J Rehabil Med 2012; 44: 65–72

ORIGINAL REPORT

MAPPING THE MAYO-PORTLAND ADAPTABILITY INVENTORY TO THE INTERNATIONAL CLASSIFICATION OF FUNCTIONING, DISABILITY AND HEALTH

Jan Lexell, MD, PhD[1,2], James F. Malec, PhD[3] and Lars J. Jacobsson, PhD[1,4]

From the [1]Department of Health Sciences, Lund University, [2]Department of Rehabilitation Medicine, Skåne University Hospital, Lund, Sweden, [3]Rehabilitation Hospital of Indiana and Indiana University School of Medicine, Indianapolis, IN, USA and [4]Medical Rehabilitation Section, Department of General Medicine, Kalix Hospital, Kalix, Sweden

Objective: **To examine the contents of the Mayo-Portland Adaptability Inventory (MPAI-4) by mapping it to the International Classification of Functioning, Disability and Health (ICF).**

Methods: **Each of the 30 scoreable items in the MPAI-4 was mapped to the most precise ICF categories.**

Results: **All 30 items could be mapped to components and categories in the ICF. A total of 88 meaningful concepts were identified. There were, on average, 2.9 meaningful concepts per item, and 65% of all concepts could be mapped. Items in the Ability and Adjustment subscales mapped to categories in both the Body Functions and Activity/Participation components of the ICF, whereas all except 1 in the Participation subscale were to categories in the Activity/Participation component. The items could also be mapped to 34 (13%) of the 258 Environmental Factors in the ICF.**

Conclusion: **This mapping provides better definition through more concrete examples (as listed in the ICF) of the types of body functions, activities, and participation indicators that are represented by the 30 scoreable MPAI-4 items. This may assist users throughout the world in understanding the intent of each item, and support further development and the possibility to report results in the form of an ICF categorical profile, making it universally interpretable.**

Key words: brain injuries; disability evaluation; outcome assessment; rehabilitation; research design.

J Rehabil Med 2012; 44: 65–72

Correspondence address: Jan Lexell, Department of Rehabilitation Medicine, Skåne University Hospital, Orupssjukhuset, SE-221 85 Lund, Sweden. E-mail: jan.lexell@skane.se

Submitted May 25, 2010; accepted August 23, 2011

INTRODUCTION

The International Classification of Functioning, Disability and Health (ICF) is a universal framework and an international language for describing all aspects of a disability (1–3). It can be used to facilitate assessment and goal planning following a trauma or disease, as well as to improve outcome research by understanding the content of measurement tools. The value of linking various outcome measures to the ICF is increasingly recognized, and rules have been developed that enable researchers to map the contents and items of measures to the ICF (4, 5). The rationale for developing such linkages is to provide a validation and better understanding of measures by describing the concrete human features and functions in the ICF to which these measures relate. Recent studies have linked a variety of measures to the ICF taxonomy (6), for example the Stroke Impact Scale (7), health-related quality of life measures (8), and measures of participation including the Mayo-Portland Adaptability Inventory (MPAI-4) (9). In this latter study, Resnick & Plow (9) reported that the MPAI-4 linked to all 9 ICF Activity and Participation chapters; however, these researchers did not extend the linkage to other ICF components and domains.

The development of the Mayo-Portland Adaptability Inventory, now in its fourth edition (MPAI-4), spans 20 years (10, 11). The MPAI-4 is a 30-item inventory that includes indicators of body functions, activities, and participation that are often affected by acquired brain injury (ABI), both traumatic and non-traumatic. The MPAI-4 was developed and refined using both contemporary (i.e. Rasch analysis) and classic psychometric procedures (12, 13). These psychometric analyses identified a strong primary factor in MPAI-4 items representing global outcome after ABI. In addition, 3 levels of complexity of functions and activities were also identified, which are represented by the 3 subscales: Ability Index, Adjustment Index and Participation Index.

Through Rasch analysis, items were identified for the inventory as a whole that define a broad range of outcome after ABI, from extremely severe disability associated with no or limited adjustment and participation to normal adjustment and participation associated with resolution of or compensation for the consequences of the ABI. The Rasch analyses yielded an ultimate set of 30 items comprising the MPAI-4. Although these 30 items by no means comprehensively describe all possible consequences and outcomes of ABI, they do satisfactorily represent the range of outcomes for reliable measurement (10). The MPAI-4 is intended to be transcultural. It has been translated into Swedish (14), Italian (15), Danish, Spanish, French, German, Portuguese and Hebrew, and is widely used in Australia and UK in addition to the USA and Canada.

