

# Structuring the Complexity of Human Functioning and Disability with Probabilistic Graphical Models

A Comparative Analysis of Data from a Spinal Cord Injured Population from Higher- and Lower-Resourced Countries

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**Abstract** The study examines whether functioning levels and underlying association patterns differ between lower- and higher-resourced countries. Based on 264 International Classification of Functioning, Disability and Health (ICF) categories, observational cross-sectional data from 1048 persons with spinal cord injury (SCI) from 14 countries were analysed. Differential association structures of the ICF categories were analysed with probabilistic graphical models. Significant differences in relative frequencies and association structures of problems in functioning and environmental factors were found between settings.

## Introduction

The complexity of human functioning and disability in relation to various environments poses major challenges to scientific understanding. On the country level, economic resources and investment in infra- and support structures play a major role in producing inequalities in functioning between higher and lower-resourced settings.

Before we can address these inequalities, evidence regarding the association of the different aspects involved in functioning needs to be generated. A prerequisite for this are functional profiles which can be compared across countries. Moreover, methodologies suited to study differential association between aspects of functioning as the basis for rational intervention planning in disability policy and clinical practice are needed. Therefore, the objective of the study was to examine whether functioning levels and underlying association patterns differ between lower- and higher-resourced countries using SCI as a case in point.

## Methods & Materials

### Design

A secondary analysis of the observational cross-sectional data, collected in the context of the ICF Core Set development project for spinal cord injury (SCI), was performed.

### Sample

Data from 1048 adults with SCI from 18 study centres in 14 countries were collected. For further analysis, the sample was divided into lower- and higher-resourced countries based on their per capita gross domestic product for 2007 (see figure 1).

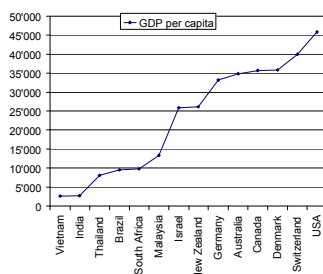
### Measurement

The functional problems of individuals with SCI were assessed using a Case Record Form (CRF) comprising of 264 second-level ICF categories. Information on the ICF components *body functions* and *body structures* was mostly based on the health professionals' assessment; information on the ICF component *activities and participation* was reported both by professionals and patients. Environmental information was obtained from the patients.

## Data Analysis

To examine whether functioning levels and association patterns of ICF categories differ between lower- and higher-resourced countries, a two part approach was chosen. Firstly, we compared relative frequencies of ICF categories between the settings in order to examine differences in the importance of problems. Secondly, we analysed and compared association structures of the ICF categories with the help of graphical models, i.e. visual representation of a network of variables. Nodes represent ICF categories. Edges between two nodes stand for conditional dependency between the categories. Bootstrap aggregated LASSO regression was applied to identify the stable associations of each node to the remaining nodes.

Figure 1: Distribution of the 2007 gross domestic product (GDP) per capita ordered by size and divided into lower- and higher resourced countries



## Results

Sample characteristics are reported in table 1. Frequency analysis did not show an univocal picture. Some problems were reported more often in lower-resourced settings, while others in higher-resourced countries. Figure 2 shows the association patterns in an overall graphical model. These patterns differed significantly between settings. For example, in lower-resourced settings assisting others was associated with caring for household objects, including animals, while in higher-resourced countries it was associated with non-remunerative employment ( $p < 0.001$ ). Generally, clusters representing environmental facilitators and barriers were only marginally associated with clusters representing functioning domains.

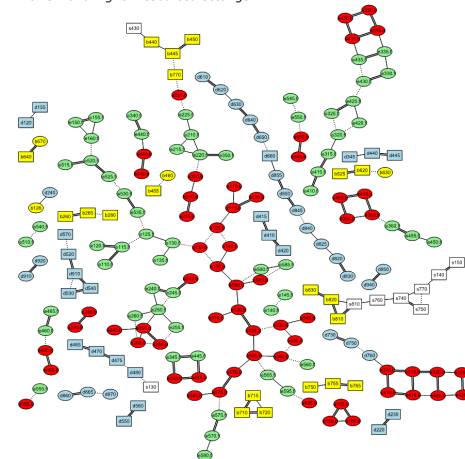


In addition, with respect to functioning categories, patient-reported categories were largely unconnected with those assessed by the health professionals. Apart from an association between skin structures and functions (s810 and b810), there were no cross-component associations which was stable across settings.

Table 1: Socio-demographic and SCI-related characteristics of the study sample

Variable	Value	Mean (SD)/Percent	Valid N
Age		42.2 (15.0)	1029
Sex	female	22.5	1048
Years of formal education		12.1 (4.5)	982
Time since injury (in years)		6.2 (9.9)	1029
Marital status	married	45.5	1043
Paid employment	yes	43.5	1046
SCI level	tetraplegic	45.3	1048
	paraplegic	54.7	
Impairment (ASIA)	complete	52.2	929
	incomplete	47.8	
Situation	chronic	53.4	1048
	early post-acute	46.6	

Figure 2: Graphical model showing association structures of functioning categories and environmental factors in comparison for lower- and higher-resourced settings



**Legend:** Yellow nodes signify body functions, white nodes depict body structures and blue nodes activity and participation categories. Red nodes stand for environmental barriers and green ones for facilitators. The dotted edges signify associations solely found in the lower-resourced settings, whilst the solid edges show association found in higher-resourced countries only. Double edges indicate associations which are stable across settings. Circles indicate patient-reported categories and squares categories assessed by the health professionals.

## Conclusions

The graphs illustrate the complexity and multidimensionality of functioning. Relevant distinctions as well as commonalities between higher- and lower-resourced countries could be elaborated. Patient and health professional perceptions seem largely unrelated, which may be due to a difference between capacity assessments on the side of the professionals and perceptions of performance on the side of the patients.