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The applicability of the FIM in patients with neurological conditions undergoing early post-acute rehabilitation

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Wir müssen die Welt nicht verstehen, wir müssen uns in ihr zurecht finden. (Albert Einstein

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Background

Acute neurological conditions such as stroke or Guillan-Barré-Syndrome and complications of chronic neurological diseases such as multiple sclerosis or spinal cord injury are among the most leading causes for an acute hospitalization (1-3). Despite the acute treatment, many patients after a neurological event may experience a significant loss of functioning, and recovery may take a long time and may not be complete. Typically, these patients may suffer from reduced consciousness, sensory deficits, motor disturbances, swallowing impairments, incontinence, deficits in memory and in communication, and depression. These impairments in body functions may result to a large variety of limitations in activities such as difficulties in communication, in mobility, in self-care activities and in interpersonal interactions and relationships (4-8).

Ideally, patients after an acute event are managed by an interdisciplinary team in an early post-acute rehabilitation facility within an acute hospital or in rehabilitation or nursing setting presuming that there is an appropriate medical infrastructure available (4). The objective of early post-acute rehabilitation is to sustain or to restore functioning by targeted interventions, for example, on mobility, mental and sensory functions or activities of daily living while taking into consideration the medical and nursing needs of patients (9). The early identification of rehabilitation needs and the early beginning of rehabilitation can avoid the need for long-term care and prevent disability (4).

Standardized measurement tools are of utmost importance to identify the patient's need for early post-acute rehabilitation, to assess the effects of interventions on

patient's functioning and health, and to give support for the decision where the patient should be discharged after completing the early post-acute rehabilitation. These measures should be based on a common understanding of functioning and health.

Measures applied in early post-acute rehabilitation

Until recently, there was no generally accepted understanding of functioning and health. Accordingly, a wide range of outcome measures covering different aspects of functioning has been developed and is used in clinical practice and research (10). With the approval of the International Classification of Functioning, Disability and Health (ICF) (11) by the 51st World Health Assembly in May 2001, we can now, for the first time, refer to a worldwide accepted understanding of functioning, the ICF framework, and to a classification to describe and classify functioning, disability and health.

The ICF framework describes functioning as an interaction of a given health condition and contextual factors such as environmental and personal factors (figure 1). Functioning is the umbrella term for Body Functions, Body Structures, Activities and Participation (11). Body Functions comprises the physiological and psychological functions, Body Structures comprises the anatomical parts such as organs and limbs, Activity is the execution of a task by an individual, and Participation is the involvement of the individual in a life situation (11). As classification, the ICF groups related physiological functions, anatomical structures, actions, tasks, or areas of life, in so-called domains (Appendix 1-3) (11).

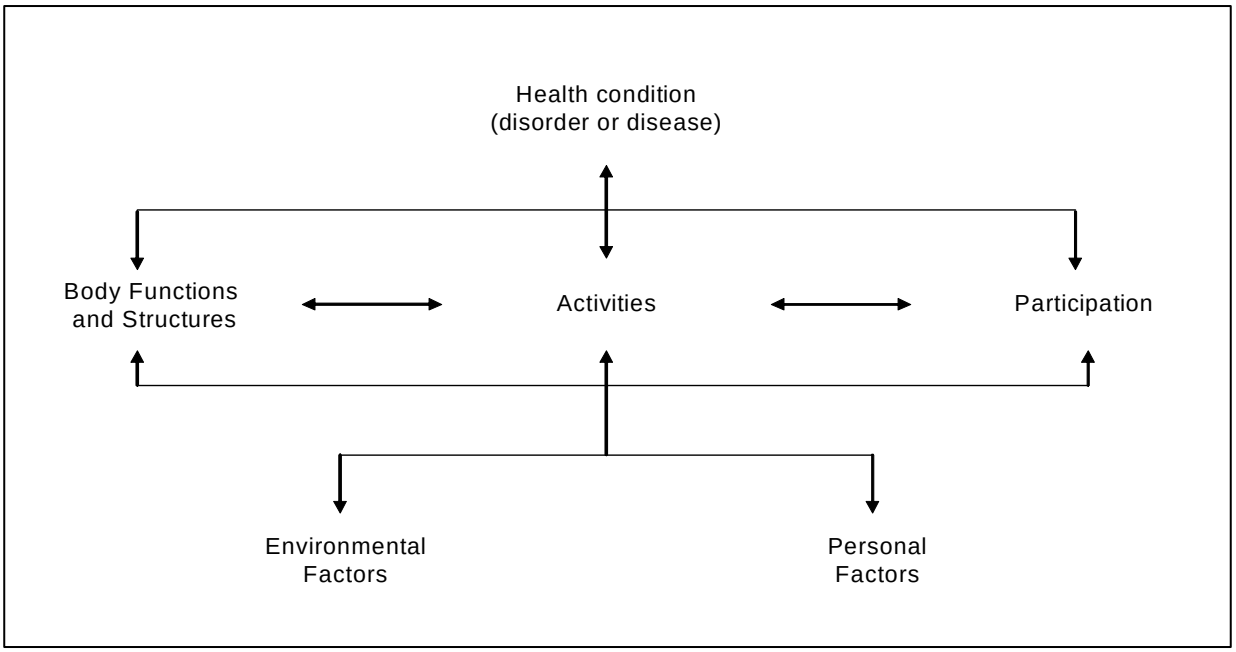

Figure 1. Interaction between the components of the ICF (11).

The ICF provides a valuable reference to map the underlying dimensions and constructs of current measures (12-22). For example, the item 'toileting' of the Functional Independence Measure (FIM) can be linked to the ICF category *d530 Toileting* while the item 'bladder management' can be linked to *b6202 Urinary continence* (23). It is not at all simple and straightforward to link concepts of clinical measures to the appropriate ICF category. Recent linkage exercises, however, have demonstrated that it is possible to examine and compare the content of measures based on the ICF framework and predefined linking rules (24, 25).

The validity of the most frequently used measure in early post-acute rehabilitation

One of the most frequently used measures of global functioning in inpatient rehabilitation is the Functional Independence Measure (26) (FIM) (27, 28). It assesses functioning in terms of functional independence in basic activities of daily living. It has proved to be a useful tool for the documentation of treatment effects in

the early post-acute rehabilitation (29). Previous studies have given evidence for the multidimensional structure of the FIM (30-32). Depending on the underlying health condition, up to four dimensions could be retrieved when using exploratory factor analysis. These four dimensions are ‘activities of daily living’, ‘sphincter management’, ‘mobility’, and ‘executive function’. As different health conditions do affect differently functional areas of the body, the knowledge of disability profiles based on these four dimensions should provide more clinical information than the overall FIM score (33-35).

The applicability of the FIM in varying rehabilitation services has to be validated. This is particularly important in settings which may differ from the settings for which the FIM has been developed such as early post-acute rehabilitation facilities. In these facilities the FIM is commonly applied to assess the burden of care (36) as well as the treatment effects of early post-acute rehabilitation (29). However, only one study including 32 patients has been published so far establishing that the FIM does assess the treatment effects of early post-acute rehabilitation (37). No study could be identified showing the validity of the FIM to assess burden of care in patients undergoing early post-acute rehabilitation.

Research Objectives

The overall objective of the current doctoral thesis is to explore the applicability of the most frequently used measure in patients undergoing early post-acute rehabilitation, the Functional Independence Measure (FIM). In the following, the doctoral thesis is subdivided into two parts presenting the two successive studies performed to pursue the specific objectives of this doctoral thesis:

1) Identification of the most frequently used measures in patients undergoing early post-acute rehabilitation

2) Examination whether the four postulated FIM dimensions ‘activities of daily living’, ‘sphincter management’, ‘mobility’, and ‘executive function’ can be supported and whether the four dimensions show floor effects in patients undergoing early post-acute rehabilitation

Measures applied in patients undergoing early post-acute rehabilitation: a systematic literature review

Specific aims

The systematic literature review was conducted to identify outcome measures cited in published studies focusing on rehabilitation in the acute hospital and in early post-acute rehabilitation facilities, and to identify and quantify concepts contained in these measures.

Methods

Search strategy

Electronic searches of Medline, Embase, CINAHL, Pedro and the Cochrane Library from 1997 to March 2002 were carried out using the search terms rehabilitation (acute, sub-acute, early, inpatient), assessment, measurement, measure, instrument, scale, questionnaire, classification, physical therapy, occupational therapy, nursing (emergency care, sub-acute care, postoperative care, critical care, intensive care).

Studies with one of the following designs were included: (1) randomised clinical trials, (2) controlled clinical trials, (3) observational studies, i.e. cohort studies and cross-sectional studies, (4) systematic reviews and meta-analyses. The target population of the included studies were patients undergoing rehabilitation in the acute hospital or in early post-acute facilities. Studies exclusively describing patients in the late post-acute situation, and studies in mental disorders including addiction disorders were excluded. Studies with persons under 18 years were excluded.

Data extraction & analyses

In a first step abstracts of the retrieved studies were checked by two independent investigators for inclusion. The two reviewers then extracted data on the outcome measures used during hospital stay and certain characteristics of the included studies using a standardised electronic form to record data (appendix 4). We used a comprehensive approach for the extraction of outcome measures including formal assessment instruments such as the Barthel Index and the Functional Independence Measure as well as single clinical examinations such as blood pressure and heart rate measurement which were highlighted in the study by the author. After data extraction both reviewers compared their results. Initial disagreement could be solved after discussion between the two reviewers. If there was disagreement after all of this a third person was consulted. In a second step the items of the questionnaires and their underlying concepts were specified. If the items of a questionnaire were not described in the study, we obtained the questionnaire by reference checking, searches in books on clinical measures, and internet searches.