Unlike the ICF, the MPAI-4 is a linear metric; that is, it provides an ordinal numeric rating describing the degree of outcome

after ABI, which, using Rasch methods, can be converted into a parametric-equivalent measure (16). The ICF, in contrast, is a taxonomy; that is, a compilation of descriptors of body structures and functions, activities, participation indicators, and the personal and environmental contexts in which these occur. Thus, mapping an existing measure to the ICF provides a validation and better understanding of the measure by describing the concrete human features and functions in the ICF to which the measure relates.

The aim of this study was more fully to describe the contents of the MPAI-4 by mapping it to the ICF. We were interested in performing this mapping procedure in order to provide better definition through more concrete examples (as listed in the ICF) of the types of functions, activities, and participation indicators that are represented by the each of the MPAI-4 items. Mapping the MPAI-4 to the ICF would also assist MPAI-4 users throughout the world in understanding the intent of each item. Although the success of the mapping procedure may provide evidence of content and construct validity of the MPAI-4, the process described in this paper was not conducted to evaluate consensual understanding of the MPAI-4. That is, we were not interested in evaluating whether a sample of users of the MPAI-4 tended to agree about the way in which MPAI-4 items linked to the ICF. Rather our intention was to map the MPAI-4 to the ICF in order to prescribe, to the degree that the MPAI-4 and the ICF describe similar domains, how MPAI-4 items should be understood in terms of the ICF. Ultimately, the benefit of such a rigorous process is to facilitate the cross-cultural use of the instrument and support the development and the possibility to report results obtained with the MPAI-4 in the universal language of the ICF.

METHODS

Mayo-Portland Adaptability Inventory

The MPAI-4 (10) was primarily designed to assist in the clinical evaluation of people during the post-acute (post-hospital) period following ABI, and to assist in the evaluation of rehabilitation programmes designed to serve these people. The 30 items are scored on a 5-point Likert scale and represent the range of physical, cognitive, emotional, behavioural and social problems that people with ABI may encounter. The instrument also provides an assessment of major obstacles to community reintegration as well as features of the social and physical environment. The MPAI-4 has 3 subscales: Ability Index (range 0–47), Adjustment Index (range 0–46) and Participation Index (range 0–30), with an overall score of 0–111, where higher scores indicate greater overall disability. Three items (Initiation, Social contact, Leisure/recreational activities) contribute to both the Adjustment Index and the Participation Index, so the total score is less than the sum of the 3 subscales. The last section of the MPAI-4 is for documenting pre-existing and associated conditions linked with the ABI. This section does not contribute to the overall score on the MPAI-4 and serves only to record other factors that may need to be considered in rehabilitation planning. Therefore, this part was not mapped to the ICF. The manual (10) provides the opportunity to compare the results converted to T-scores with 2 reference samples of people treated for ABI. T-scores below 30 are considered as a relatively good outcome, 30–40 as mild disability, and above 60 as severe disability, even compared with other individuals with ABI.

Procedure

The previously established and updated rules were used as a basis for the mapping of the MPAI-4 to the ICF (5). The procedure was carried out by the authors, who have experience of clinical work and research related to ABI, and, in addition, have worked with and used the ICF.

In the first step, each of us independently identified all meaningful concepts within the 30 scoreable items of the MPAI-4 and then selected ICF codes that could apply. If a meaningful concept of an item was explained by examples, both the concept and the examples were mapped (5). We also intended to map the response option of an item if it contained a meaningful concept. However, no item response option contained meaningful concepts that were not already contained in the item description itself. The final step of mapping the meaningful concepts identified to the most precise or best ICF category was accomplished by consensus of the authors. As the primary developer of the MPAI-4 (JFM) was involved throughout the entire process, it allowed us to specify the intent of each item from the perspective of the developer as well as from the verbal explanations of the item and the examples given in the inventory itself and in the manual (11).

