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ORGANIZING HUMAN FUNCTIONING AND REHABILITATION RESEARCH INTO DISTINCT SCIENTIFIC FIELDS. PART I: DEVELOPING A COMPREHENSIVE STRUCTURE FROM THE CELL TO SOCIETY*

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There is a need to organize rehabilitation and related research into distinct scientific fields in order to overcome the current limitations of rehabilitation research. Based on the general distinction in basic, applied and professional sciences applicable to research in general, and the rehabilitation relevant distinction between the comprehensive perspective based on WHO's integrative model of human functioning (ICF) and the partial perspective focusing on the biomedical aspects of functioning, it is possible to identify 5 distinct scientific fields of human functioning and rehabilitation research. These are the emerging human functioning sciences and integrative rehabilitation sciences from the comprehensive perspective, the established biosciences and biomedical rehabilitation sciences and engineering from the partial perspective, and the professional rehabilitation sciences at the cutting edge of research and practice. 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. The biosciences in rehabilitation aim to explain body injury and repair and to identify targets for biomedical interventions. 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 biomedical rehabilitation sciences and engineering study diagnostic measures and interventions suitable to minimize impairment, including symptom control, and to optimize people's capacity. 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 organization of human functioning and rehabilitation research into the 5 distinct scientific fields facilitates the development of academic training programs and career building as well as the development of research structures dedicated to human functioning and rehabilitation research.

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

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INTRODUCTION

There is an urgent need to enhance our knowledge base on human functioning, disability and rehabilitation (1–5) and to translate this knowledge into effective policy, service and care provision and clinical and community practice. Major advances in human functioning and rehabilitation research are needed, better to understand how to optimize functioning in individuals and groups of people with health conditions experiencing or likely to experience disability. This also includes research to "bring the evidence up to date with current treatment practice" (6). Currently, research productivity, e.g. across the rehabilitation professions including physical and rehabilitation medicine (PRM), occupational therapy and physiotherapy, is limited (6). Therefore, rehabilitation research capacity, e.g. with respect to researchers, research facilities and funding opportunities, needs to be enhanced (4, 6, 7).

A main, if not the main, reason for the current limitations in rehabilitation research is the lack of organization of rehabilitation research into distinct scientific fields (2, 6–8). According to Professor Harvey Fineberg, the president of the American Institute of Medicine (IOM), the definition and coherent conceptualization of rehabilitation research, which is "so diversely represented across a range of clinical conditions and types of expertise" is one of the great challenges scientists and practitioners in rehabilitation are currently facing (8). A recent American summit on how to enhance rehabilitation research capacity (7) has therefore called for the organization of rehabilitation research into distinct scientific fields based on a unifying scientific model. Indeed, with the adoption of the International Classification of Functioning, Disability and Health (ICF) we can now, for the first time, rely on such a unifying conceptual model for rehabilitation (2, 5, 9). Therefore, the adoption of the ICF as unifying conceptual model for rehabilitation provides a unique opportunity for the organization of human functioning and rehabilitation research into distinct scientific fields.

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The organization into distinct scientific fields is a *conditio sine qua non* for striving research in any area. Distinct scientific fields are more likely to provide innovations (6). They facilitate the integration and further development of methods from related scientific disciplines to address relevant research questions. They also facilitate the exchange of ideas through a common taxonomy and continuously evolving methods and concepts. This exchange takes place in scientific meetings, working groups, committees and journals run by scientific organizations around distinct scientific fields (10). Often, new scientific organizations are created by scientists engaging in emerging scientific fields.

The objective of this paper therefore is to develop a comprehensive structure for human functioning and rehabilitation research, which is consistent with the unifying conceptual model of human functioning, the ICF.

The specific aims are: (*i*) to identify generally acceptable distinctions for the organization of rehabilitation and related research; (*ii*) to develop a structure based on these distinctions; and (*iii*) to identify the distinct scientific fields according to this structure.

An outline of the domains for research and conceptual descriptions of the identified distinct scientific fields is provided in an accompanying paper (11).

DISTINCTIONS RELEVANT TO THE ORGANIZATION OF HUMAN FUNCTIONING AND REHABILITATION RESEARCH

Human functioning and rehabilitation research can be organized along many distinctions. Thus, there is no single valid approach. However, to be meaningful and useful the envisioned distinct scientific fields should be structured along key distinctions that are firstly relevant to the organization of research in general and, secondly, for the specific organization of human functioning and rehabilitation research. These distinctions provide the frame for the envisioned structure within which the distinct scientific fields can be identified.