The concepts of the retrieved outcome measures were then linked to ICF categories using standardised linkage rules (24). For practical reasons a measure was regarded as relevant if it was used in at least two different studies. Each relevant measure was linked separately by two health professionals who were experts in the ICF and in the application of the linkage rules. After the linking process of an outcome measure both experts compared their results. Initial disagreement could be solved after discussion between the two experts. If there was disagreement after all of this a third person was consulted.

If a concept pertained to a specific chapter or domain of the ICF but the information was not sufficient to choose a specific category, the ICF codes ‘unspecified’ or ‘other specified’ were attributed. For example, the concept ‘Who usually plans social arrangements such as get-togethers with family and friends?’ was linked to the category *interpersonal interactions and relationships, unspecified*, ‘Alternate foot on stool’ to the category *mobility, other specified*.

Concepts of measures which could not be linked to the ICF were documented. If a concept was too general to allow a decision on the linkage to a specific ICF chapter, domain or category, the concept was considered as ‘not defined’. For example, concepts such as ‘identification of infective organism’, ‘neurological and urological examination’ ‘blood tests’, ‘physical examination’ or ‘sonography’ were considered as ‘not defined’. If a concept pertained to personal factors, which are not coded within the system of the ICF, the code ‘personal factor’ was attributed. To give an example, concepts such as ‘My health is excellent’, ‘height’, ‘gender’, ‘mortality’ were considered as ‘personal factors’.

Absolute frequencies and relative frequencies of the outcome measures and the linked ICF categories were reported along with their 95% confidence intervals (CI) (38). If an ICF category was assigned repeatedly in a study, it was counted only once to avoid bias. All resulting ICF categories which referred to concepts measured in more than 5% of the studies were reported.

ICF categories are presented at the second-level. If a concept was linked to a third- or forth-level ICF category, the corresponding second-level category is reported. This

is appropriate, because the lower-level categories share the attributes of the higher-level category (11).

Results

From the 1,657 abstracts retrieved, 630 studies were excluded. Of these 1,027 retrieved studies, 259 studies met the inclusion criteria. In 207 (80%) of the studies, the study population consisted of patients with neurological conditions, 61 (24%) of the studies consisted of patients with musculoskeletal conditions, and 41 (16%) of the studies consisted of patients with cardiopulmonary conditions. 18 studies reported on all three conditions, 14 studies on two conditions, and 228 studies on one single condition. The included studies consisted of 193 cohort studies, 32 randomised controlled trials, 22 cross-sectional studies, 7 case-control studies and 5 meta-analyses and reviews respectively.

We retrieved 277 formal assessment instruments and 351 single clinical measures. Tables 1 and 2 give the 76 formal assessment instruments and 44 single clinical measures which were used in at least two different studies.

The most frequently used formal assessment instruments were the Functional Independence Measure (FIM) (26) with a prevalence of 39%, the Barthel Activities of Daily Living Index (BI) (17%) (39), the Glasgow Coma Scale (GCS) (13%) (40) and the Mini Mental State (MMS) (8%) (41). The most frequently used single clinical measures were cerebral computer tomography (CCT) with a prevalence of 15%, measurement of blood pressure (7%), electrocardiogram (ECG) (5%) and magnetic resonance imaging (MRI) (5%).

A total of 1,353 concepts were extracted from the outcome measures. 96% of these concepts could be linked to ICF categories. 75 concepts of those (6%) were linked to the first-level of the ICF, 593 concepts (44%) to second-level ICF categories, 554 concepts (41%) to third-level ICF categories and 63 concepts (5%) to forth-level ICF categories. 10 concepts (1%) were linked to the ICF categories ‘other specified’ or ‘unspecified’, 11 concepts (1%) were considered as ‘not defined’, and 47 concepts (3%) were considered as ‘personal factors’. In the linkage process a large number of decisions were made by the two experts. In very infrequent cases a third person was consulted if no agreement could be found after the initial discussion between both experts.

Table 3 to 5 list the 56 second-level ICF categories representing the concepts contained in the measures. 26 of the 56 categories (46%) belong to the component Body Functions, 5 (9%) to the component Body Structures, and 25 (45%) to the component Activities and Participation.

Discussion

Using the ICF as a reference it was possible to identify and quantify concepts of outcome measures cited in published studies focusing on rehabilitation in the acute hospital and early post-acute facilities. A large part of these concepts could be linked to the ICF.

It is not surprising that the Functional Independence Measure (FIM) (26), the Barthel Index (BI) (39) and the Glasgow Coma Scale (GCS) (40) were found to be the most often cited formal assessment instruments. This is in line with the neurological scope of the retrieved studies and commonly used measures in neurological rehabilitation in

countries such as in the UK (42). The FIM is among the most frequently used measures of global functioning in rehabilitation (43). The FIM is widely used to measure disability in neurological rehabilitation. The BI arguably is one of the most frequently used outcome measures used in stroke patients (44). The Glasgow Coma Scale is equally a recommended and validated measure for the classification of cognitive function in patients after traumatic brain injury (45). All other formal assessment instruments were applied in less than 10% of the studies. None of the retrieved formal assessment instruments was used in a majority of studies, and, although the FIM was used in about 40% of the studies, no single measure could be identified which represents an overall standard of measurement.

The frequency and contents of the linked ICF categories show the major areas of research focusing on rehabilitation in the acute hospital and in early post-acute facilities. There were eleven categories which were measured very frequently (at least 50% of the studies), and 24 categories measured frequently (at least 10% of the studies). Nine of the very frequent ICF categories belong to the Mobility and Self-care chapters of the component Activities and Participation.

In the component Body Functions the categories *defecation functions* and *urination functions* were very frequent, two functions with high predictive value for outcome (46, 47), both of which are also addressed by the FIM and the BI. Other frequent categories from the component Body Functions, such as *consciousness functions*, *orientation functions*, and *memory functions* are covered by the GCS and the Mini Mental State Examination.

A small number of Body Structures were also included; *structure of the brain* being the most frequently assessed structure. This is plausible as brain scans are used to classify structural damage of the brain (48-50). Equally, *structure of the spinal cord* was assessed frequently.

Less than 5% of the retrieved studies contained concepts which could be linked to categories of the component Environmental Factors. Although *social network* and *family relationships* are perceived as important factors influencing prognosis and recovery of patients in the acute hospital and early post-acute facilities (51), these factors were not covered by the retrieved measures.

Our presented results have some potential limitations. Most included articles reported results from observational studies, but only a small number reported results from randomized controlled studies. However, the results reflect the special situation of inpatient rehabilitation where interventions are not or not easily randomized or blinded. A recently published systematic review of the outcome measures used in randomized clinical trials of stroke retrieved a similar choice of measures (21). It is not at all simple and straightforward to link concepts of clinical measures to the appropriate ICF category. Recent linkage exercises, however, have demonstrated that it is possible to examine and compare the content of measures based on the ICF framework and predefined linking rules (18-22).

The ICF provides a valuable reference to identify and quantify the concepts of outcome measures focusing on rehabilitation in the acute hospital and in early post-acute rehabilitation facilities. Our findings indicate a need to define and to agree on 'what should be measured' in rehabilitation care to allow for a comparison of patient

populations. This is the goal of the ICF Core Set development for the acute hospital and early post-acute rehabilitation facilities (4, 52). ICF Core Sets should allow for a comparable and comprehensive description of patient populations, their functioning, and health across studies and interventions.

Table 1. Formal assessment instruments used in 259 studies in the acute hospital and early post-acute rehabilitation facilities (CI = Confidence interval).

type of measure	measure	% (95% CI)
Generic for diagnostic category		
Generic health	SF-36 (53)	2.3 (1.0; 4.6)
	Sickness Impact Profile (54)	0.8 (0.2; 2.6)
Activities of daily living/Functional health status		
	Functional Independence Measure (26)	39.0 (33.4; 44.8)
	Barthel Activities of Daily Living (ADL) Index (39)	16.6 (12.7; 21.4)
	Rankin Score Modified (55)	4.2 (2.5; 7.4)
	Barthel Index Modified (56)	1.9 (0.8; 4.2)
	Activities of Daily Living Katz-Index (57)	1.5 (0.6; 3.7)
	Frenchay Activities Index (58)	1.5 (0.6; 3.7)
	Nottingham Extended Activities of Daily Living Index (59)	1.2 (0.4; 3.1)
	Rehabilitation Institute of Chicago Functional Assessment Scale (60)	0.8 (0.2; 2.6)
	Karnofsky Performance Scale (61)	0.8 (0.2; 2.6)
	Functional Assessment Measure (62)	0.8 (0.2; 2.6)
	Australian Activities of Daily Living (63)	0.8 (0.2; 2.6)
	Lawton Instrumental ADL Scale (64)	0.8 (0.2; 2.6)
Cognitive function		
	Glasgow Coma Scale (40)	12.7 (9.2; 17.1)
	Mini Mental State Examination (41)	8.1 (5.3; 11.7)
	Glasgow Outcome Scale (65)	2.7 (1.2; 5.1)
	Rancho Los Amigos Cognitive Functioning Scale (66)	2.3 (1.0; 4.6)
	Orientation Log (67)	1.5 (0.6; 3.7)
	Controlled Oral Word Association Test (68)	1.2 (0.4; 3.1)
	Koma-Remissions-Skala (69)	1.2 (0.4; 3.1)
	Mattis Dementia Rating Scale (70)	1.2 (0.4; 3.1)
	Stroop Color Word Test (71)	1.2 (0.4; 3.1)
	Token Test (68)	1.2 (0.4; 3.1)
	Visual Form Discrimination Test (72)	1.2 (0.4; 3.1)
	Wechsler Memory Scale Revised-Logical Memory Subtest (73)	1.2 (0.4; 3.1)
	Wisconsin Card Sorting Test (74)	1.2 (0.4; 3.1)
	Letter-Number Span (75)	0.8 (0.2; 2.6)
	Loewenstein Occupational Therapy Cognitive Assessment (76)	0.8 (0.2; 2.6)
	Trail-Making-Test Part B (77)	0.8 (0.2; 2.6)
	Wechsler Adult Intelliegence Scale Revised (78)	0.8 (0.2; 2.6)
	Wechsler Memory Scale Revised-Digit Span Subtest (73)	0.8 (0.2; 2.6)
	Wide-Range Achievement Test Revised – Reading Subtest (79)	0.8 (0.2; 2.6)
Emotional function		
	Geriatric Depression Scale (80)	2.7 (1.2; 5.1)
	Spielberger´s Trait Anxiety Scale (81)	1.5 (0.6; 3.7)
	Center for Epidemiological Studies - Depression Scale (82)	1.2 (0.4; 3.1)
	Geriatric Depression Scale - Short Form (83)	1.2 (0.4; 3.1)
	Agitated Behaviour Scale (84)	0.8 (0.2; 2.6)
	Beck Depression Inventory (82)	0.8 (0.2; 2.6)
	Hospital Anxiety and Depression Scale (85)	0.8 (0.2; 2.6)
	Zung Self-Rating Depression Scale (86)	0.8 (0.2; 2.6)