Following Geyh et al. (8), we calculated and reported: (*i*) the number of meaningful concepts identified; (*ii*) content density (i.e. the number of meaningful concepts identified divided by the number of items); (*iii*) the number of meaningful concepts mapped to the ICF; (*iv*) number of

Table I. *Summary of the mapping of the Mayo-Portland Adaptability Inventory (MPAI-4) to the International Classification of Functioning, Disability and Health (ICF)*

	MPAI-4 subscales		
	Abilities	Adjustment	Participation
Items, *n*	13	9	8
Meaningful concepts identified, *n*	29	32	27
Content density, % (number of meaningful concepts identified/number of items)	2.2	3.6	3.4
Meaningful concepts mapped to ICF, *n* (%)	24 (83)	9 (28)	24 (89)
Meaningful concepts not mapped to ICF, *n* (%)	5 (17)	23 (72)	3 (11)
Number of unique ICF categories identified, *n*[a]	81	46	73
Bandwidth of content coverage, % (number of ICF categories identified/total number of ICF categories, i.e. 1454)	6	3	5
Content diversity (number of ICF categories/number of meaningful concepts identified)	2.8	1.4	2.7
ICF categories per component, *n* (%)			
Body Functions (*n*=493)	41 (8)	40 (8)[b]	1 (0.2)
Activity and Participation (*n*=393)	40 (10)	20 (5)	75 (19)[c]
Environmental Factors (*n*=258)[d]	10 (4)	9 (3)	27 (10)

[a]As several ICF categories were mapped to multiple items, the total number of unique ICF categories was 200.

[b]Three items were mapped to three ICF categories and two items were mapped to eight ICF categories, respectively.

[c]Two items were mapped to three ICF categories.

[d]Ten environmental factors were linked to more than one subscale; the total number of unique factors were 34.

Table II. *Mapping of the Mayo-Portland Adaptability Inventory (MPAI-4) subscale Ability Index (Items 1–12) to the International Classification of Functioning, Disability and Health (ICF)*

Item	Meaningful concept	Main ICF code
1. Mobility	Walking	b770 Gait pattern functions
	Moving	d4500 Walking short distances
	Balance	d4501 Walking long distances
		d4502 Walking on different surfaces
		d4503 Walking around obstacles
		d4600 Moving around within the home
		d4601 Moving around within buildings other than home
		d4602 Moving around outside the home and other buildings
		d465 Moving around using equipment
2. Use of hands	Use of hands	b7300 Power of isolated muscles and muscle groups
	Strength in hands	b7600 Control of simple voluntary movements
	Coordination in hands	b7601 Control of complex voluntary movements
		b7602 Coordination of voluntary movements
		d4400 Picking up
		d4401 Grasping
		d4402 Manipulating
		d4403 Releasing
		d4450 Pulling
		d4451 Pushing
		d4452 Reaching
		d4453 Turning or twisting the hands or arms
		d4454 Throwing
		d4455 Catching
3. Vision	Seeing	b2100 Visual acuity functions
		b2101 Visual field functions
		b2102 Quality of vision
4. Audition	Hearing	b2300 Sound detection
	Ringing in ears	b2301 Sound discrimination
		b2302 Localisation of sound source
		b2303 Lateralization of sound
		b2304 Speech discrimination
		b2400 Ringing in ears or tinnitus
5. Dizziness	Feeling unsteady	b2402 Sensation of falling
	Dizzy	b2401 Dizziness
	Light-headed	
6. Motor speech	Clearness of speech	b3100 Production of voice
		b3101 Quality of voice
	Rate of speech	b320 Articulation functions
	Stuttering	b3300 Fluency of speech
		b3301 Rhythm of speech
		b3302 Speed of speech
		b3303 Melody of speech
7A. Verbal communication	Communication	b1670 Reception of language
	Expressing language	b1671 Expression of language
		b1672 Integrative language functions
	Understanding language	d166 Reading
		d170 Writing
		d310 Communicating with – receiving – spoken messages
		d320 Communicating with – receiving – formal sign language messages
		d325 Communicating with – receiving – written messages
		d330 Speaking
		d340 Producing messages in formal sign language
		d345 Writing messages
		d3600 Using telecommunication devices
		d3601 Using writing machines
		d3602 Using communication techniques
7B. Non-verbal communication	Non-verbal communication	d3150 Communicating with – receiving – body gestures
		d3350 Producing body language
		d3500 Starting a conversation
		d3501 Sustaining a conversation
		d3502 Ending a conversation
		d3503 Conversing with one person
		d3504 Conversing with many people
		d7104 Social cues in relationships
8. Attention/ concentration	Attention	b1400 Sustaining attention
	Concentration	b1401 Shifting attention
		b1402 Dividing attention
		b1403 Sharing attention
		d160 Focusing attention
9. Memory	Learning	b1440 Short-term memory
	Recalling new information	b1442 Retrieval of memory
10. Fund of information	Remembering information	b1441 Long-term memory
11. Novel problem-solving	Problem-solving	b1646 Problem-solving
		b1640 Abstraction
		b1641 Organization and planning
		b1642 Time management
		b1643 Cognitive flexibility
		b1645 Judgement
		d1750 Solving simple problems
		d1751 Solving complex problems
12. Visuospatial abilities	Drawing	b1561 Visual perception
	Assembling things	b1565 Visuospatial perception
		d3352 Producing drawings and photographs
	Route-finding	
	Being visually aware	

