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ORGANIZING HUMAN FUNCTIONING AND REHABILITATION RESEARCH INTO DISTINCT SCIENTIFIC FIELDS. PART II: CONCEPTUAL DESCRIPTIONS AND DOMAINS FOR RESEARCH*

Gerold Stucki[1,2,3], Jan D. Reinhardt[3] and Gunnar Grimby[4]

From the [1]Department of Physical Medicine and Rehabilitation, [2]ICF Research Branch of the WHO CC FIC (DIMDI), Institute for Health and Rehabilitation Sciences, Ludwig-Maximilian University, Munich, Germany, [3]Swiss Paraplegic Research, Nottwil, Switzerland and [4]Rehabilitation Medicine, Institute of Neuroscience and Physiology, Sahlgrenska Academy, Göteborg University, Göteborg, Sweden

Human functioning and rehabilitation research can be organized into 5 distinct scientific fields. The objective of this paper is to provide conceptual descriptions and to outline selected research domains for 4 of the 5 distinct scientific fields. A conceptual description of the biosciences in rehabilitation and the presentation of respective research domains are beyond the scope of this paper. The research domains of the human functioning sciences can be identified and described according to the generic research process, which involves theory building and observation. The according domains include theory and models of human functioning, classification and measurement of functioning, functioning epidemiology and functioning impact assessment. The research domains of the integrative rehabilitation sciences can be identified and described by drawing on the public health approach. They include rehabilitation services research, rehabilitation intervention research and rehabilitation administration and management. There are many conceivable research domains within the realms of the biomedical rehabilitation sciences and engineering. They are often defined in relation to an organ system or in relation to an intervention approach. The research domains of the professional rehabilitation sciences are well established and include professional standards and guidelines for the provision of best care, rehabilitation quality management, scientific education and training of professionals in rehabilitation, and development and evaluation of the rehabilitation team.

Key words: rehabilitation, science, research, ICF, classification.

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Correspondence address: Gerold Stucki, Department of Physical Medicine and Rehabilitation, University Hospital Munich, Marchioninistrasse 15, DE-81377 Munich, Germany. E-mail: gerold.stucki@med.uni-muenchen.de

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INTRODUCTION

There is an acknowledged need to organize human functioning and rehabilitation research into distinct scientific fields in order to enhance research capacity (1–4). The first step towards distinct scientific fields is the development of a comprehensive structure from the cell to society. Based on the World Health Organization's (WHO) unifying conceptual model of functioning (5) and key distinctions common both to research in general and to rehabilitation in particular we have developed such a structure (2). Within this structure we have identified 5 distinct scientific fields of human functioning and rehabilitation research (2).

The objective of this paper is to provide conceptual descriptions and to outline selected research domains for 4 of the 5 distinct scientific fields. A conceptual description of the biosciences in rehabilitation and a presentation of respective research domains are beyond the scope of this paper.

CONCEPTUAL DESCRIPTIONS

Tables I–IV show ICF-based conceptual descriptions of the human functioning sciences, integrative rehabilitation sciences, biomedical rehabilitation sciences and engineering, and professional rehabilitation sciences. A description of physical and rehabilitation medicine (PRM) as an example of a rehabilitation profession applying and contributing to scientific knowledge in human functioning and rehabilitation can be found in an accompanying paper (6). In order to illustrate the conceptual descriptions, selected research domains are outlined in the next section.

DOMAINS FOR RESEARCH

Human functioning sciences

The human functioning sciences aim to understand human functioning and to identify targets for comprehensive interventions, with the goal of contributing to the minimization of the experience of disability in the population.

As with any basic science, the domains of research in human functioning sciences reflect the generic research process (7, 8). According to this process, scientific observation without theory is impossible, and scientific discovery is always made against the background of paradigms that are more or less shared in the scientific community (9). Without theory and theoretical description we would not know what to observe and study. But

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Table I. *ICF-based conceptual description of human functioning sciences. Terms referring to components of the ICF model are written in bold.*

Human functioning sciences
are basic sciences, which,
based on WHO's integrative **model of human functioning and disability**
and focusing on populations:

- develop and test theories and models of **functioning**;
- develop classifications and measurements of **functioning**;
- study the incidence, prevalence, and distribution of factors associated with **functioning** and **disability** across **health conditions**, populations and **environments**, and over time;
- predict the impact of intended and non-intended changes in the physical and social **environment** on **functioning** including the impact of:
  proposals (policies, programmes and projects) in the health sector and across sectors;
  changes in the provision of and the payment for services;
  the costs and benefits of implementing new products and procedures;
- inform and advise the public, policy- and decision-makers about the burden associated with **health conditions** and the consequences of intended and non-intended changes in the physical and social **environment** on **functioning**,

with the goal:
to contribute to the understanding of **functioning** of people with **health conditions** and the minimization of the experience of **disability** in the population and in specific groups.