Mobility		
	Ashworth Spasticity Scale Modified (87)	1.5 (0.6; 3.7)
	Berg Balance Scale (88)	1.5 (0.6; 3.7)
	Brunnstrom´s States of Motor Recovery (89)	1.5 (0.6; 3.7)
	10-meter Walk Test (90)	1.2 (0.4; 3.1)
	Functional Independence Measure: motor score (26)	1.2 (0.4; 3.1)
	Fugl-Meyer Motor Assessment (91)	1.2 (0.4; 3.1)
	Rivermead Mobility Index (92)	1.2 (0.4; 3.1)
	6-min-Walking Test (93)	0.8 (0.2; 2.6)
	Action Research Armtest (94)	0.8 (0.2; 2.6)
	Buck-Gramcko-Score (95)	0.8 (0.2; 2.6)
	Functional Ambulation Classification (96)	0.8 (0.2; 2.6)
	Timed Up & Go test (97)	0.8 (0.2; 2.6)
Pain		
	Ritchie Articular Index (98)	1.2 (0.4; 3.1)
	Visual Analogue Scale for Pain (99)	1.2 (0.4; 3.1)
	Numeric Rating Scale for Pain (100)	0.8 (0.2; 2.6)
Skin function		
	Braden Scale (101)	0.8 (0.2; 2.6)
Diagnostic-specific		
Stroke		
	National Institute of Health Stroke Severity Scale (102)	3.5 (2.0; 6.5)
	Scandinavian Stroke Scale (103)	3.5 (2.0; 6.5)
	European Stroke Scale (104)	1.5 (0.6; 3.7)
	Motricity Index (105)	1.5 (0.6; 3.7)
	Motor Assessment Scale (106)	1.5 (0.6; 3.7)
	Guy's Hospital Prognostic Score (107)	0.8 (0.2; 2.6)
Brain injury	Galveston Orientation and Amnesia Test (108)	5.4 (3.3; 8.7)
	Disability Rating Scale (109)	4.6 (2.8; 7.9)
	Canadian Neurological Scale (110)	1.2 (0.4; 3.1)
	Neurobehavioral Cognitive Status Examination (111)	1.2 (0.4; 3.1)
	Barrow Neurological Institute Screen (BNIS) for Higher Cerebral Function (112)	0.8 (0.2; 2.6)
	Community Integration Questionnaire (113)	0.8 (0.2; 2.6)
	Western Neuro Sensory Stimulation Profile (114)	0.8 (0.2; 2.6)
Spinal cord injury		
	Neurological and Functional Classification of Spinal Cord Injury (ASIA) (115)	7.3 (4.7; 10.9)
Cardiac condition (ICD I20 – I52, ICD I70 – I79)		
	Quality of Life after Myocardial Infarction (116)	0.8 (0.2; 2.6)
Trauma (ICD S00 – T98)		
	Trauma Score-revised (117)	0.8 (0.2; 2.6)
Miscellaneous		
	Acute Physiology and Chronic Health Evaluation II (118)	0.8 (0.2; 2.6)
	Borg´s Scale for Ratings of Perceived Exertion (119)	0.8 (0.2; 2.6)
	Minimum Data Set of Resident Assessment Protocol (120)	0.8 (0.2; 2.6)

Table 2. Single clinical measures used in 259 studies in the acute hospital and early post-acute rehabilitation facilities (CI = Confidence interval)

	Measure	% (95% CI)
Vital signs		
	Blood pressure	4.8 (3.0; 7.6)
	Heart rate	1.7 (0.8; 3.7)
	Body temperature	1.1 (0.4; 2.9)
	Respiration rate	0.9 (0.3; 2.5)
	Pulse	0.9 (0.3; 2.5)
Imaging		
	Cerebral computer tomography (CCT)	10.8 (8.0; 14.5)
	Electrocardiogram (ECG)	3.7 (2.2; 6.2)
	Magnetic resonance imaging (MRI)	3.7 (2.2; 6.2)
	Doppler	1.4 (0.6; 3.3)
	Electroencephalogram (EEG)	0.9 (0.3; 2.5)
	Electromyogram (EMG)	0.9 (0.3; 2.5)
	Angiography	0.9 (0.3; 2.5)
	Sonography	0.9 (0.3; 2.5)
	Videofluoroscopy	0.6 (0.2; 2.1)
Body chemistry		
	Albumin	1.1 (0.4; 2.9)
	Creatinine	1.1 (0.4; 2.9)
	Haemoglobin	1.1 (0.4; 2.9)
	Oxygen saturation	1.1 (0.4; 2.9)
	Arterial blood gas	0.6 (0.2; 2.1)
	Laboratory values	0.6 (0.2; 2.1)
	Serum haemoglobin	0.6 (0.2; 2.1)
	White blood cell	0.6 (0.2; 2.1)
Formal quantified functions		
	Pain	3.1 (1.8; 5.5)
	Bladder incontinence	1.1 (0.4; 2.9)
	Aphasia	0.9 (0.3; 2.5)
	Isokinetic strength evaluation	0.9 (0.3; 2.5)
	Sleep	0.9 (0.3; 2.5)
	Anxiety	0.6 (0.2; 2.1)
	Depression	0.6 (0.2; 2.1)
	Gait	0.6 (0.2; 2.1)
	Physical examination	0.6 (0.2; 2.1)
	Range of motion	0.6 (0.2; 2.1)
	Swallowing deficit	0.6 (0.2; 2.1)
	Maximal inspiratory pressure	0.6 (0.2; 2.1)
	Vital capacity	0.6 (0.2; 2.1)
	Visual acuity	0.6 (0.2; 2.1)
Miscellaneous		
	Weight	1.4 (0.6; 3.3)
	Body mass index	1.1 (0.4; 2.9)
	Medication	0.9 (0.3; 2.5)
	Living arrangements	0.6 (0.2; 2.1)
	Height	0.6 (0.2; 2.1)
	Location of lesion	0.6 (0.2; 2.1)
	Tracheostoma tube	0.6 (0.2; 2.1)
	Type of stroke	0.6 (0.2; 2.1)

Table 3. Relative frequency of second-level categories of the International Classification of Functioning, Disability and Health (ICF) linked to the concepts contained in the measures of 259 studies: component Body Functions (CI = Confidence interval).

ICF Code	ICF Code Description	% (95% CI)
	Chapter mental functions (13 categories selected out of 22 chapter categories)	
b110	Consciousness functions	29.0 (23.8; 34.8)
b114	Orientation functions	23.6 (18.8; 29.1)
b117	Intellectual functions	15.8 (11.9; 20.8)
b126	Temperament and personality functions	10.4 (7.3; 14.7)
b130	Energy and drive functions	9.7 (6.6; 13.9)
b140	Attention functions	16.2 (12.2; 21.2)
b144	Memory functions	19.3 (15.0; 24.5)
b147	Psychomotor functions	6.2 (3.8; 9.8)
b152	Emotional functions	14.3 (10.5; 19.1)
b156	Perceptual functions	6.2 (3.8; 9.8)
b160	Thought functions	8.9 (6.0; 13.0)
b164	Higher-level cognitive functions	10.0 (6.9; 14.3)
b167	Mental functions of language	13.1 (9.5; 17.8)
	Chapter sensory functions and pain (4 categories selected out of 18 chapter categories)	
b210	Seeing functions	7.7 (5.1; 11.6)
b215	Function of structures adjoining the eye	6.9 (4.4; 10.7)
b270	Sensory functions related to temperature and other stimuli	9.7 (6.6; 13.9)
b280	Sensation of pain	10.4 (7.3; 14.7)
	Chapter voice and speech function (1 category selected out of 6 chapter categories)	
b320	Articulation functions	9.7 (6.6; 13.9)
	Chapter functions of cardiovascular, haematological, immunological and respiratory systems (2 categories selected out of 16 chapter categories)	
b410	Heart functions	8.9 (6.0; 13.0)
b420	Blood pressure functions	7.7 (5.1; 11.6)
	Chapter functions of digestive, metabolic and endocrine systems (1 category selected out of 14 chapter categories)	
b525	Defecation functions	54.8 (48.7; 60.8)
	Chapter genitourinary and reproductive functions (1 category selected out of 11 chapter categories)	
b620	Urination functions	55.2 (49.1; 61.1)
	Chapter neuromusculoskeletal and movement-related functions (4 categories selected out of 17 chapter categories)	
b730	Muscle power functions	24.7 (19.9; 30.3)
b735	Muscle tone functions	8.9 (6.0; 13.0)
b750	Motor reflex functions	10.4 (7.3; 14.7)
b760	Control of voluntary movement functions	15.8 (11.9; 20.8)

Table 4. Relative frequency of second-level categories of the International Classification of Functioning, Disability and Health (ICF) linked to the concepts contained in the measures of 259 studies: component Body Structures (CI = Confidence interval).