unique ICF categories identified; (*v*) the bandwidth of content coverage (i.e. the number of ICF categories that we were able to identify divided by the total number of ICF categories, i.e. 1454); and (*vi*) content diversity (i.e. the ratio of ICF categories to meaningful concepts identified). We also reported the number of mapped categories at specific ICF levels and the specific linkages between the MPAI-4 items and ICF categories. Finally, we reported on the 30 scoreable MPAI-4 items relating to the different environmental factors. Taken together, points (*i*) to (*vi*) give a quantitative summary of the mapping and enable a more concrete comparison with other instruments that are mapped to the ICF.

RESULTS

A summary of the mapping of the MPAI-4 to the ICF is shown in Table I. All items in the 3 subscales of the MPAI-4 could be

Table III. *Mapping of the Mayo-Portland Adaptability Inventory (MPAI-4) subscale Adjustment Index (Items 13–21) to the International Classification of Functioning, Disability and Health (ICF)*

Item	Meaningful concept	Main ICF code
13. Anxiety	Anxiety	b1341 Onset of sleep
	Being tense	b1520 Appropriateness of emotion
	Fearful	b1521 Regulation of emotion
	Flashbacks of stressful events	b1522 Range of emotion
14. Depression	Depression	b1302 Appetite
	Sad	b1340 Amount of sleep
	Hopeless	b1342 Maintenance of sleep
	Poor appetite	b1343 Quality of sleep
	Poor sleep	b1344 Functions involving sleep cycle
	Worry	
	Self-criticism	b1520 Appropriateness of emotion
		b1521 Regulation of emotion
		b1522 Range of emotion
15. Irritability, anger, aggression	Irritability	b1520 Appropriateness of emotion
	Anger	b1521 Regulation of emotion
	Aggression	b1522 Range of emotion
		b1304 Impulse control
16. Pain and headache	Pain	b2800 Generalized pain
	Headache	b2801 Pain in body part
		b28010 Pain in head and neck
		b2802 Pain in multiple body parts
		b2803 Radiating pain in a dermatome
		b2804 Radiating pain in a segment or region
17. Fatigue	Fatigue	b1300 Energy level
	Lack of energy	b4552 Fatiguability
	Tired	
18. Sensitivity to mild symptoms	Sensitivity to mild symptoms attributed to brain injury	b1601 Form of thought
		b1602 Content of thought
		b1603 Control of thought
		b1520 Appropriateness of emotion
	Concern of symptoms	b1644 Insight
		b1800 Experience of self
	Worry of symptoms	b1801 Body image
		b1802 Experience of time
19. Inappropriate social interaction	Social interaction	d7100 Respect and warmth in relationships
	Childish	d7101 Appreciation in relationships
	Silly	d7102 Tolerance in relationships
	Rude	d7103 Criticism in relationships
	Behaviour not fitting	d7104 Social cues in relationships
		d7105 Physical contact in relationships
		d7202 Regulating behaviours within interactions
		d7203 Interacting according to social rules
		d7204 Maintaining social space
20. Impaired self-awareness	Recognition of limitations	b1601 Form of thought
		b1602 Content of thought
	Recognition of disabilities	b1603 Control of thought
		b1520 Appropriateness of emotion
		b1644 Insight
		b1800 Experience of self
		b1801 Body image
		b1802 Experience of time
21. Family/ significant relationships	Interactions with close others	d6600 Assisting others with self-care
	Stress within the family	d6601 Assisting others in movement
	Cooperation to accomplish tasks to keep household running	d6602 Assisting others in communication
		d6603 Assisting others in interpersonal relations
		d6604 Assisting others in nutrition
		d6605 Assisting others in health maintenance
		d7600 Parent-child relationships
		d7601 Child-parent relationships
		d7602 Sibling relationships
		d7603 Extended family relationships
		d7701 Spousal relationships

