.80 (0.07)	0.35 (0.10)
Number of perceived facilitators in systems	−0.43 (.06)	−1.42 (0.03)	1.40 (0.04)	−0.64 (0.05)
Number of perceived barriers in products and technology	**3.60*** (0.10)**	**2.37** (0.04)**	**7.83*** (0.06)**	**5.21*** (0.08)**
Number of perceived barriers in nature	**2.78*** (0.11)**	**3.18*** (0.05)**	−1.20 (0.06)	0.94 (0.09)
Number of perceived barriers in social relations	−1.09 (0.13)	−1.27 (0.06)	0.85 (0.08)	0.53 (0.12)
Number of perceived barriers in attitudes	**2.17** (0.11)**	0.60 (0.05)	**2.16** (0.06)**	0.70 (0.09)
Number of perceived barriers in systems	−1.70* (0.06)	0.39 (0.03)	1.20 (0.04)	−2.73*** (0.05)
Gini region*tetraplegia (reference: all paraplegics and tetraplegics in more equal countries)	0.57 (0.94)	**−3.41*** (0.40)**	0.07 (0.57)	**2.61*** (0.81)**
GDP-region*tetraplegia (reference: all paraplegics and tetraplegics in higher-resourced countries)	−1.39 (0.97)	−1.64*(0.42)	**2.23** (0.59)**	**2.78*** (0.84)**
GDP × Gini	−0.76 (<0.01)	0.20 (<0.01)	1.11 (<0.01)	0.36 (<0.01)
Gin × Age	**2.40*** (<0.01)**	−1.03 (<0.01)	**1.93** (<0.01)**	**2.20** (<0.01)**

Multi-centre study 2006–2008: International Classification of Functioning, Disability and Health (ICF) Core Sets for Spinal Cord Injury (SCI)

GDP gross domestic product per capita of the country in which the person with SCI lives, *Gini* Gini coefficient of the country in which the person with SCI lives, *B* standardized parameter, *SE* standard error of the parameter, *GDP-region* GDP dichotomized (graphical cutoff), *Gini region* Gini coefficients dichotomized (median split)

* $p \leq 0.1$, ** $p \leq 0.05$, *** $p \leq 0.01$

relations and more barriers in products and technology as well as for older participants in the less equal countries. The number of health professional-reported problems in activity and participation decreases with the country's Gini coefficient, as well as with the participants' years of formal education and time since onset of injury.

Differential association structures of functioning and environmental factors between lower- and higher-resourced countries

Figure 3 shows the association graph between ICF categories for higher- and lower-resourced countries. Clusters representing environmental facilitators (green) and barriers (red) were only marginally associated with clusters representing functioning. Also, within the functioning categories, patient-reported categories (circles) are largely unconnected with those assessed by health professionals (squares). Body functions (yellow) and structures (white), activity and participation categories (blue), environmental barriers and facilitators often built their own clusters.

The overall differences in the association structures between lower- and higher-resourced countries were highly significant. Also, a number of specific categories showed differential association structures. To give an example, assisting others (d650) is associated with caring for household objects (d660) in lower-resourced countries, but with non-remunerative employment (d855) in higher-resourced countries ($p < 0.001$). Figure 2 suggests that there are longer chains of problems in body functions and structures, and that body functions are more often associated with problems in corresponding body structures within higher-resourced countries.

Particular environmental categories were more often simultaneously perceived as both facilitator and barrier in lower-resourced countries (13 associations in lower-, 4 in higher-resourced countries, and 3 in both). This finding could be confirmed at the 1% level of significance. To give an example, in lower-resourced countries, the perception of societal attitudes (e460) as a barrier increased the probability that societal attitudes were simultaneously perceived as a facilitator.

Few cross-component associations could be observed. For example, one association between the perception of climatic barriers (e225b) and gait pattern functions (b770) was found for lower-resourced countries. In higher-resourced countries, a cluster of barriers in the categories support and attitudes of family, friends and acquaintances (e310–e325, e410–e425) was associated with problems in family relationships (d760).

Common association structures of functioning and environmental factors between lower- and higher-resourced countries

Several independent clusters in activity and participation, and environmental factors were found that persisted across countries (Fig. 3). In the case of the components body functions and structures, the common clusters are smaller consisting of up to three categories. Apart from an association between skin structures and functions (s810 and b810), there was no cross-ICF component association, which was stable across countries.