General distinctions in research

The organization of rehabilitation research along a distinction applicable to research in general ensures its acceptance and usefulness in the related scientific disciplines contributing to human functioning and rehabilitation research. Since almost any science may be relevant to human functioning and rehabilitation research (6), the general distinction needs to be common to such diverse areas as the natural and engineering sciences, the rehabilitation professions, the behavioural sciences and psychology, and the social sciences.

The differentiation in basic sciences (understanding phenomena and how to influence them; advancing our knowledge), applied sciences (how to influence phenomena with a specified goal; how to solve real world problems) and professional sciences (how to address people's needs with professional action based on research results and scientific methods) is arguably the only and, at the same time, most common general distinction in research (12). Since the differentiation in basic, applied and professional sciences is well known and has been described elsewhere, e.g. in the IOM report on "Enabling America" (12), we do not review this differentiation in detail in this paper.

Distinctions in human functioning and rehabilitation research

The organization along one or more key distinctions relevant to rehabilitation research should ensure acceptance and usefulness with the rehabilitation professions and rehabilitation researchers. Arguably, the most important distinction in rehabilitation research is the perspective taken by the researcher.

The comprehensive perspective based on the integrative model of human functioning provides the common ground for all rehabilitation research. The comprehensive perspective based on the integrative model is also the ultimately relevant perspective for rehabilitation care and service provision as well as the medical specialty PRM.

However, researchers may also pursue their research from a partial perspective. Research is more focused and, accordingly, more likely to be successful if explicitly conducted either from the comprehensive or from a partial perspective.

Partial perspectives can be identified easily in relation to the ICF. The partial perspective in relation to health conditions is interested in the biomedical aspects, the partial perspective in relation to personal factors is interested in psychosocial and behavioural aspects, and finally the partial perspective in relation to environmental factors is particularly interested in the social aspects functioning.

When organizing rehabilitation research into distinct scientific fields, the distinction of the comprehensive perspective based on the integrative model vs the partial perspective interested in the biomedical aspects of functioning is arguably the most relevant and useful distinction. The distinction mirrors the 2 perspectives of the medical specialty PRM. Rehabilitation medicine takes the comprehensive perspective based on the integrative model and focuses on people's performance in the interaction with the environment. Instead, physical medicine takes the partial perspective interested in the biomedical aspects of functioning and focuses on people's capacity.

Research from the comprehensive perspective is conducted by "integrative" researchers who take a humanistic and holistic view of the world (Fig. 1). Researchers are imprinted by the social sciences, psychology and the behavioural sciences, public health and epidemiology. Translational research may be referred to as from "theory to integrated care and service provision". The ultimate goal is to optimize a person's performance in the interaction with the environment and hence in real life.

Instead, research from the partial perspective interested in the biomedical aspects of functioning focuses on body functions and structures on the level of organ systems, organs, cells, molecules and even smaller units (Fig. 1). Researchers are imprinted by the experimental methods of the natural sciences. Research is conducted in biomedical and function laboratories. Translational research is often referred to as "from