Table II. *ICF-based conceptual descriptions of integrative rehabilitation sciences. Terms referring to components of the ICF model are written in bold.*

Integrative rehabilitation sciences
are applied sciences, which,
based on the understanding of **human functioning**
and the rehabilitation strategy:

- identify what is currently done vs what could be done at the clinical and community level and study how to close the gap;

including:
the study of the laws which provide the institutional framework for policy-making, the policy- and law-making process, the implementation of laws and the identification of differences between "law on the books" and "law in practice";'
the study of the use, accessibility, delivery, costs, organization, financing, outcomes and quality of rehabilitation and related services;
for example, the development of payment schemes that facilitate and provide incentives for optimal service provision within and across services and across sectors;

- assess the evidence with regard to the safety, efficacy, effectiveness, and cost-effectiveness of products, procedures and intervention programmes;
- examine and compare, develop and evaluate and, where appropriate, modify intervention programmes based on and integrating:
  biomedical and engineering approaches to optimize **capacity**;
  approaches which build on and strengthen the resources of the **person**;
  approaches which provide a facilitating **environment**; and
  approaches which develop a person's **performance** in the interaction with the **environment**.
- identify **barriers** and **facilitators** to the implementation of more effective services, intervention programmes, products and procedures into practice and develop approaches for more effective implementation;
- develop and evaluate management concepts and tools for the continuum of care from the acute hospital to the community and across services, payers and sectors from the perspective of and useful for:
  intervention programme directors, service providers and payers;
  communities and public administrators;
- inform and advise the public and decision-makers about suitable policies, laws, service provision, payment schemes and intervention programmes which:
  ensure broad access to rehabilitation and health services and community services as a human right;
  empower service providers, intervention programme directors, professionals and communities to provide timely and effective services and care

with the goal:
to contribute to the optimal provision of services and the **performance** of people with a health condition experiencing or likely to experience disability.

for the testing of theories and hypotheses it may also hold true, "that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind" (10).

Applying these considerations to human functioning, the according domains for research can be described as theories and models of human functioning, classification and measurement of human functioning, human functioning epidemiology and human functioning impact assessment (Table V). The last 2 domains refer to concrete scientific observation. While human functioning epidemiology refers to the observation of *current* functioning in the population, human functioning impact assessment models *future* functioning in relation to intended or non-intended changes in the physical and social environment.

Theory and models of human functioning. It has recently been stated for rehabilitation research that theory development has traditionally been neglected leading to frictions in empirical theory testing and a lack of public recognition of rehabilitation as a unified scientific area (11). Hence, the human functioning sciences should be comitted to theoretically enriching the conceptual framework of functioning and disability provided by WHO's International Classification of Functioning, Disability and Health (ICF) (5).

The aim of a respective domain is thus the development and validation of theories and models of human functioning. Ultimately, the aim is to develop a comprehensive or general theory of human functioning and disability applicable to different health conditions, persons and environments.

Human functioning scientists pursuing research in the domain of theories and models of functioning should have a background in related scientific disciplines such as philosophy, sociology, behavioural sciences or mathematics. Their theories and models will provide the foundation for the development of theoretically sound classifications and measurements and the

Table III. *ICF-based conceptual descriptions of biomedical rehabilitation sciences and engineering. Terms referring to components of the ICF model are written in bold.*

Biomedical rehabilitation sciences and engineering
are applied sciences, which,
from the biomedical perspective of **human functioning,**
develop and evaluate:

- diagnostic measures for the assessment of **impairment in body functions** and **structures** as well as the evaluation of **capacity** with regard to activity;
  including physical diagnostics, e.g. electro-neurophysiologic testing, assessment of endurance, strength and coordination, and testing of cognitive function;
- interventions to stabilize, improve, restore or compensate for **impaired body functions** and **structures**;
  including, e.g. autonomous dysregulation; deconditioning; incontinence; sleep and swallowing disturbance; joint instability; pain, fatigue; memory problems and other mental symptoms; amputations; vision and hearing impairments;
- *interventions to prevent secondary* **impairment,** *medical complications and risks;*
  including, e.g. depression, sleep disturbance, skin ulcers, thrombosis, joint contractures and muscle atrophy, osteoporosis and fractures due to falls;

applying a wide range of techniques;
including physical modalities such as mechano-therapy including massage, exercise, strengthening and mobilization techniques, heat and cold, water and balneology, light and climate, electric currents including functional electro-physiological stimulation; neuropsychological interventions; acupuncture, nerve root blockades and local infiltrations; nutritional and pharmacological interventions; engineering techniques including, e.g. implants, prostheses and orthoses, aids and devices; and the teaching of new skills;

with the goal:
to contribute to the minimization of impairment and optimal **capacity** and safety of people with a **health condition**.

Table IV. *ICF-based conceptual descriptions of professional rehabilitation sciences. Terms referring to components of the ICF model are written in bold.*

The professional rehabilitation sciences
are professional sciences, which,
based on and rooted in the rehabilitation professions and according experiences with **human functioning** and **disability** in professional practice:

study how to provide best care;
including the prevention or minimization of **impairment**, **activity limitations** and **participation restrictions** of people with a **health condition** in specific settings,

by developing, implementing and evaluating:

- standards and guidelines for the optimal provision of care in rehabilitation practice
  including principles of evidence-based medicine and medical decision-making;
- systems of rehabilitation quality management ensuring iterative quality improvement and continuously learning organizations;
  in order to uncover gaps between standards and practice as well as between supply and demand;
  and to apply knowledge about what works in principle to continuously improve processes of care and support as well as patient outcomes in a particular setting
- curricula and courses for the education and training of rehabilitation professionals which aim at the application of scientific methods in rehabilitation
- methods to build and improve the performance of inter- or trans-disciplinary teams in rehabilitation practice;

with the goal:
to enable people with **health conditions** experiencing or likely to experience **disability** to achieve and maintain optimal functioning in interaction with the evironment..

planning of meaningful epidemiological studies and functioning impact models.

The starting point for the development of theories and models is often undertaken from a partial perspective. To understand human functioning from the environmental factor perspective, human functioning scientists thus may collaborate with, for example, economists and cultural anthropologists as well as with political and law scientists. They may also work with public health scientists with an expertise in health systems and policy research or with architects and engineers with an expertise in the built environment. A key topic from the environmental factor perspective is, for example, the study of how political, economic and cultural structures interact with the views and attitudes towards disability, for instance with respect to inclusion and exclusion. The basis for this research is the study of perceptions of, actions towards, and the communication about people experiencing disability. Another key topic is the study of how the built environment interacts with functioning of people with varying health conditions. An example is the analysis of the secular trend towards universal design.

To understand human functioning from the personal factor perspective, human functioning scientists may co-operate with behavioural scientists and psychologists. A key topic from the personal factor perspective is the study of how certain traits, such as health locus of control, influence coping styles and the experience of disability.

To understand human functioning from the biomedical perspective, human functioning scientists may collaborate with clinician-scientists with an expertise in congenital and developmental disorders, chronic disease, injury or ageing, or with movement scientists and physiologists with an expertise in body functions and activities. The comparison and exchange of theories and models across conditions and impairments can provide human functioning scientists with most valuable insights and ideas. Vice versa, clinician scientists, movement scientists and physiologists who see functioning primarily as a consequence of disease or in relation to impairments would benefit from a broader understanding of human functioning.

While theories and models are often developed from a partial perspective, there is the need to develop a better understanding of the complex interactions between these points of view. In terms of the ICF model, there is the need to better understand the interplay of the constituent components; i.e. the arrows in its graphical depiction. A major task in the following years is thus the development and application of transdisciplinary theories and models (12) that are able to link the partial perspectives.