Discussion

In SCI, experiences of functioning and environmental factors differ between lower- and higher-resourced countries. While commonalities were found in body functions, body structures and mobility, differences prevailed in other ICF components and chapters. The differences in functioning were not univocal. However, more environmental barriers and fewer facilitators were perceived in lower-resourced countries.

We could not confirm the general hypotheses that more functional problems are reported in the lower-resourced and less equal countries (H1). However, it is possible that the readiness to participate in the study may have decreased with increasing impairment and decreasing resources available. Also, a self-selection bias of centres that perform above the usual level of service provision in the lower-resourced countries cannot be excluded.

More specific hypotheses were confirmed. We found that more problems in activity and participation were reported for tetraplegics living in the lower-resourced countries and for older persons living in less equal countries (H2, H4). Also, more problems in body functions occurred in tetraplegics and the elderly in the less equal countries (H3, H4). We conclude that the lack of resources particularly affects technology-intensive rehabilitation, i.e. of persons with tetraplegia, while unequal resource distribution affects the vulnerable groups, i.e. tetraplegics and the elderly. Possibly, less return on investment is expected from these groups: They are already marginalized and have no voice in political institutions and media. As hypothesized (H5), the associations were converse for problems in body structures. Environmental factors (H6) showed significant influence. Barriers were better predictors of problems in functioning than facilitators. The number of perceived barriers in products and technology was one of the strongest predictors. Unexpectedly (according to H6), we found that more facilitators in social relations and fewer barriers in systems, services and policies increased the number of health professional-reported problems in activity and participation. One possible explanation would be that people perceiving fewer barriers in systems, services and policies and more facilitators in social relations receive more comprehensive assessments of functioning in rehabilitation services.

Our hypothesis that problems in functioning decrease with years of formal education (H7) was only partially confirmed. The number of problems in activity and participation decreased with education but not problems in body functions or structures.

In the explorative part of the study, differential association structures of ICF categories for lower- and