ICF Code	ICF Code Description	% (95% CI)
	Chapter structures of the nervous system (2 categories selected out of 7chapter categories)	
s110	Structure of brain	18.9 (14.6; 24.1)
s120	Spinal cord and related structures	6.9 (4.4; 10.7)
	Chapter structures related to movement (3 categories selected out of 9 chapter categories)	
s730	Structure of upper extremity	6.9 (4.4; 10.7)
s740	Structure of pelvic region	6.9 (4.4; 10.7)
s750	Structure of lower extremity	6.9 (4.4; 10.7)

Table 5. Relative frequency of second-level categories of the International Classification of Functioning, Disability and Health (ICF) linked to the concepts contained in the measures of 259 studies: component Activities and Participation (CI = Confidence interval).

ICF Code	ICF Code Description	% (95% CI)
	Chapter general tasks and demands	
	(1 category selected out of 6 chapter categories)	
d230	Carrying out daily routine	44.0 (38.1; 50.1)
	Chapter communication	
	(5 category selected out of 16 chapter categories)	
d310	Communicating with - receiving -spoken messages	39.0 (33.3; 45.1)
d315	Communicating with - receiving - nonverbal messages	38.2 (32.5; 44.3)
d330	Speaking	39.0 (33.3; 45.1)
d335	Producing nonverbal messages	39.0 (33.3; 45.1)
d350	Conversation	6.6 (4.1; 10.3)
	Chapter mobility	
	(8 categories selected out of 20 chapter categories)	
d410	Changing basic body position	21.6 (17.0; 27.0)
d415	Maintaining a body position	13.1 (9.5; 17.8)
d420	Transferring oneself	57.1 (51.1; 63.0)
d445	Hand and arm use	8.9 (6.0; 13.0)
d450	Walking	57.9 (51.8; 63.8)
d455	Moving around	57.1 (51.1; 63.0)
d465	Moving around using equipment	54.8 (48.7; 60.8)
d470	Using transportation	7.3 (4.7; 11.2)
	Chapter self-care	
	(7 categories selected out of 9 chapter categories)	
d510	Washing oneself	57.1 (51.1; 63.0)
d520	Caring for body parts	54.8 (48.7; 60.8)
d530	Toileting	56.4 (50.3; 62.3)
d540	Dressing	57.1 (51.1; 63.0)
d550	Eating	57.5 (51.4; 63.4)
d560	Drinking	40.9 (35.1; 47.0)
d570	Looking after one`s health	6.6 (4.1; 10.3)
	Chapter self-care	
	(2 categories selected out of 9 chapter categories)	
d620	Acquisition of goods and services	5.4(3.2; 8.9)
d640	Doing housework	5.4(3.2; 8.9)
	Chapter interpersonal interactions and relationships	
	(1 category selected out of 11 chapter categories)	
d710	Basic interpersonal interactions	40.2(34.4; 46.2)
	Chapter community, social and civic life	
	(1 category selected out of 7 chapter categories)	
d920	Recreation and leisure	13.5(9.9; 18.2)

The validity of the most frequently used measure in early post-acute rehabilitation: a latent class factor analysis of the FIM

Specific Aims

The specific aims of the study were to examine (1) whether the four FIM dimensions 'activities of daily living', 'sphincter management', 'mobility', and 'executive function' can be supported and (2) whether the four dimensions show floor effects in patients undergoing early post-acute rehabilitation.

Methods

Study design

Data presented here is part of a larger multi-centric cross-sectional study describing functioning, disability and health using the International Classification of Functioning, Disability and Health (ICF) in patients with neurological, cardiopulmonary and musculoskeletal conditions undergoing early post-acute rehabilitation (11) (121). Patients were included if they were admitted to early post-acute rehabilitation care, if they were at least 18 years old, if they had sufficient knowledge of the German language, if the purpose and reason of the study was understood, and if an informed consent was signed. Patients who were re-admitted to early post-acute rehabilitation were excluded. All eligible patients were enrolled in the study. The study was approved by the Ethics Committee of the Medical School of the University of Munich in accordance with the declaration of Helsinki.

We analysed secondary data of patients with neurological conditions treated in the neurological therapy centre Burgau, Germany, and the neurological hospital Bad

Aibling, Germany, between 06/02 and 04/03. Well-trained (122) and experienced nurses administered the FIM regularly each week to document the treatment effects of early post-acute rehabilitation. The most recent FIM data prior to the individual's interview, as well as the socio-demographic variables and the diagnoses, were extracted from the patient's medical record sheets.

Measures

The FIM measures patients' performance of basic activities of daily living using 18 items (feeding, grooming, bathing, dressing upper and lower body, toileting, bladder and bowel management, transfers to bed/chair/wheelchair/toilet/tub/shower, walking/wheeling, stair climbing, comprehension, expression, social interaction, memory, problem solving). The FIM is a summated Likert rating scale, with response categories for each item ranging from 1 to 7. Scores 1 and 2 indicate stages of complete dependence, scores 3 to 5 stages of modified dependence, and scores 6 and 7 stages of independence.

Data analyses

Descriptive statistics were used to examine the study population (age, gender, and days since event). We examined whether the mean, standard deviation (SD), median, and the frequency of item responses of the FIM items were similar. This is necessary as the dimensions should be identified based on their content similarity and not on their similar statistical distributions.

To test the postulated four-dimensional structure of the FIM, a factor analysis was performed using Latent Class Factor Analysis (LCFA) (123). We used LCFA in contrast to traditional factor analysis because our data was highly skewed and the

distributions of most FIM items were bimodal. The LCFA model assumes that the latent variables (‘factors’) may be mutually dependent or independent; that the response variables (e.g. items of a questionnaire) can be nominal, ordinal, continuous, and/or counts; that certain correlations between factor and response variables (‘factor loadings’) may be restricted to zero; and that there are correlations between response variables (124). The parameters of the models are estimated by means of Maximum Likelihood (ML) methods. All analyses were conducted using Latent GOLD 4.0 (125).

The definition of a LCFA model consists of three parts. One part deals with the assumed probability of belonging to a certain latent class based on the observed variable. A further part deals with the assumed distribution for the response variables. For example, categorical variables can be modelled via multinomial distribution, continuous variables via normal distributions, and counts via Poisson or binomial distributions. Finally, one part deals with the regression-type assumptions used to gain parsimony in the description of the relationships between the variables in the model. For example, if the factor is assumed to be a continuous variable the linear regression model is applied (124).

The log-likelihood-statistics L^2 is used as Goodness-of-Fit index. L^2 provides a test of the null hypothesis that the reproduced probability structure has the specified model structure, i.e. how similar model-based estimated frequencies are to observed frequencies. It can be interpreted as an indicator of the unexplained amount of the observed relationship between the variables. Thus the larger the value, the poorer the model fit[126]. The asymptotic p-value derives from the chi-squared value taking into account the corresponding number of degrees of freedom. Rather than relying

on the asymptotic p-value, it is also possible to estimate the p-value associated with the L^2 statistic by means of a parametric bootstrap(126). The model of interest is estimated for replicated samples generated from the probability distribution defined by the Maximum Likelihood estimates of the original sample. The null hypothesis of this test is that the specified model holds true in the population. Thus, $p<.05$ indicates a poor fit (126).

The L^2 Difference Statistic indicates whether the addition of factor(s) results in a significant improvement in the model's fit. For example, if the L^2 for the initial model is 36.84 ($df_1 = 4$) and the L^2 of the revised model is 11.20 ($df_2 = 3$), the L^2 Difference statistic is 25.64. With one degree of freedom ($df_{df1 - df2} = 1$), the L^2 Difference Statistic is significant ($p < .001$), indicating that the revised model provides a better fit to the data (127).

Further model fit indices are reported, namely the Bayesian Information Criterion (BIC), the Akaike Information Criterion (AIC), Akaike Information Criterion 3 (AIC3), and the Consistent Akaike Information Criterion (CAIC), which are based on the L^2 and the number of degrees of freedom. They quantify the relative Goodness-of-Fit of various derived models based on a given data sample. These indices inform which minimal model correctly explains the data and thus discourage overfitting. The lower the value of these indices, the better is the model (124).

In our data analysis each of the FIM items was assigned to one of the four dimensions according to the postulated model. This means that the factor loadings on the other than the postulated dimensions were restricted to zero. No fixed values were assumed for correlations between factors, factor loadings on the corresponding

factor, or residual variances of the items. To compare the model fit of the four-dimensional model, a single-dimensional as well as a two-dimensional model was performed. The two dimensions are ‘motor function’ comprising the items feeding, grooming, bathing, dressing upper and lower body, toileting, bladder and bowel management, transfers to bed/chair/wheelchair/toilet/tub/shower, walking/wheeling, stair climbing, and the ‘cognitive function’ comprising the items comprehension, expression, social interaction, memory, problem solving.