Table V. *Domains of research in 4 distinct scientific fields of human functioning and rehabilitation research.*

Human functioning sciences
Theory and models of functioning
Classification and measurement of functioning
Functioning epidemiology
Functioning impact assessment
Integrative rehabilitation sciences
Rehabilitation services research, including health policy and law, rehabilitation economics and community-based participatory research;
Rehabilitation intervention research, including rehabilitation intervention programme research; rehabilitation technology assessment in clinical and community settings, technology transfer; and applying research designs ranging from randomized controlled trials to observational studies;
Rehabilitation administration and management, including the development of integrated care and service concepts and ICF-based case management programmes as well as the design of other structures and processes in rehabilitation institutions.
Biomedical rehabilitation sciences and engineering
Research in relation to organ systems, e.g. cardiopulmonary, musculoskeletal or neurological rehabilitation research
Research in relation to intervention principles, e.g. rehabilitation engineering, occupational therapy and physiotherapy research, drug trials
Professional rehabilitation sciences
Standards and guidelines for the provision of best care
Rehabilitation quality management
Scientific education and training of professionals in rehabilitation
Development and evaluation of the rehabilitation team

For example, participation in society is only possible through the incumbency of social roles. Roles include, by definition, normative expectations of the social environment, but also provide more or less space for subjective experience and personal evolvement. For example, a scientist has more leeway in shaping his role than does a factory worker on the assembly line. Roles therefore influence, for example, locus of control (13), which is a personal factor. Additionally, role expectations of the same roles vary across cultures. Thus potential environmental barriers may be perceived in different ways. In this context, differences concerning the sick role (14, 15) may be important. When a person is cared for like a child, and is not expected to leave the house autonomously, he or she may not encounter certain environmental barriers (16). Conversely, personal factors, such as coping behaviours, may influence the management of role conflicts. Also, psychological distress entailed by role conflicts, may directly affect body functions and structures (17).

The study of the complex interactions of the components and elements of human functioning may rely on mathematical models suitable for analysing complex data structures. The analysis of complex data structures based on the integrative model of human functioning goes beyond analyses used in public health based on the ecological model. Based on the ecological model, determinants of health ranging from genes to social and behavioural variables are examined. Analyses therefore deal with a defined dependent variable (health vs disease). The determinants are generally analysed as unidirectional independent variables. While models of human functioning may also explain a dependent variable, e.g. work participation, they should also model the complex interactions between the components and elements of human functioning (18). Health conditions, personal and environmental factors should be analysed as associated with functioning rather than as unidirectional determinants of functioning (18). Human functioning scientists are thus challenged to identify, apply and possibly further develop suitable methods used in other scientific disciplines and fields. For this they may, for instance, consider methods developed in bioinformatics, such as graphical modelling used to study the interactions of genes and gene expression.

Classification and measurement of human functioning. In one way or another, virtually all scientists are involved in the development, modification and testing of instruments used to describe, classify and measure their study objects. The human functioning sciences must develop a wide range of instruments for clinical practice, clinical trials and outcomes studies, health services and quality of life studies, as well as international surveys.

Arguably due to its complexity, the classification and measurement of human functioning is now highly specialized. Human functioning scientists working in this domain may have a background in the related scientific disciplines of psychology or the behavioural sciences, or in the clinical sciences including PRM, with an additional qualification in epidemiology. They may have been trained or may have worked in outcomes or quality of life research. Their methodological expertise should be in psychometrics including classical test theory, recent item response theory and Rasch analysis. They should work closely with all other domains on the selection, comparison, testing, validation, adaptation and development of measures suited to a specified purpose or situation.

Currently, human functioning scientists are faced with the challenge of mapping the world of the ICF classification to the world of health status, outcome and quality of life measures. The potential of the ICF, methodological challenges in its application and ways to apply the ICF to the classification and measurement of human functioning have been described elsewhere (19–21).

Human functioning epidemiology. The aim of human functioning epidemiology is to examine the incidence, prevalence and distribution of factors associated with human functioning and disability across health conditions, populations and environments, and over time. The ultimate goal is to understand functioning of people with health conditions and how to prevent or minimize the experience of disability in the general population and in specific groups.

Scientists in this area may have a background in related scientific disciplines, such as epidemiology, statistics and public health.