mapped to components and categories in the ICF. A total of 88 meaningful concepts in the instrument were identified. For the 30 scoreable items of the MPAI-4, there were, on average, 2.9 meaningful concepts per item (content density), and 65% of all concepts could be mapped. Bandwidth, i.e. the breadth of the aspects measured, is represented by the absolute and relative number of the 1454 unique categories in the ICF that we were able to link to the items in the MPAI-4 (200; 14%). Content diversity was 2.3, indicating a relatively high amount of diversity, i.e. 2 or more ICF categories per meaningful concept on the average. The items in the MPAI-4 could be mapped to 34 (13%) of the 258 Environmental Factors in the ICF.

The results of the mapping are shown in Tables II–IV. It should be noted that several items could be mapped to the same ICF category, so the sum of all unique ICF categories is less than for the 3 subscales together (cf. Table I). In the Ability Index, the mapping was equally divided between Body Functions (b) categories and Activity/Participation (d) categories. Items in the Adjustment Index (not including the 3 that also contributed to the Participation Index) mapped primarily to Body Functions, but also to Activity/Participation categories. Of the 76 mappings for the Participation Index, all except 1 was to Activity/Participation categories. For all 3 subscales, 19 mappings were at the 3rd level (3 digits), 1 at the 5th level and the remaining at the 4th level.

The different MPAI-4 items and how they relate to the Environmental Factors in ICF are shown in Table V. Many of the MPAI-4 items could be mapped to the same environmental factor, but there were also several items that mapped to different factors. In summary, 14 of the 34 (41%) environmental factors were identified and used to map an item, whereas the other 20 environmental factors (59%) were linked to only 1 item.

DISCUSSION

Since the introduction of the ICF in 2001, there has been a rapid increase in the number of studies using the ICF in a variety of fields (2, 3, 6). With the development of a systematic set of rules for linking the ICF to existing health status measures, the nature of the measures can be clarified (5) and this will assist researchers and other users in selecting measures that

Table IV. *Mapping of the Mayo-Portland Adaptability Inventory (MPAI-4) subscale Participation Index (Items 22–29) to the International Classification of Functioning, Disability and Health (ICF)*

Item	Meaningful concept	Main ICF code
22. Initiation	Getting started on activities	b1301 Motivation
23. Social contacts with friends, work associates, and other people who are not family, significant others, or professionals	Social contacts with friends, work associates, and other people	d7200 Forming relationships d7500 Informal relationships with friends d7501 Informal relationships with neighbours d7502 Informal relationships with acquaintances d7503 Informal relationships with co-inhabitants d7504 Informal relationships with peers
24. Leisure and recreational activities	Leisure Recreational activities	d9100 Informal associations d9102 Ceremonies d9200 Play d9201 Sports d9202 Arts and culture d9203 Crafts d9204 Hobbies d9205 Socializing
25. Self-care	Self-care Eating Dressing Bathing Hygiene	d2301 Managing daily routine d2302 Completing the daily routine d2303 Managing one's own activity level d5100 Washing body parts d5101 Washing whole body d5102 Drying oneself d5200 Caring for skin d5201 Caring for teeth d5203 Caring for fingernails d5204 Caring for toenails d5300 Regulating urination d5301 Regulating defecation d5302 Menstrual care d5400 Putting on clothes d5401 Taking off clothes d5402 Putting on footwear d5403 Taking off footwear d5404 Choosing appropriate clothing d550 Eating d560 Drinking
26. Residence	Homemaking Meal preparation Home repairs Personal health maintenance	d2301 Managing daily routine d2302 Completing the daily routine d2303 Managing one's own activity level d5700 Ensuring one's physical comfort d5701 Managing diet and fitness d5702 Maintaining one's health d6300 Preparing simple meals d6301 Preparing complex meals d6400 Washing and drying clothes and garments d6401 Cleaning cooking area and utensils d6402 Cleaning living area d6403 Using household appliances d6404 Storing daily necessities d6405 Disposing of garbage d6500 Making and repairing clothes d6501 Maintaining dwelling and furnishings d6502 Maintaining domestic appliances d6503 Maintaining vehicles d6504 Maintaining assistive devices d6505 Taking care of plants, indoors and outdoors d6506 Taking care of animals
27. Transportation	Transportation	d4700 Using human-powered vehicles d4701 Using private motorized transportation d4702 Using public motorized transportation d4750 Driving human-powered transportation d4751 Driving motorized vehicles d4752 Driving animal-powered vehicles d480 Riding animals for transportation
28A. Paid employment	Employment Full-time Part-time Supported Sheltered	d825 Vocational training d840 Apprenticeship (work preparation) d8450 Seeking employment d8451 Maintaining a job d8500 Self-employment d8501 Part-time employment d8502 Full-time employment
28B. Other employment	Homemaking Studying Volunteer work Retired	d820 School education d830 Higher education d855 Non-remunerative employment
29. Managing money and finances	Managing money Managing finances Shopping Keeping an account	d6200 Shopping d860 Basic economic transactions d865 Complex economic transactions