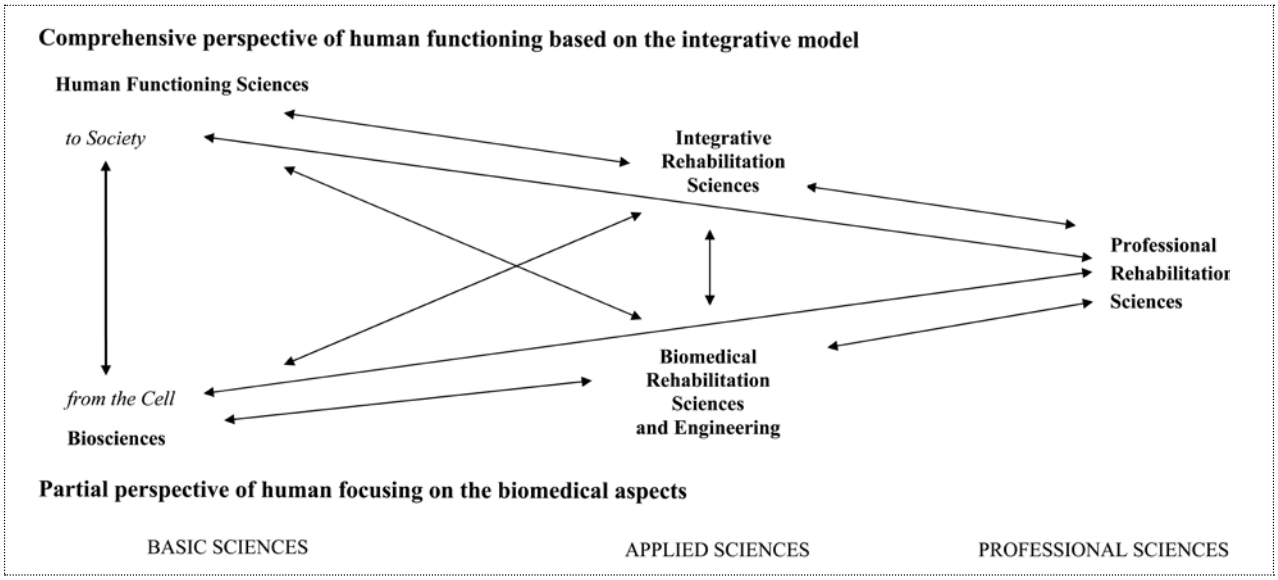

Fig. 1. A structure for the organization of human functioning and rehabilitation research. The figure illustrates relations for the communication of scientific knowledge between the distinct scientific fields. The double arrows indicate that knowledge may be communicated in both directions. The horizontal dimension symbolizes the confluence of knowledge generated by the basic and applied sciences to serve the professional sciences and vice versa. The vertical dimension distinguishes the comprehensive perspective based on the integrative model of functioning from the partial perspective focusing on the biomedical aspects of functioning. Diagonal arrows thus display flows of knowledge with respect to both dimensions.

the bench to the bedside". The ultimate goal is to optimize a person's capacity.

While there is a common knowledge base in relation to rehabilitation understood as a healthcare strategy (13), the specific knowledge and skills required to succeed as an integrative researcher in the emerging and distinct scientific fields human functioning sciences and integrative rehabilitation sciences outlined below are clearly different from the knowledge and skills required to succeed in biomedical rehabilitation sciences and engineering.

STRUCTURING HUMAN FUNCTIONING AND REHABILITATION RESEARCH

Based on the discussed distinctions it is possible to structure human functioning and rehabilitation research and to identify 5 distinct scientific fields. Fig. 1 shows the according organization of human functioning and rehabilitation research. The identified distinct scientific fields are described in the following sections. Domains for research and conceptual descriptions are outlined in an accompanying paper (11).

The integrative rehabilitation sciences, biomedical rehabilitation sciences and engineering and the professional rehabilitation sciences are fields for rehabilitation research. Instead, the human functioning sciences and biosciences are related fields. Much research in the human functioning sciences and biosciences is relevant to rehabilitation and vice versa rehabilitation has important questions for these basic sciences.

DISTINCT SCIENTIFIC FIELDS FOR HUMAN FUNCTIONING AND REHABILITATION RESEARCH

The basic sciences: human functioning sciences and biosciences in rehabilitation

The basic sciences are committed to uncover, describe, understand and explain phenomena. The goal is to advance our knowledge. Pure research conducted by the basic sciences is important irrespective of its immediate or potential usefulness for solving practical problems of everyday life. Efforts to understand human functioning span from the cell to participation in society. Both human functioning sciences and biosciences in rehabilitation aim to understand human functioning. However, they do this on a largely different scale.

Human functioning sciences. Different from the biosciences, there is currently no established distinct scientific field focusing on the understanding of human functioning based on the integrative model. However, there have been important developments in the context of disability studies (14). In 1991 a report by the IOM called "Disability in America" (15) identified disability as a comprehensive and coherent field of inquiry. However, current research in this field is limited (12). Also, it is often not conducted from a truly comprehensive perspective based on the integrative model of human functioning (16, 17). More often, research is conducted from the partial perspective relevant to the researcher's scientific discipline (16). Sociological research is often conducted from a partial perspective interested in environmental factors. Outcomes

research is often conducted from a condition perspective with a focus on disease consequences.