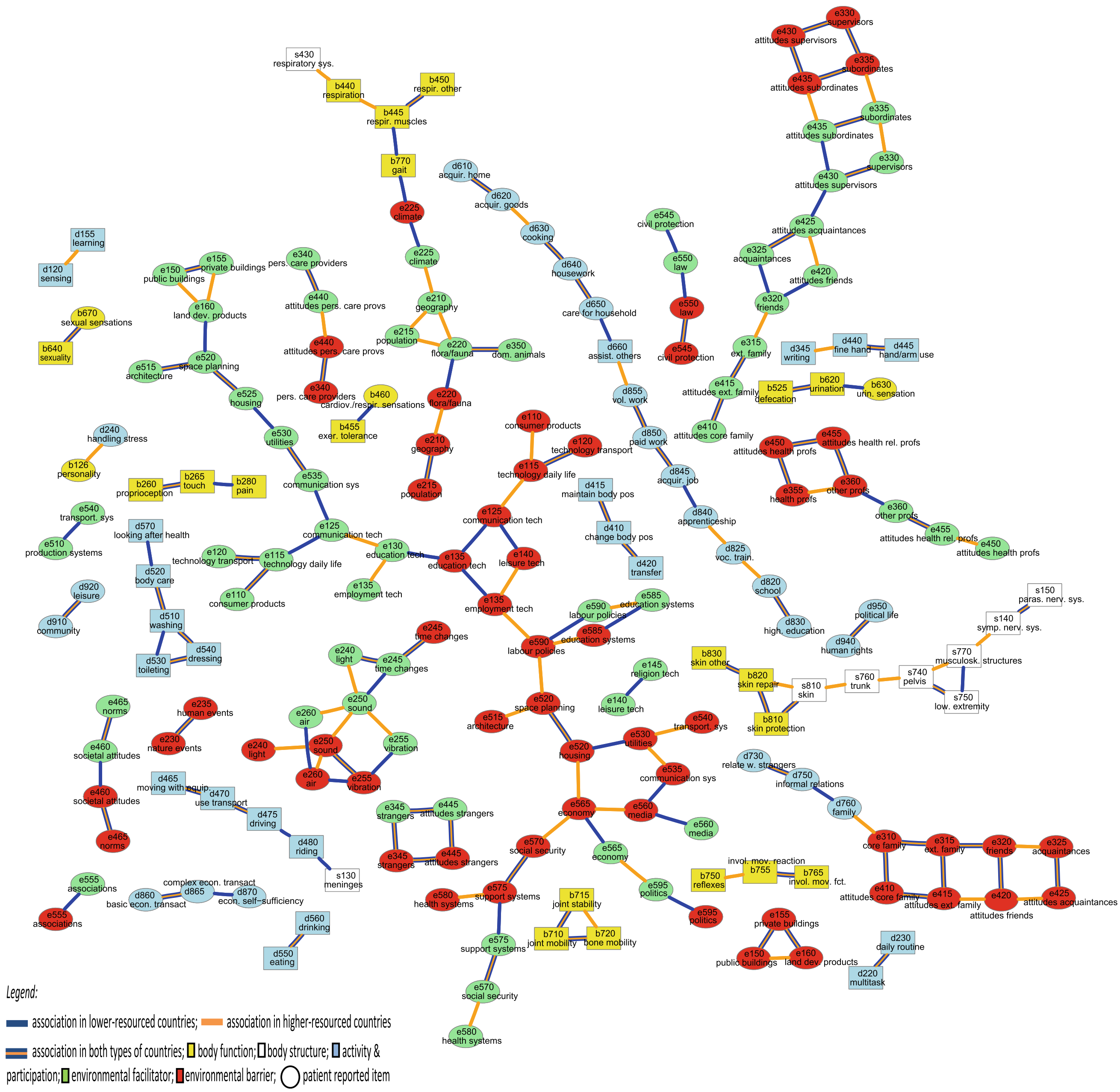

Fig. 3 Comparison of association structures of International Classification of Functioning, Disability and Health (ICF) functioning and environmental categories (2nd level) between higher- and lower-resourced countries. *Orange edges* signify stable association of categories in higher-resourced countries, *blue* in lower-resourced, and *blue* and *red-striped edges* mean stable association across all countries. Multi-centre study 2006–2008: ICF Core Sets for Spinal Cord Injury (SCI)

higher-resourced countries could be discovered with the graphical model. We obtained a more fractionate graph in lower-resourced countries. In body functions and structures, smaller chains and a larger number of separate clusters were observed. In higher-resourced countries, impairments in body structures were more often correlated with problems in body functions. This finding may be due to differential diagnostic procedures. Technology such as magnet resonance imaging (MRI) for detecting impairments in body structures might not always be readily available in lower-resourced countries.

In environmental factors, we found more pairwise combinations of facilitators and barriers for specific categories in lower-resourced countries. This suggests a more ambivalent perception of the environment. The use of different strategies in dealing with environmental barriers, however, is also conceivable.

The association structures that stayed stable across countries demonstrate the multi-dimensionality of functioning. An important result is that the participants' perception of their environment seems largely unrelated to the health professionals' assessment of the same participants' functioning. Mostly, health professionals know only little about the environment of their patients. Their functional capacity is assessed in a clinical environment. Since there is no population-based reference data on functioning, the assessment is done in relation to other patients that setting or data from earlier examinations. Participants, however, may have assessed their own functioning in a community environment and used different reference groups for judging their own functional problems.

A potential weakness of our study is the sampling strategy, i.e. there was no population-based random sample of persons with SCI living in the respective country. Since central registries are not available in many countries, such random samples are, however, virtually impossible to obtain. Also, the binary coding of the ICF categories may be criticized, because information on the severity of existing problems is not available. Valid and reliable scales for ICF categories are yet to be developed (Stucki et al. 2008). Also, we could not influence the selection of the study countries and may be criticized for dividing the sample into more or less equal countries by median split to construct an interaction term of tetraplegia and resource distribution for the hierarchical regression modelling. The choice of another cutoff may have produced different results.

Furthermore, problems in some categories are patient reported, whilst others are based on the health professionals' opinion. This raises the controversial issue of patient- versus clinician-reported outcomes. Our results suggest differing perceptions of functioning and contextual factors by study participants and professionals. This hypothesis could, however, only be fully confirmed with patient-reported and professional data on the same categories (Kwoh et al. 1992).

In future research, the stable association structures in our analysis need to be confirmed with other data. Only then can we move step by step to a general model of human functioning in SCI.

We conclude that functioning of persons with SCI is multi-dimensional and dependent on environmental factors at multiple levels. Our results show that the distribution of problems in functioning across countries is more inconsistent and complex than that suggested by the results of existing studies (Allotey et al. 2003; Dijkers et al. 2002). Differences across countries are not univocal. Particularly, vulnerable groups, such as persons with tetraplegia as well as the elderly, are negatively affected by scarcity of resources and their unequal distribution.

Conflict of interest The authors declare that they have no competing interests.

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