relate to specific outcomes, as described in the ICF. Despite this development and our knowledge of the importance of such a rigorous and somewhat time-consuming process, too few existing measures have been mapped to the ICF. With all the advantages of this process, we can assume that further efforts will be undertaken to perform such work.

The process of mapping the MPAI-4 to the ICF revealed the MPAI-4 to be a relatively diverse and broadly based assessment instrument characterized by 88 meaningful concepts

Table V. *Mapping the Mayo-Portland Adaptability Inventory (MPAI-4) to the Environmental Factors of the International Classification of Functioning, Disability and Health (ICF)*

Item number of the MPAI-4	Environmental categories
	Chapter 1: Products and Technology
1–20, 22, 25	e110 Products or substances for personal consumption
1–20, 22, 25, 26	e115 Products and technology for personal use in daily living
1, 27	e120 Products and technology for personal indoor and outdoor mobility and transportation
6, 7A, 7B	e125 Products and technology for communication
28B	e130 Products and technology for education
28A	e135 Products and technology for employment
24	e140 Products and technology for culture, recreation and sport
26	e155 Design, construction and building products and technology of buildings for private use
29	e165 Assets
	Chapter 2: Natural environment and human-made changes to environment
3	e240 Light
4	e250 Sound
	Chapter 3: Support and relationships
21	e310 Immediate family
21	e315 Extended family
23	e320 Friends
23	e325 Acquaintances, peers, colleagues, neighbours and community members
	Chapter 4: Attitudes
21	e410 Individual attitudes of immediate family members
21	e415 Individual attitudes of extended family members
23	e420 Individual attitudes of friends
23	e425 Individual attitudes of acquaintances, peers, colleagues, neighbours and community members
19, 21, 23, 24, 26, 27, 28A, 28B, 29	e460 Societal attitudes
19, 21, 23, 24, 26, 27, 28A, 28B, 29	e465 Social norms, practices and ideologies
	Chapter 5: Services, systems and policies
1, 3, 23, 24, 26, 28A, 28B	e515 Architecture and construction services, systems and policies
1, 3, 23, 24, 26	e520 Open space planning services, systems and policies
26	e525 Housing services, systems and policies
25, 26, 27, 28A, 28B, 29	e530 Utilities services, systems and policies
3, 4, 6, 7A, 7B, 23, 24, 28A, 28B, 29	e535 Communication services, systems and policies
27	e540 Transportation services, systems and policies
23, 24, 28B	e555 Associations and organizational services, systems and policies
29	e565 Economic services, systems and policies
23, 24, 25, 26, 27, 28B, 29	e570 Social security services, systems and policies
23, 24, 25, 26, 27, 28B, 29	e575 General social support services, systems and policies
1-20, 22, 25, 26	e580 Health services, systems and policies
28B	e585 Education and training services, systems and policies
28A	e590 Labour and employment services, systems and policies

that mapped to 200 unique ICF categories. A large majority (90%) of mappings could also be made at the specific 4th level of the ICF. As might be expected, the MPAI-4 Ability and Adjustment Indices were mainly mapped to the Body Functions categories. However, items on these subscales also mapped frequently to the Activity/Participation ICF categories. For example, a thorough assessment of even basic abilities, such as language reception and expression, often requires evaluation of more complex communication activities. These mappings to the Activity/Participation domain are consistent with the original design of the MPAI-4 as an evaluation of abilities that are instrumental to activities of daily living, adaptation and community integration.