Human functioning epidemiologists should co-operate with human functioning scientists engaged in theories and models, with the aim of validating their theories and models

or of generating new hypotheses. They may also co-operate with human functioning scientists focusing on classification and measurement in the development of instruments suitable for epidemiological studies. Moreover, they can provide valid empirical data for functioning impact models. In the future, human functioning epidemiologists will be challenged with the integration of genomic information in their studies to explore disability in the presence of a health condition in relation to genes.

There is a wide range of conceivable epidemiological studies of human functioning. They include studies in groups of people with a specific health condition in clinical settings, as well as studies of people's experiences of disability in the community or in the general population. To examine the influence of specific health conditions as well as environmental and personal factors on functioning, human functioning epidemiologists may conduct international surveys in which all these factors vary. An example is the ongoing international testing and validation study of the ICF Core Set development project (19, 22–26).

Human functioning epidemiologists may co-operate with integrative rehabilitation scientists in the planning, conduct and analysis of health services and quality of life studies in groups of people with a health condition or in the general population. Such studies increasingly require a transdisciplinary research approach (12), a comprehensive understanding of interventions, and the involvement of community partners through community-based participatory research (27).

Human functioning epidemiologists co-operate with integrative and biomedical rehabilitation scientists and rehabilitation engineers as well as with rehabilitation professionals in the planning and analysis of clinical outcomes studies. The use of ICF-based outcome instruments or the systematic linkage of outcome instruments used in different phases of recovery to the ICF (28) facilitates the modelling of functioning along the continuum of care from the acute hospital phase to reintegration in the community. The main goals are to gain an improved understanding of the course of recovery and to identify major outcome determinants. The identification of such determinants can lead to better predictions, assignment to appropriate services and the development of interventions targeting the most relevant and relatively well modifiable determinants. Human functioning scientists may accordingly initiate or co-operate in consecutive intervention trials testing the efficacy, effectiveness and efficiency of respective interventions.

Functioning impact assessment. Human functioning scientists in this domain aim to predict the impact of intended and non-intended changes in the physical and social environment on functioning. The methods for impact assessment have been established in other areas, e.g. environmental, social and health impact assessment (29, 30). The research domain is of interest to human functioning scientists with a background in a wide range of related scientific disciplines and with an expertise in modelling or decision sciences.

The aim of human functioning scientists engaged in this area is to provide policy- and decision-makers with relevant information on the impact of intended changes and possibly to identify and compare alternatives. This will enable policy- and decision-makers to make rational choices beyond best guesses, based on appropriate scientific evidence. Ultimately, this may contribute to better functioning of groups of people with health conditions and thus contribute to future population health.

There is a wide range of conceivable topics. These include the study of expected changes which are obviously or directly related to health and functioning. However, they also involve expected changes that are not, or are only indirectly, related to health and functioning, e.g. regulations in relation to food production and marketing, public transportation and building construction.

Another important topic is the prognosis of dissemination and implementation trends with respect to new products or procedures and new services or payment schemes. Typical examples include the study of the costs and benefits associated with the implementation of a new rehabilitation technology.

In the case of products and procedures, impact assessment can build on assessments of their efficacy, effectiveness and cost-effectiveness provided by health technology assessment. Methodologically and conceptually, there is a close relationship between impact assessment and technology assessment. While technology assessment examines the evidence regarding the efficacy, effectiveness and cost-effectiveness of a product or procedure, impact assessment examines diffusion processes and the impact of the implementation of new products or procedures in the target population. Both approaches typically integrate qualitative and quantitative approaches.

In the future, human functioning scientists may model the relative benefits and costs of competitive policies in relation to the ICF components. This ranges from investment in medicine and rehabilitation services to alternative investment in labour, education or the physical environment. Such comparisons will enable policy- and decision-makers to spend resources optimally.

Human functioning scientists engaged in this area may themselves become active and develop and assess innovative policies based on their understanding of the determinants of human functioning and bring them to the attention of the public, disability advocacy organizations and policy- and decision-makers.

Integrative rehabilitation sciences

The integrative rehabilitation sciences design and study comprehensive assessments and interventions that integrate biomedical, personal factor and environmental approaches suited to optimize people's performance.