We used Cronbach’s alpha to examine how consistently individuals respond to the items within the four retrieved dimensions (128). The values of Cronbach’s alpha coefficients range from 0 to 1 and a value of at least 0.7 is regarded as satisfactory (129). Item-total correlation was calculated to examine whether the correlation of an item with the hypothesized dimension is substantial (> .40) and correlations with other dimensions are lower (130).

Finally, we examined the distribution of each dimension to identify whether floor effects existed. Floor effects indicate that a measure is not able to discriminate across patients(131). In this study a floor effect was defined as the percentage of the patients scoring the minimum possible score of a dimension. The scores of the dimensions are computed by summarizing the scores of the assigned items. For example, the score of the dimension ‘activities of daily living’ corresponds to the summated scores of the items ‘feeding’, ‘grooming’, ‘bathing’, ‘dressing upper body’, ‘dressing lower body’ and ‘toileting’. No more than 20% of patients’ measurement should show floor effects (33). Since the state of consciousness is one aspect that may provoke floor effects in a measure focusing on functional independence in basic activities of daily living, we performed the analysis regarding the floor effects stratified

by the state of consciousness. The presence of impairment in the consciousness was documented with the ICF category consciousness functions (b110). This ICF category is defined as ‘general mental functions of the state of awareness and alertness, including clarity and continuity of the wakeful state’ (11). This ICF category was graded with the qualifiers 0 for ‘no impairment/limitation’ and 1 for ‘impairment/limitation’. Floor effects are reported stratified by the state of consciousness.

Results

269 patients (92.1%) had complete information on all FIM items. Socio-demographic characteristics and diagnoses were comparable in both sites (121), therefore pooled results are presented. The patients were 18 to 88 years old (median 60.0 years); 107 (39.8%) patients were female. The mean number of days since event ranges from 16 to 774 days (median 87; means 117.2 days; SD 107.9) for all patients. Main conditions responsible for inpatient stay were cerebrovascular disease (ICD-10: I60–I69; 51.0% of the patients), head injuries (S00-S09; 22.1 %) and diseases of the nervous system (G00-G99; 14.6%). 55 patients (20.5%) had impairment in the ICF category consciousness functions (b110). Patients with impaired consciousness were younger (median 55.0 years) and with a higher percentage of females (49.1%). Socio-demographic data of patients without impaired consciousness is similar to those of all patients.

Table 6 shows the means, standard deviations, medians and frequency distributions of each of the FIM items. Item scores ranged from 1 to 7, which corresponded to the entire item scale range, except for the item “stair ascending/descending”. Frequency distributions of most items were bimodal and patients were clustered at the lower end

of the item scale (score 1). In more than half of the patients the scores of the items “dressing lower body”, “toileting”, “bowel management”, “bladder management”, “walking/wheelchair”, and “stair ascending/descending” were under 2.

Compared to the single-dimensional and two-dimensional model, the Goodness-of-Fit indices indicate that the four-dimensional model fitted better to the given data (table 2). In addition, the L^2 Difference Statistic comparing the two-dimensional model to the four-dimensional model was significant ($p<.001$), indicating that the addition of two further factors resulted in a better fit to the data. The explained variance of the FIM items as well as the factor loadings of the FIM items on the assigned factors of the four-dimensional model are presented in table 3.

Cronbach’s alpha was 0.96 for the dimension ‘activity of daily living’, 0.95 for the dimensions ‘mobility’ and ‘executive function’, and 0.91 for the dimension ‘sphincter management’. Item-total correlations are shown in table 8.

Table 9 shows the percentage of patients scoring the minimum possible score in each of the retrieved dimensions for all patients as well as stratified by impairment of consciousness.

Discussion

In this study we could support the four dimensions within the FIM in patients with neurological conditions undergoing early post-acute rehabilitation. The distribution of the scores of the four dimensions ‘activities of daily living’, ‘sphincter management’, ‘mobility’, and ‘executive function’ demonstrate substantial floor effects suggesting

limitations for their potential to discriminate between patients undergoing early post-acute rehabilitation, particularly in those with impaired consciousness.

More than half of the patients were completely dependent in the items ‘dressing lower body’, ‘toileting’, ‘bowel management’, ‘bladder management’, ‘walking/wheelchair’, and ‘stair ascending/descending’. This reflects the severe health condition of our study population and their demand for specialized early post-acute care. The percentage of patients scoring the lowest possible score in the item ‘stair ascending/descending’ was extremely high. This suggests a modification or exclusion of the item ‘stair ascending/descending’ from further analysis due to the inability to discriminate across our patients. Authors of previous studies (32, 33) have already suggested the modification of the item ‘stair ascending/descending’. An argument against exclusion of this item is the consequent decrease in comprehensiveness of the corresponding dimension and the loss of comparability of the FIM across different study populations and across follow ups.

The identification of the four domains ‘activities of daily living’, ‘sphincter management’, ‘mobility’ and ‘executive function’ may have clinical utility as change in function may occur in some sets of items but not in others. For example, in this study one patient with a total FIM score of 63 was modified dependent in the dimension ‘activities of daily living’ (score 22), and completely dependent in the dimensions ‘sphincter management’ (score 2) and ‘mobility’ (score 6). In contrast, another patient scoring the same total FIM score was completely dependent in the dimension ‘activities of daily living’ (score 11), independent in the dimension ‘sphincter control’ (score 12), and modified dependent in the dimension ‘mobility’ (score 12). This example and examples of previous studies (34, 35) illustrate that by limiting the

assessment of patients to an overall dimension, clinically important differences in the finer dimensions may be missed.

We restricted the factor analysis to four dimensions to examine the validity of the four-dimensional structure of the FIM (31, 32). In addition, we performed a single-dimensional and two-dimensional model as reference models. The comparison of the three models suggested that the four-dimensional model better fitted the data. To our knowledge, this is the first time that LCFA has been applied to examine the dimensional structure of the FIM. Despite latent class analysis was introduced in 1950 (132), only a few studies exist in which LCFA has already been applied (133-137). One of the reasons for the sparseness of studies using LCFA might be the requirement of today's technical equipment to estimate latent class models with many cases and many observed responses. We also performed a traditional confirmatory factor analysis (CFA) using SAS System's CALIS procedure (138) to compare the results of these two different approaches. The four-dimensional model could be retrieved. But in contrast to the LCFA, the Goodness-of-Fit indices should not be interpreted as the FIM data does not meet the requirement for the CFA such as linearity, normal distribution of data, or homogeneity of variances (127).

The internal consistency of the four retrieved dimensions was high. This means that individuals respond consistently to the items within the four retrieved dimensions. Previous studies also reported acceptable but lower internal consistency of these FIM subscales (31-33). The high percentage of patients scoring the lowest score in each of the FIM items might be one reason for this notable high internal consistency. The item-total correlations of each dimension were higher than the minimal standard (0.4) and higher than the correlations of items with other dimensions. This means

that the relationship between the item and the dimension to which it was assigned is strong. However, the correlations with other dimensions are remarkable higher than those reported in published studies indicating that the items may discriminate less in our study population (30, 139). One reason for these results could be the reduced variability of the data due to the large proportion of patients scoring the minimum item scores.

Scores of each of the four dimensions showed substantial floor effects. This reflects the high level of dependence suffered by patients with neurological conditions undergoing early post-acute rehabilitation regardless of time since the acute onset of the neurological event. Floor effects within the FIM dimensions ‘sphincter management’ and ‘mobility’ were also reported in patients receiving rehabilitation in skilled nursing facilities (33). The results suggest that the FIM may not be sensitive to differentiate among patients undergoing early post-acute rehabilitation. For example, in patients with impaired consciousness about 50% achieved a total FIM score of 18 (lowest possible score). This questions to what extent the FIM can assess the burden of care in these patients which is one of its original intent in early post-acute rehabilitation (36). So far no study has been published dealing with this issue.

Our study has some limitations that need to be addressed. Firstly, our results derived from convenience samples of patients from two German study centers. Future research is necessary to replicate our findings. Secondly, previous studies report dimensional structure of the FIM stratified by health condition (31, 32). As the focus in this study was to evaluate the applicability of the FIM in a specific rehabilitation service, the analysis were carried out without stratification for health conditions. Thirdly, the results showed that the length of time since the onset of the acute event

varies broadly in patients undergoing early post-acute rehabilitation. This fact has already been reported previously (140) and reflects the variability of the length of time for medical and nursing needs of patients after an acute neurological event. The provision of early post-acute rehabilitation rather depends on patients' functioning and need for acute and specialized nursing care than on a certain time cut-off.

The study supports the four-dimensional structure of the FIM in patients with neurological conditions undergoing early post-acute rehabilitation. The capability of the subscales 'activities of daily living', 'sphincter management', 'mobility', and 'executive function' to discriminate across these patients, particularly in those with impaired consciousness, is poor due to floor effects. Future research is necessary to replicate the findings and to investigate the ability of the four retrieved dimensions to detect changes that occur over time in a larger number of patients treated in early post-acute rehabilitation facilities.