The success of the mapping procedure and the rich linkages that were identified between most items of the MPAI-4 and the ICF provide evidence of the construct validity of the MPAI-4. However, our intention in conducting this mapping procedure was not to evaluate how well the MPAI-4 could be translated into ICF terms by most users. Rather, our small group of two expert users and one of the developers of the MPAI-4 (instead of a larger group of raters, as suggested in the linking rules (4, 5)) intended to augment the understanding of the MPAI-4 items through examples furnished by the ICF and to enhance the usefulness of the MPAI-4 in this way. Mapping the MPAI-4 to the categories of the ICF provides a more detailed description through examples of the types of functions and activities that are represented by each item.

For the speech and communication items of the MPAI-4, the intent was to cover communication broadly in both basic functions and activities, but not to include an assessment of more complex human activities, such as, conversation and discussion (d350). Mapping the ICF to the MPAI-4 item "Non-verbal communication" allowed a more detailed description of this item describing not only non-verbal means of communication, e.g. gestures, but also the pragmatics of communication, e.g. starting and ending conversations appropriately, and conversing with multiple people. Similarly, the item "Use of hands" was intended to cover the use of hands in daily activities;

hence, the mappings were mainly to categories in the Activity/Participation component.

This study also suggested possible limitations of and challenges to the ICF taxonomy when being used in a mapping process. For example, "short-term" and "long-term" memory have different meanings in different contexts. We believe that the MPAI-4 memory item, which rates new learning capacity, was appropriately mapped to the ICF category "short-term memory" and that the MPAI-4 "Fund of Information" item (which refers to remotely acquired knowledge) was appropriately mapped to the ICF category "long-term memory". However, in other contexts, both short-term and long-term memory can refer to different components of the new learning process. The division between functions and activities is at times vague in the cognitive domain. The MPAI-4 "Problem-solving" item mapped to "solving simple problems" and "solving complex problems" in the Activity/Participation component and also mapped to apparently similar cognitive functions, e.g. "problem-solving", "organization" and "time management", in the Body Functions component.

The items "Anxiety", "Depression", and "Irritability/Anger/Aggression" in the MPAI-4 did not map to any specific ICF categories. Instead, these items mapped to more general categories describing appropriateness, regulation, and range of emotions in the ICF. The ICF is focused on positive functions and activities rather than psychopathology. However, identification of more specific human functions and activities that assist in the regulation of specific negative emotions would appear to be a necessary elaboration of the ICF. For instance, specific coping skills to prevent persistence of depression might be identified distinctly from coping skills involved in managing aggressive impulses following an ABI. Similar shortcomings were found for the MPAI-4 items "Sensitivity to Mild Symptoms" and "Impaired Self-awareness". While the MPAI-4 item "Initiation" could be mapped to the ICF category "Motivation", other categories are lacking to more fully describe the cognitive and affective processes involved in beginning and sustaining a behavioural sequence appropriately.

On the other hand, the MPAI-4 "Self-care" and "Residence" items were mapped to substantially more ICF categories. In these cases, the ICF provides a detailed listing of activities that might be targeted for intervention in a rehabilitation plan for those individuals who are rated with limitations and restrictions in these areas on the MPAI-4. In general, mapping of the Participation Index of the MPAI-4 to the ICF (cf. Table IV) was relatively rich, detailed, and not specific to ABI. With reference to these ICF linkages, the Participation Index may furnish an extensive list of goals for the rehabilitation process for individuals with ABI as well as other disability groups. Assessments with the Participation Index identifies the broad areas for intervention and provides a quantifiable measure of progress, whereas, the ICF linkages identify specific activities for rehabilitation.

Although the MPAI-4 was not intended to assess environmental factors relevant to brain injury medicine and rehabilitation, many items could be mapped to many of the ICF Environmental categories. This provides additional information that may be used to enhance the rehabilitation process by identifying intervention targets not only within the person but also within his or her environment.