The population focus and the community perspective in relation to the interaction with the environment are quite similar to the approach taken in public health. When outlining research domains for integrative rehabilitation sciences, one may therefore draw on domains established in public health. They encompass health services research including: health policy and law and health economics; health administration and management; health intervention research; health technology assessment and technology transfer. There are comprehensive

descriptions of these domains in the public health literature (31, 32). Accordingly, in the following paragraphs we outline selected and exemplary research domains for the integrative rehabilitation sciences (Table V). While rehabilitation services research identifies service gaps and designs respective interventions, rehabilitation intervention research examines the efficacy, effectiveness and efficiency of a wide range of rehabilitation interventions and across settings. Rehabilitation management and administration develops organizational concepts suitable for the delivery of comprehensive care and services.

Rehabilitation services research. Rehabilitation services research is rooted in and committed to the communities it serves. It is therefore an inherently applied research domain and focuses on the local reality. Rehabilitation service research identifies what is currently done as opposed to what could be done at the community level and studies how to close the gap.

Integrative rehabilitation scientists thus study the use, accessibility, delivery, costs, organization, financing, outcomes and quality of rehabilitation and related services. They then identify, develop and communicate effective ways concerning how to organize, manage, finance, and deliver high-quality and broadly accessible services. Finally, they identify barriers and facilitators for the implementation of more effective services and develop approaches to overcome them.

Integrative rehabilitation scientists in this domain should have a background in PRM, a rehabilitation profession or in a related scientific field, including sociology, psychology or economics. The work approach is per definition highly interdisciplinary. Scientists in this domain may work closely with epidemiologists and many related disciplines when identifying the problems and needs of groups of people with a health condition or when examining how, for example, financing systems, organizational structures and processes, rehabilitation technologies, and lifestyles affect access to healthcare, the quality and cost of healthcare, and ultimately functioning and disability.

Rehabilitation services researchers may also work with economists in the area of rehabilitation economics to develop payment schemes that facilitate and provide incentives for optimal service provision within and across services and sectors. Similar to trends in public health (31), integrative rehabilitation scientists may in the future also move towards community-based participatory research (CBPR). According to the American National Institute of Health (33) CBPR is a methodological approach "that promotes active community involvement in the processes that shape research and intervention strategies, as well as in the conduct of research studies."

Another important area that has been largely neglected is policy and law. Law provides the institutional framework and procedures with which policies are debated, codified, implemented and interpreted (34). Research in this area can help to understand how policies and laws relevant to rehabilitation are made and whether there are differences between "law on the books" and "law in practice" that would potentially result in lost opportunities (35).

Rehabilitation intervention research. Research in this domain systematically reviews and assesses products and procedures for professional interventions in clinical as well as community settings and their use by people with health conditions (rehabilitation technology assessment). It develops and evaluates rehabilitation intervention programmes (rehabilitation intervention programme research) and explores ways to implement research into practice (technology transfer; dissemination and implementation research; get research into practice research). Research designs range from randomized controlled trials to observational studies.

Rehabilitation technology assessment informs professionals, payers and providers, the public and disability advocacy organizations about the evidence with regard to the safety and cost-effectiveness of products and procedures. It also provides the essential information for the compilation of rehabilitation intervention programmes integrating a number of products and procedures.

Rehabilitation intervention programme research examines and compares, develops and evaluates and, where appropriate, modifies intervention programmes based on and integrating biomedical and engineering approaches to optimize capacity, approaches which build on and strengthen the resources of the person, approaches which provide a facilitating environment and approaches which develop a person's performance in the interaction with the environment. Rehabilitation intervention programmes are evaluated with respect to their safety, efficacy, effectiveness, cost-effectiveness and quality. Researchers use methods established in programme evaluation, economic evaluation and decision sciences.

Programme evaluation is a very challenging task. Studies have to deal with much more heterogeneity of study subjects, settings, interventions and contextual factors than in classical clinical trials that evaluate a clearly defined single intervention in a homogenous population and standardized setting. Researchers are also faced with the difficulty to "open the black box" by identifying the relative contribution of individual interventions as well as the added value of the overall programme (36).

Another major challenge is the development and evaluation of long-term strategies involving repeated provision of intervention programmes. Examples are re-rehabilitation programmes to maintain the level of functioning achieved in a first-rehabilitation. Rehabilitation intervention programmes may be developed for inpatient or outpatient services or for the community. Payers of programmes and hence stakeholders for research and their willingness to pay for intervention programmes may considerably vary and involve not only the health but also other sectors including education, labour and social affairs. A major challenge both for research and implementation is the frequent situation in which one payer or sector would have to pay for a programme that results in a cost reduction for another payer or sector. For example, health insurers may be reluctant to pay for rehabilitation intervention programmes in the acute hospital if this results in additional costs, despite the fact that savings for subsequent services paid for by another payer would outweigh these additional costs.