Table 6: Descriptive analysis of the FIM items: mean, standard deviation (SD), median and response frequency

	Item score		Response Frequency (%)						
Item	Mean ± SD	Median	1	2	3	4	5	6	7
activities of daily living									
feeding	3.1 ± 2.0	3.0	42.4	5.6	7.1	6.3	26.4	9.3	3.0
grooming	2.8 ± 1.7	2.0	33.5	18.2	11.5	16.7	11.9	6.7	1.5
bathing	2.3 ± 1.5	2.0	45.0	16.7	17.8	10.0	5.6	4.5	0.4
dressing - upper body	2.5 ± 1.6	2.0	39.0	20.8	14.5	13.0	6.3	4.5	1.9
dressing - lower body	2.1 ± 1.4	1.0	51.3	20.1	14.1	5.6	5.6	2.2	1.1
toileting	2.0 ± 1.6	1.0	58.0	13.4	12.6	5.2	5.6	3.3	1.9
sphincter control									
bowel management	2.4 ± 2.0	1.0	55.8	13.0	8.2	4.5	4.1	7.8	6.7
bladder management	2.6 ± 2.1	1.0	51.7	13.0	8.6	5.6	4.8	8.9	7.4
mobility									
bed/chair/wheelchair transfer	2.7 ± 1.6	3.0	33.1	16.0	27.1	10.0	5.9	5.6	2.2
toilet transfer	2.4 ± 1.7	2.0	48.0	11.9	17.5	9.3	4.8	6.7	1.9
tub/shower transfer	2.3 ± 1.5	2.0	44.6	14.5	20.4	9.3	7.1	3.7	0.4
walking/wheelchair	2.2 ± 1.7	1.0	60.6	7.1	9.3	7.8	9.3	4.8	1.1
stair ascending/descending	1.4 ± 1.0	1.0	85.9	3.3	3.7	3.0	3.3	0.7	0.0
executive function									
comprehension	3.5 ± 2.1	3.0	26.8	14.5	16.0	9.3	9.3	10.8	13.4
expression	3.0 ± 2.1	2.0	36.1	17.8	11.2	9.3	8.2	7.1	10.4
social interaction	2.8 ± 1.9	2.0	36.4	16.0	14.9	11.2	10.0	4.1	7.4
problem solving	2.2 ± 1.6	2.0	49.4	18.6	11.5	9.7	5.6	3.0	2.2
memory	2.6 ± 1.9	2.0	44.2	16.0	14.5	8.2	6.3	3.3	7.4

Table 7: Summary of model fit indices of the Latent Class Factor Analysis

				Information Criteria°			
	df[§]	$L^{2\%}$	p-value*	BIC	AIC	AIC3	CAIC
single-dimensional model	142	8188,37	p=0.02	7393,92	7904,37	7762,37	7251,92
two-dimensional model	139	7713,02	p=0.12	6935,35	7435,02	7296,02	6796,35
four-dimensional model	130	7358,76	p=0.20	6631,45	7098,76	6968,76	6501,45

NOTE.

[§]degree of freedom

[%]Log-Likelihood-Statistics (L^2) provides a test of the null hypothesis that the reproduced probability structure has the specified model structure. The larger the value, the poorer the model fit (126).

* Bootstrap estimate of the p-value associated with the L2: a value of <.05 indicates a poor fit (126).

°The Information Criteria comprise the Bayesian Information Criterion (BIC), the Akaike Information Criterion (AIC), the Akaike Information Criterion 3 (AIC3), and the Consistent Akaike Information Criterion (CAIC) and quantify the relative Goodness-of-Fit of various derived models based on a given data sample. The lower the values of these indices, the better the model (126).

Table 8: Factor Analysis of the four-dimensional model: explained variances, factor loadings, and item-total correlations

Item	Explained Variance°	Factor loadings+				Item-total correlations#			
		activities of daily living	*sphincter control*	*mobility*	*executive function*	*activities of daily living*	*sphincter control*	*mobility*	*executive function*
Feeding	0.75	0.84	*	*	*	0.87	0.73	0.73	0.74
Grooming	0.80	0.82	*	*	*	0.89	0.76	0.75	0.77
Bathing	0.73	0.71	*	*	*	0.83	0.72	0.70	0.72
dressing - upper body	0.73	0.73	*	*	*	0.84	0.73	0.71	0.73
dressing - lower body	0.62	0.61	*	*	*	0.75	0.66	0.64	0.66
Toileting	0.63	0.56	*	*	*	0.73	0.66	0.63	0.65
bowel management	0.81	*	0.93	*	*	0.68	0.85	0.66	0.67
bladder management	0.90	*	0.98	*	*	0.75	0.92	0.71	0.73
bed/chair/wheelchair transfer	0.81	*	*	0.92	*	0.74	0.70	0.90	0.61
toilet transfer	0.81	*	*	0.94	*	0.72	0.69	0.89	0.59
tub/shower transfer	0.79	*	*	0.91	*	0.72	0.69	0.88	0.59
walking/wheelchair	0.72	*	*	0.89	*	0.63	0.62	0.80	0.52
stair ascending/descending	0.46	*	*	0.68	*	0.42	0.43	0.56	0.36
Comprehension	0.74	*	*	*	0.85	0.73	0.70	0.58	0.85
Expression	0.61	*	*	*	0.75	0.65	0.63	0.52	0.76
social interaction	0.78	*	*	*	0.86	0.74	0.72	0.60	0.87
problem solving	0.74	*	*	*	0.80	0.70	0.69	0.57	0.82
Memory	0.77	*	*	*	0.83	0.72	0.71	0.59	0.85

*indicates that the factor loadings for these variables were restricted to zero

NOTE.
°The variance of the variable explained by the corresponding factor

+Correlation between factor and variables

#Correlation between the scores of the four FIM dimension with the scores of the FIM items

Table 9: Percentage of the patients scoring the minimum possible score in the four FIM dimensions (stratified by the state of consciousness)

Name of FIM dimension	All patients (n=269)	Patients without impaired consciousness (n=214)	Patients with impaired consciousness (n=55)
activities of daily living	**29.0**	17.8	**72.7**
sphincter management	**47.9**	**36.9**	**90.9**
mobility	**31.6**	**22.4**	**67.3**
executive function	**22.3**	10.3	**69.1**

NOTE.
Boldface indicates substantial floor effects, i.e. more than 20% of the patients scored the minimal minimum possible score of this dimension.

Conclusion

The doctoral thesis presented here, identified the Functional Independence Measure (FIM) as the most often cited measure in studies focusing on patients undergoing early post-acute rehabilitation. The results support the validity of the four-dimensional structure of the FIM. However, the applicability of the FIM seems to be limited due to the reduced capability of the subscales to discriminate across patients undergoing early post-acute rehabilitation.

These findings have two major implications. Firstly, they demonstrate that caution is required when limiting the assessment of patients to an overall dimension because clinically important but subtle changes going on in the finer dimensions may be missed. Secondly, they are an indication that additional health domains not covered by the FIM items such as mental functions, pain, muscle functions may be relevant to assess the needs of patients undergoing early post-acute rehabilitation.

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Summary

Background: Standardized measurement tools are of utmost importance to identify the patient's need for early post-acute rehabilitation and to assess the effects of interventions on patient's functioning and health. One of the most frequently used measures of global functioning in inpatient rehabilitation is the Functional Independence Measure (FIM). The applicability of the FIM in early post-acute rehabilitation facilities, which may differ from the setting for which the FIM has been developed, has to be validated.

Objective: The purpose of the current doctoral thesis is to explore the applicability of the most frequently used measure in patients undergoing early post-acute rehabilitation, the Functional Independence Measure (FIM). The specific aims are 1) the identification of the most frequently used measures in patients undergoing early post-acute rehabilitation, and 2) the examination whether the four postulated FIM dimensions 'activities of daily living', 'sphincter management', 'mobility', and 'executive function' can be supported and whether the four dimensions show floor effects in patients undergoing early post-acute rehabilitation.

Methods and Results: In the following, the doctoral thesis is subdivided into two parts presenting the two successive studies performed to pursue the specific objectives of this doctoral thesis.

A ***Systematic Literature Review*** including Medline, Embase, CINAHL, Pedro and the Cochrane Library from 1997 to 2002 were carried out. Retrieved studies were checked on outcome measures; the items of the questionnaires and their underlying concepts were specified. 259 studies met the inclusion criteria for the systematic literature review; 277 formal assessment instruments and 351 single clinical measures were retrieved. The FIM was the most often cited outcome measure.

A ***Latent Class Factor Analysis*** was performed using the FIM data of neurological patients collected within a multi-centric cross-sectional survey. The four postulated dimensions within the FIM could be identified. The explained variance of items assigned to the four dimensions "activities of daily living", "sphincter management", "mobility", and "executive function" ranged from 46% to 89%. Cronbach's alpha coefficients of the four subscales ranged from 0.94 to 0.96. The percentage of patients scoring the minimum possible score in each of the retrieved dimensions ranged from 22.3% to 47.9%. This is an indication that floor effects were present in all four dimensions.

Conclusion: The doctoral thesis presented here, identified the Functional Independence Measure (FIM) as the most often cited measure in studies focusing on patients undergoing early post-acute rehabilitation. The results support the validity of the postulated four-dimensional structure of the FIM. However, the applicability of the FIM seems to be limited due to floor effects of the subscales resulting to the reduced capability to discriminate across patients undergoing early post-acute rehabilitation.

Zusammenfassung

Hintergrund: Standardisierte Erhebungsinstrumente sind in der Frührehabilitation von großer Bedeutung, um die Probleme der Patienten zu identifizieren und die Wirksamkeit von therapeutischen Maßnahmen auf die Funktionsfähigkeit und Gesundheit zu evaluieren. Der Funktionale Selbständigkeitsindex (FIM) ist das am häufigsten angewandte Erhebungsinstrument in der Frührehabilitation. Die Anwendbarkeit des FIM in diesem Setting, das erheblich von den Rehabilitationseinrichtungen abweicht, für die der FIM entwickelt wurde, muss jedoch überprüft werden.