In conclusion, this study shows that all items in the MPAI-4 could be mapped to the ICF and a standard coding framework. This provides better definition through more concrete examples (as listed in the ICF) of the types of body functions, activities, and participation indicators that are represented by each of the MPAI-4 items. Thereby, ICF descriptors, which are meant to be transcultural, may assist MPAI-4 users throughout the world in understanding the intent of each item. Successful mapping also offers a type of construct validation for the MPAI-4, in that a relationship between the MPAI-4 metric and the widely accepted ICF taxonomy were established. In a broader perspective, such a rigorous process may support further development of the MPAI-4 and the possibility of reporting results obtained with the MPAI-4 in the form of an ICF categorical profile, making it universally interpretable.

ACKNOWLEDGEMENTS

The study was completed within the context of the Centre for Ageing and Supportive Environments (CASE) at Lund University, funded by the Swedish Council for Working Life and Social Research. Financial support was received from Skane County Council's research and development foundation and from Norrbotten County Council.

REFERENCES

1. World Health Organization (WHO). International Classification of Functioning, Disability and Health. Geneva: World Health Organization; 2001. Avalible from: www.who.int/classifications/icf/en.
2. Stucki G, Cieza A, Melvin J. The International Classification of Functioning, Disability and Health: a unifying model for the conceptual description of the rehabilitation strategy. J Rehabil Med 2007; 39: 279–285.
3. Cieza A, Stucki G. The International Classification of Functioning, Disability and Health: its development process and content validity. Eur J Phys Rehabil Med 2008; 44: 303–313.
4. Cieza A, Brockow T, Ewert T, Amman E, Kollerits B, Chatteri S, et al. Linking health-status measurements to the international classification of functioning, disability and health. J Rehabil Med 2002; 34: 205–210.
5. Cieza A, Geyh S, Chatterji S, Kostanjsek N, Üstün B, Stucki G. ICF linking rules: an update based on lessons learned. J Rehabil Med 2005; 37: 212–218.
6. Fayed N, Cieza A, Bickenbach JE. Linking health and health-related information to the ICF: a systematic review of the literature from 2001 to 2008. Disabil Rehabil 2011; 33: 1941–1951.
7. Moriello C, Byrne K, Cieza A, Nash C, Stolee P, Mayo N. Mapping the Stroke Impact Scale (SIS-16) to the International Classification of Functioning, Disability and Health. J Rehabil Med 2008; 40: 102–106.
8. Geyh S, Cieza A, Kollerits B, Grimby G, Stucki G. Content comparison of health-related quality of life measures used in stroke based on the international classification of functioning, disability and health (ICF): a systematic review. Qual Life Res 2007; 16: 833–851.
9. Resnik L, Plow MA. Measuring participation as defined by the international classification of functioning, disability and health: an evaluation of existing measures. Arch Phys Med Rehabil 2009;

90: 856–866.
10. Malec JF, Kragness M, Evans RW, Finlay KL, Kent A, Lezak MD. Further psychometric evaluation and revision of the Mayo-Portland Adaptability Inventory in a national sample. J Head Trauma Rehabil 2003; 18: 479–492.
11. Malec J. The Mayo-Portland Adaptability Inventory. The Center for Outcome Measurement in Brain Injury. 2005. Available from: http://www.tbims.org/combi/mpai [cited October 18 2011].
12. Bohac DL, Malec JF, Moessner AM. Factor analysis of the Mayo-Portland Adaptability Inventory: structure and validity. Brain Inj 1997; 11: 469–482.
13. Malec JF, Moessner AM, Kragness M, Lezak MD. Refining a measure of brain injury sequelae to predict postacute rehabilitation outcome: rating scale analysis of the Mayo-Portland Adaptability Inventory. J Head Trauma Rehabil 2000; 15: 670–682.
14. Jacobsson LJ, Westerberg M, Söderberg S, Lexell J. Functioning and disability 6–15 years after traumatic brain injuries in northern Sweden. Acta Neurol Scand 2009; 120: 389–395.
15. Cattelani R, Corsine D, Posteraro L, Agosti M, Saccavani M. The Italian version of the Mayo-Portland Adaptability Inventory-4. A new measure of brain injury outcome. Eur J Phys Rehabil Med 2009; 45: 513–519.
16. Wright BD, Masters GN. Rating scale analysis. Chicago: Mesa Press; 1982.