Integrative rehabilitation scientists involved in rehabilitation intervention research generally do not themselves develop biomedical products and procedures or interventions from the personal or environmental perspectives. However, they may explore how intervention principles within the realms of these areas can be applied within rehabilitation intervention programmes. Hence they may, for example, collaborate with behavioural scientists, psychologists, health education and health promotion researchers with respect to the application of interventions in relation to coping, motivation, self-management and healthy lifestyles. A related important topic in this regard is the development of health and wellness strategies for people with health conditions.

Rehabilitation intervention researchers may also work with occupational therapists, architects and engineers and product designers on the application of interventions for independent living, barrier-free public transportation and community environments. Alternatively, they may work with social workers and other community professionals on programmes for personal assistance services or vocational rehabilitation including programmes for students with impairments making the transition from school to work.

Rehabilitation administration and management. The aim of this practice-orientated research domain is to develop organizational models and management concepts for intervention programme and service directors, service providers and payers and public administrators. Scientists in this area should have a background in management and an expertise in public health or a health profession. Closely related scientific fields are healthcare management, organizational development, quality assurance and evaluation science.

A key topic in this area will be the development of management concepts and tools useful for clinicians and case-managers to advise and guide patients and their significant others along the continuum of care from the acute hospital to the community and across services, payers and sectors. Examples are integrated care and service concepts and ICF-based case management programmes such as the "Rehab-CYCLE" (37).

Another key topic for rehabilitation administration and management is the division of labour in rehabilitation institutions and other issues in organizational development.

Biomedical rehabilitation sciences and engineering

The biomedical rehabilitation sciences and engineering study diagnostic measures and interventions suitable to minimize impairment, including symptom control, and to optimize people's capacity.

There are many conceivable research domains in this field. Research domains are often developed in relation to organ systems (Table V). This reflects the specialization in physiology and biomechanics, e.g. for the cardiopulmonary, the musculoskeletal or the nervous system.

Research domains may also be developed in relation to intervention approaches (Table V) including, for example, engineering, exercise, pharmacological and nutritional approaches. Closely related disciplines and partners for co-operation thus include engineering; physical medicine, physiotherapy and sports medicine; clinical psychology and speech therapy; pharmacology and nutrition science.

Research domains in relation to organ systems. Research units committed to research in relation to an organ system generally apply their expertise in organ system physiology and pathophysiology, including associated symptoms, not only to one but to a number of health conditions (38). A group with an expertise in respiratory physiology may, for example, examine ways to restore or improve respiratory function and how to prevent complications including pneumonia and related mortality, not only in people with spinal cord injury but also in neuromuscular dystrophies or in multiple sclerosis. A group with an expertise in tissue injury and healing of the musculoskeletal system may develop rehabilitation approaches for sports injuries and for different regional musculoskeletal disorders, but also for rehabilitation and joint protection in inflammatory rheumatic diseases. Likewise, a group with an expertise in neuro-cognition may study rehabilitation approaches not only for patients with stroke but also for patients with traumatic brain injury.

Researchers in these areas typically have a background in medicine, physiology, sports and movement sciences, or in the neurosciences. Ideally, they are also trained in the principles of human functioning and rehabilitation (39).

Research domains in relation to intervention principles. A typical example of a research domain in relation to an intervention principle is rehabilitation engineering. Rehabilitation engineering aims to design, develop, adapt or enhance technological solutions suitable to compensate for the absence, loss of or problems in body functions and structures and, hence, to optimize capacity. Solutions include aids and devices, rehabilitation training technology including gait trainers, and adaptations of the environment. Areas include mobility, communication, hearing and vision. The first step typically involves the development of prototype devices and instrumentation, the second step the evaluation of safety, efficacy and cost-effectiveness and the third step the transfer to the market.

Rehabilitation engineers work closely with scientists in the domains of organ-systems, but also with integrative rehabilitation scientists developing rehabilitation intervention programmes.