Ziel: Das Ziel der vorliegenden Doktorarbeit ist die Untersuchung der Anwendbarkeit des am häufigsten in der Frührehabilitation angewandten Erhebungsinstruments – dem Funktionalen Selbständigkeitsindex (FIM). Die speziellen Fragestellungen sind (1) die Identifizierung der am häufigsten angewandten Erhebungsinstrumente in der Frührehabilitation, (2) die Überprüfung, ob die vier postulierten FIM-Dimensionen „Selbstversorgung“, „Kontinenz“, „Mobilität“ und „Kognitive Fähigkeiten nachgewiesen werden können und ob diese vier Subskalen Bodeneffekte in Daten von neurologischen Frührehabilitationspatienten zeigen.

Methoden und Ergebnisse: Im Folgenden werden die Methoden und Ergebnisse von zwei Studien zusammengefasst berichtet. Jede dieser Studien beantwortet jeweils eine der speziellen Fragestellung der Doktorarbeit.

Eine ***Systematische Literatursuche*** wurde in den Datenbanken Medline, Embase, CINAHL, Pedro und dem Cochrane Library für den Zeitraum von 1997 bis 2002 durchgeführt. Die Studien wurden hinsichtlich der angewandten Messinstrumente überprüft. Anschließend wurden die Items der Fragebögen und ihre zugrundeliegenden Konstrukte spezifiziert. 259 Studien erfüllten die Einschlußkriterien für diesen Review. Insgesamt wurden 277 Erhebungsinstrumente und 351 klinische Messverfahren extrahiert. Der FIM war das am häufigsten zitierte Erhebungsinstrument.

Die ***Latent Class Factor Analysis*** wurde mit FIM-Daten von neurologischen Frührehabilitationspatienten aus einer multizentrischen Querschnittstudie durchgeführt. Die Ergebnisse unterstützen die Annahme der vier FIM-Dimensionen „Selbstversorgung“, „Kontinenz“, „Mobilität“ und „Kognitive Fähigkeiten“. Die erklärte Varianz der einzelnen Items durch die jeweilige FIM-Dimension reicht von 46% bis 89%. Cronbach’s Alpha der vier Subskalen reicht von 0.94 bis 0.96. Der relative Anteil jener Patienten, die den minimalen Summenscore in den vier FIM Dimensionen erreichten, reichte von 22.3% bis 47.9%. Das ist ein Hinweis, dass Bodeneffekte in allen vier Subskalen vorhanden waren.

Schlussfolgerung: Der FIM ist das am häufigsten angewandte Erhebungsinstrument in der Frührehabilitation. Die Ergebnisse stützen die Validität der vierdimensionalen Struktur des FIMs. Die Anwendbarkeit des FIMs in der Frührehabilitation scheint jedoch durch die ausgeprägten Bodeneffekte der Subskalen und der damit verbundenen reduzierten Diskriminierungsfähigkeit zwischen Patienten eingeschränkt zu sein.

Appendix

Appendix 1 Overview of ICF domains – Body Functions (11)

CHAPTER 1	MENTAL FUNCTIONS
	This chapter is about the functions of the brain: both global mental functions, such as consciousness, energy and drive, and specific mental functions, such as memory, language and calculation mental functions.
CHAPTER 2	SENSORY FUNCTIONS AND PAIN
	This chapter is about the functions of the senses, seeing, hearing, tasting and so on, as well as the sensation of pain.
CHAPTER 3	VOICE AND SPEECH FUNCTIONS
	This chapter is about the functions of producing sounds and speech.
CHAPTER 4	FUNCTIONS OF THE CARDIOVASCULAR, HAEMATOLOGICAL, IMMUNOLOGICAL AND RESPIRATORY SYSTEMS
	This chapter is about the functions involved in the cardiovascular system (functions of the heart and blood vessels), the haematological and immunological systems (functions of blood production and immunity), and the respiratory system (functions of respiration and exercise tolerance).
CHAPTER 5	FUNCTIONS OF THE DIGESTIVE, METABOLIC AND ENDOCRINE SYSTEMS
	This chapter is about the functions of ingestion, digestion and elimination, as well as functions involved in metabolism and the endocrine glands.
CHAPTER 6	GENITOURINARY AND REPRODUCTIVE FUNCTIONS
	This chapter is about the functions of urination and the reproductive functions, including sexual and procreative functions.
CHAPTER 7	NEUROMUSCULOSKELETAL AND MOVEMENT-RELATED FUNCTIONS
	This chapter is about the functions of movement and mobility, including functions of joints, bones, reflexes and muscles.
CHAPTER 8	FUNCTIONS OF THE SKIN AND RELATED STRUCTURES
	This chapter is about the functions of skin, nails and hair.

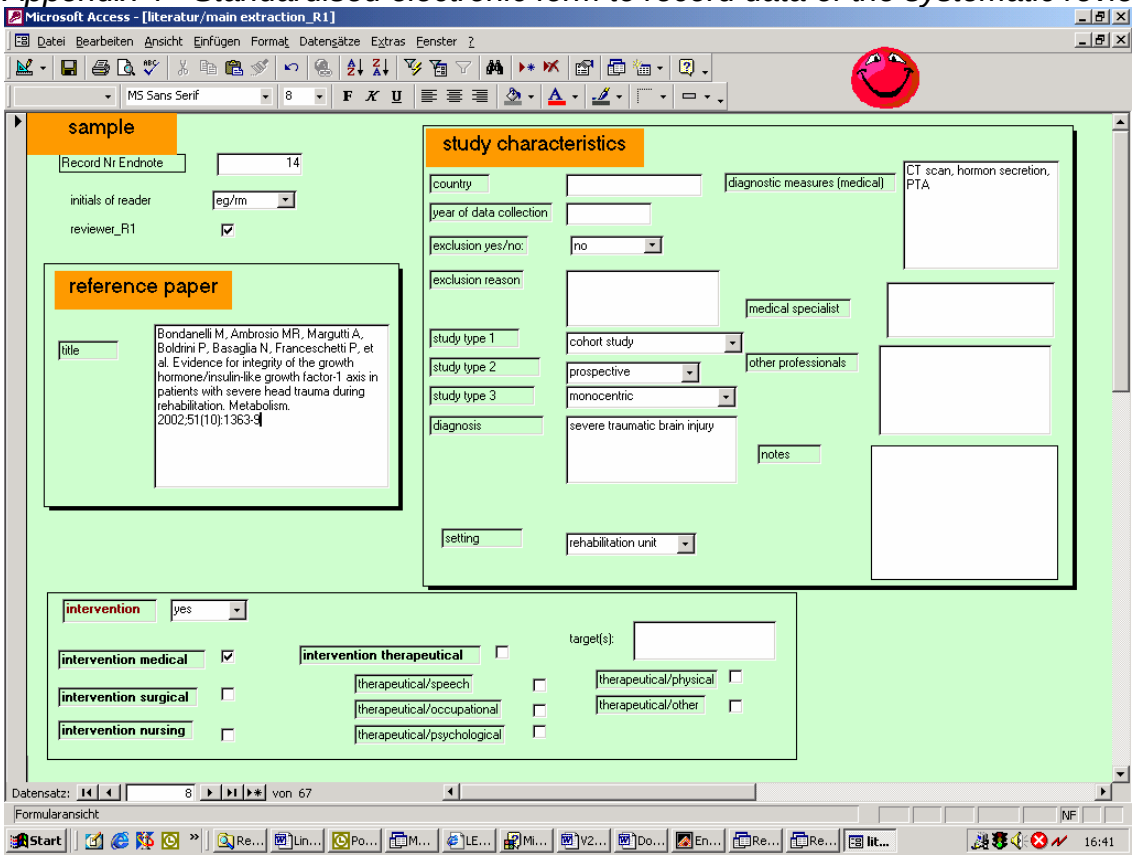
Appendix 2 Overview of ICF domains – Body Structures (11)

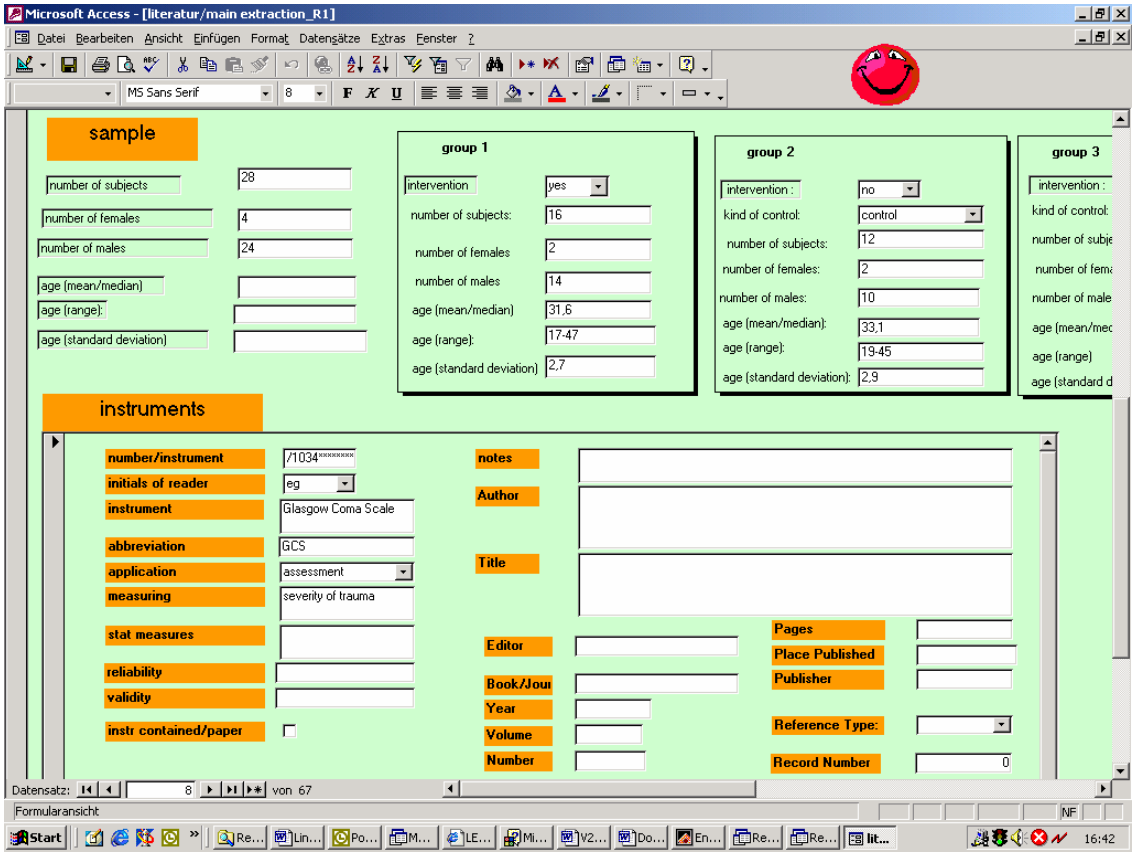
CHAPTER 1	STRUCTURES OF THE NERVOUS SYSTEM
CHAPTER 2	THE EYE, EAR AND RELATED STRUCTURES
CHAPTER 3	STRUCTURES INVOLVED IN VOICE AND SPEECH
CHAPTER 4	STRUCTURES OF THE CARDIOVASCULAR, IMMUNOLOGICAL AND RESPIRATORY SYSTEMS
CHAPTER 5	STRUCTURES RELATED TO THE DIGESTIVE, METABOLIC AND ENDOCRINE SYSTEMS
CHAPTER 6	STRUCTURES RELATED TO THE GENITOURINARY AND REPRODUCTIVE SYSTEMS
CHAPTER 7	STRUCTURES RELATED TO MOVEMENT
CHAPTER 8	SKIN AND RELATED STRUCTURES

Appendix 3 Overview of ICF domains – Activities and Participation (11)

CHAPTER 1	LEARNING AND APPLYING KNOWLEDGE
	This chapter is about learning, applying the knowledge that is learned, thinking, solving problems, and making decisions.
CHAPTER 2	GENERAL TASKS AND DEMANDS
	This chapter is about general aspects of carrying out single or multiple tasks, organizing routines and handling stress. These items can be used in conjunction with more specific tasks or actions to identify the underlying features of the execution of tasks under different circumstances.
CHAPTER 3	COMMUNICATION
	This chapter is about general and specific features of communicating by language, signs and symbols, including receiving and producing messages, carrying on conversations, and using communication devices and techniques.
CHAPTER 4	MOBILITY
	This chapter is about moving by changing body position or location or by transferring from one place to another, by carrying, moving or manipulating objects, by walking, running or climbing, and by using various forms of transportation.
CHAPTER 5	SELF-CARE
	This chapter is about caring for oneself, washing and drying oneself, caring for one's body and body parts, dressing, eating and drinking, and looking after one's health.
CHAPTER 6	DOMESTIC LIFE
	This chapter is about carrying out domestic and everyday actions and tasks. Areas of domestic life include acquiring a place to live, food, clothing and other necessities, household cleaning and repairing, caring for personal and other household objects, and assisting others.
CHAPTER 7	INTERPERSONAL INTERACTIONS AND RELATIONSHIPS
	This chapter is about carrying out the actions and tasks required for basic and complex interactions with people (strangers, friends, relatives, family members and lovers) in a contextually and socially appropriate manner.
CHAPTER 8	MAJOR LIFE AREAS
	This chapter is about carrying out the tasks and actions required to engage in education, work and employment and to conduct economic transactions.
CHAPTER 9	COMMUNITY, SOCIAL AND CIVIC LIFE
	This chapter is about the actions and tasks required to engage in organized social life outside the family, in community, social and civic areas of life.

Appendix 4 Standardised electronic form to record data of the systematic review





Curriculum Vitae

Personal Information

Name	Scheuringer Monika
Address	Kolumbusstraße 5, 81543 Munich, Germany
Nationality	Austria
Date of birth	May 24, 1974
Gender	Female

Work Experience

Date	1996 – 1997
Name and address of employer	schwa-medico Medizintechnik GmbH, Annenstraße 57, 8020 Graz, Austria
Main activities/responsibilities	Working in the field and in the office
	1997-2001
Main activities/responsibilities	Working as instructor in projects focusing on youth sport, as outdoor instructor, and as fitness consultant for a life assurance company
Auftraggeber	X-citing sports, Graz; Primärsportmodell, Graz; Degi's Abenteuerschule, Deutschlandsberg; Merkur VersicherungsAG, Graz;
	2000-2001
Name and address of employer	Steirische Gesellschaft für Gesundheitsschutz, Marburger Kai 51/II, 8010 Graz, Austria
Main activities/responsibilities	Field interviewer in the project ‚Healthy Communities'
	2002
Name and address of employer	Bayerischen Forschungsverbund für Public Health, Tegernseer Landstraße 243, 81549 Munich, Germany
Main activities/responsibilities	Performance of forecasting analyses and publishing the results within the project 'Orthopaedics 2010 – evaluation of the demand for the orthopaedic work force in the year 2010'
	Since 2003
Name and address of employer	ICF Research Branch of the WHO CC FIC (DIMDI), Institute for Health and Rehabilitation Sciences, Ludwig-Maximilian University, Marchioninistraße 17, 81377 Munich, Germany
Main activities/responsibilities	Since 2005 leader of the project ‚Development of ICF Core Sets for Spinal Cord Injury': this international project is a collaboration between the ICF Research Branch Munich, the World Health Organization and partner institutions throughout the world

Education and Training

Date	1994 – 2000
Title of qualification awarded	Diploma in Kinesiology
Name and type of organization	Karl-Franzens-University Graz, Austria
Date	2001 – 2003
Title of qualification awarded	Diploma in Public Health and Epidemiology
Name and type of organization	Ludwig-Maximilian University Munich, Deutschland

List of Presentations & Publications

2004

14th European Congress of Physical and Rehabilitation Medicine, May 12-15, 2004, Vienna, Austria: Systematic review of measures and their concepts used in published studies focusing on rehabilitation in the acute hospital and in early post-acute rehabilitation facilities (poster presentation).

2005

44th Annual Scientific Meeting of the International Spinal Cord Society (ISCoS), October 4-8, 2005, Munich/Murnau, Germany: Development of ICF Core Sets as a way to specify functioning of persons with spinal cord injuries (poster presentation).

15th European Congress of Physical and Rehabilitation Medicine, October 2005, Munich, Germany: Examination of the validity of the FIM in patients with neurological conditions in early post-acute rehabilitation facilities (poster presentation).

Scheuringer M, Grill E, Boldt C, Mittrach R, Mullner P, Stucki G. Systematic review of measures and their concepts used in published studies focusing on rehabilitation in the acute hospital and in early post-acute rehabilitation facilities. Disabil Rehabil. 2005 Apr 8-22;27(7-8):419-29.

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Scheuringer M, Wildner M, Gotte S, Dreinhofer KE. [Inpatient health care utilization for musculoskeletal disorders and injuries: a forecast study for Germany up to 2010]. Z Orthop Ihre Grenzgeb. 2005 Sep-Oct;143(5):509-19.

Boldt C, Scheuringer M, Grill E. [Functional health and nursing performance: WHO classification challenge]. Pflege Z. 2005 Mar;58(3):164-8.

Stoll T, Brach M, Huber EO, Scheuringer M, Schwarzkopf SR, Konstanjsek N, et al. ICF Core Set for patients with musculoskeletal conditions in the acute hospital. Disabil Rehabil. 2005 Apr 8-22;27(7-8):381-7.

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2006

Joint scientific meeting of the American Spinal Injury Association and the International Spinal Cord Society, June 24-28, 2006, Boston (MA), USA: Workshop about the development of ICF Core Sets for persons with spinal cord injuries.

Scheuringer M, Wildner M, Gotte S, Dreinhofer EK. [Inpatient care utilization in musculoskeletal diseases and injuries]. Chirurg. 2006 Mar;Suppl:80-9.

Biering-Sorensen F, Scheuringer M, Baumberger M, Charlifue SW, Post MW, Montero F, et al. Developing core sets for persons with spinal cord injuries based on the International Classification of Functioning, Disability and Health as a way to specify functioning. Spinal Cord. 2006 Sep;44(9):541-6.

Grill E, Stucki G, Scheuringer M, Melvin J. Validation of International Classification of Functioning, Disability, and Health (ICF) Core Sets for early postacute rehabilitation facilities: comparisons with three other functional measures. Am J Phys Med Rehabil. 2006 Aug;85(8):640-9.

Zochling J, Grill E, Scheuringer M, Liman W, Stucki G, Braun J. Identification of health problems in patients with acute inflammatory arthritis, using the International Classification of Functioning, Disability and Health (ICF). Clin Exp Rheumatol. 2006 May-Jun;24(3):239-46.

Zochling J, Bonjean M, Grill E, Scheuringer M, Stucki G, Braun J. Systematic review of measures and their concepts used in published studies focusing on the treatment of acute inflammatory arthritis. Clin Rheumatol. 2006 Nov;25(6):807-13.

2007

Scheuringer M, Grill E, Boldt C, Stucki G. Examination of the validity of the FIM in patients with neurological conditions in early post-acute rehabilitation facilities. Submitted 2007