Professional rehabilitation sciences

The professional rehabilitation sciences study how to provide best care with the goal of enabling people with health conditions experiencing or likely to experience disability to achieve and maintain optimal functioning in interaction with the environment.

The professional rehabilitation sciences are operating at the cutting edge between rehabilitation research and practice. They are thus uniquely positioned to improve the transition from translational research to research translation. While it

makes sense to differentiate between professional rehabilitation sciences (study how to provide best care) and professional rehabilitation practice (provision of best care), the distinction between professional rehabilitation scientists and professionals in rehabilitation is only of analytical value. Indeed, every rehabilitation professional should apply scientific standards to the accomplishment of his or her work, should contribute to the development of new research questions and interventions related to his practical experience, and should be a qualified partner for clinical or community-placed trials as well as outcome and validation studies in specific settings. In turn, every professional rehabilitation scientist should be rooted and experienced in a professional rehabilitation discipline, such as PRM, rehabilitation nursing, occupational therapy, physiotherapy or speech therapy. While biomedical rehabilitation scientists and engineers primarily concentrate on the efficacy of interventions, rehabilitation professionals should be interested in the scientific study of the interventions' effectiveness in their particular setting.

There is a wide range of well-known research domains and topics in the professional health sciences (40). Most of them also apply to rehabilitation. We present 4 conceivable domains and topics (Table V) in order to illustrate research in the field.

Standards and guidelines for the provision of best care. Based on models and evidence generated in the basic and applied fields of human functioning and rehabilitation research, the professional rehabilitation sciences develop standards and guidelines for the optimal provision of care in rehabilitation practice. These standards can largely build on the well-known principles of evidence-based medicine (41) and medical decision-making, including methods of decision analysis.

Rehabilitation quality management. The professional rehabilitation sciences are also committed to the supervision of the application of respective standards and guidelines in rehabilitation practice. They develop methods in order to examine the delivery of care in professional settings, to uncover gaps between actual practice and scientific standards as well as between demand and supply of care, and to close these gaps. These methods are incorporated in systems of clinical quality management ensuring iterative quality improvement and continuously learning organizations (42). In order to also include outpatient services and community settings the term rehabilitation quality management is chosen here. The generic question, however, stays the same: how can we apply knowledge about what works in principle to continuously improve processes of care and support as well as patient outcomes in a particular setting? (42)

Scientific education and training of professionals in rehabilitation. The professional rehabilitation sciences develop curricula and courses for the education and training of rehabilitation professionals. Respective education and training programmes in particular aim at the application of scientific methods in rehabilitation practice and the dissemination of scientific thinking across rehabilitation professions, e.g. through courses in rehabilitation effectiveness (39). They foster co-learning and knowledge exchange between rehabilitation research and practice, e.g. by including methods of problem-based learning (43).

Development and evaluation of the rehabilitation team. The needs and problems of people with a health condition experiencing disability do not follow disciplinary boundaries. Therefore, the rehabilitation team is inherently interdisciplinary (44) or even transdisciplinary (45). The professional rehabilitation sciences develop and apply strategies for the building and evaluation of inter- or transdisciplinary teams in rehabilitation practice. In doing so, they may draw on models and methods designed in organizational psychology and sociology, e.g. the team building approach suggested by Liebowitz & DeMuse (46). This approach analyses norms, values, intentions, and interpersonal relations within the team with the goal of enhancing the effectiveness of team work and the problem-solving abilities of individual team members.

Inter- or transdisciplinary team-building in rehabilitation also requires respective programmes for inter-professional education which can rely largely on the integrative framework and common terminology provided by the ICF (47).

CONCLUSION

The domains presented here are suggestions to illustrate the content of the distinct scientific fields identified in the accompanying paper on the organization of human functioning and rehabilitation research from the cell to society (2). The domains are not mutually exclusive, but complement each other and overlap to a certain extent. There are certainly many other conceivable domains, and the domains could be structured and named differently.

To further develop the understanding of what constitutes human functioning and rehabilitation research we therefore encourage commentaries to be submitted to the *Journal of Rehabilitation Medicine*, including comments, for example: (*i*) on the description and naming of the shown domains; (*ii*) about additional important domains to be included in descriptions of the distinct scientific fields; and (*iii*) the presented conceptual descriptions.

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