Since the understanding of human functioning and its determinants is of utmost importance to rehabilitation research and practice, there is a clear need to establish a distinct scientific field. Based on its mission it can be called human functioning sciences. Alternatively it could be named disability sciences. While this term would have the advantage of broader recognition with the public and other scientific disciplines, it has the disadvantage of a term focusing on the negative aspects of health. Also, the term disability is currently tied to advocacy and political action rather than to the name of a basic science. Disability is also widely associated with the distinction of being disabled vs being healthy. Instead, human functioning is more likely to be accepted as a term to describe a universal experience of all people (17). The use of the term human functioning therefore seems preferable. With the implementation of the ICF the term functioning will become familiar to professionals and scientists in the next years. Indeed, if consistently used, the term *human functioning sciences* has the potential to become as widely known and accepted as the terms human biology or biosciences.

Biosciences in rehabilitation. The biosciences, the basic sciences from the partial perspective based on the biomedical model of disease, are well established. Specific areas such as biology, neurobiology or physiology are encompassed in the broader term biosciences. Medical research in the biosciences is dedicated mainly to the understanding of diseases. Research in relation to rehabilitation aims to explain, for example, acute and chronic tissue injury and repair as well as the mechanism underlying rehabilitation interventions, which are often developed based on clinical observations. Those insights may be translated into new or modified interventions to control injury and thus minimize impairments and to facilitate recovery and repair.

The applied sciences: integrative rehabilitation sciences and biomedical rehabilitation sciences and engineering

The applied sciences are committed to influence phenomena with a specified goal. Different from the basic sciences the applied sciences aim to solve practical problems of everyday life. The results of the applied sciences are immediately relevant to the professional sciences' interest in the provision of best care (18).

According to our proposed framework, 2 distinct scientific fields can be identified with respect to applied rehabilitation research. The first, tentatively called *integrative rehabilitation sciences*, refers to the comprehensive perspective based on the integrative model. The second, tentatively called *biomedical rehabilitation sciences and engineering*, refers to the partial perspective focusing on the biomedical aspects of functioning.

While the biomedical rehabilitation sciences and engineering focus on capacity defined as what a person can do in a standardized environment, the integrative rehabilitation sciences focus on performance defined as what a person does in real world. The biomedical rehabilitation sciences and engineering focus on the individual. Instead, the integrative rehabilitation sciences focus both on the individual and on populations. This is in line with the ICF, which is the WHO's framework for measuring health and disability at both individual and population levels (19).

Since both fields currently lack generally accepted names and conceptualizations, there is a need to name and conceptualize both fields. While both fields may be summarized under the currently used term rehabilitation science (12) or better rehabilitation sciences, the successful development of both fields may be enhanced by 2 distinct names that more clearly identify the respective fields.

Integrative rehabilitation sciences. The term integrative rehabilitation sciences seems the obvious and appropriate one for the field that explores approaches to achieve optimal functioning from the comprehensive perspective based on the integrative model of human functioning. The field aims to achieve optimal functioning by integrating biomedical and engineering approaches with efforts that build on and strengthen the resources of the person and approaches that provide a facilitating environment. It therefore translates the benefits from these approaches into improvements in functioning and the minimization or prevention of disability, both at the individual and the population level. Its focus is on life involvement or, in the ICF taxonomy, participation. While integrating approaches to achieve optimal capacity in a "standard situation or environment", its ultimate goal is optimal performance in real life. At the individual level, the integrative rehabilitation sciences are committed to research on closing the gap between capacity and performance, or closing the gap between what is possible in principle and what is possible in people's life. At the population level, the integrative rehabilitation sciences are committed to research on closing the gap between what is being done and what could be done to address people's needs.

Biomedical rehabilitation sciences and engineering. The field referring to the partial perspective interested in the biomedical aspect of functioning can be called biomedical rehabilitation sciences and engineering. The term engineering is added in line with the respective suggestion of the IOM (12) and reflects the importance of technological solutions such as prostheses to optimize the capacity of the individual or to adapt the environment.

The development of the biomedical rehabilitation sciences and engineering can importantly contribute to rehabilitation research. As a distinct field it can make major contributions to translate biomedical and engineering advances into rehabilitation practice and hence to enable patients to take faster advantage of biomedical and engineering progresses (8). Biomedical rehabilitation sciences and engineering with their close link to the professional rehabilitation sciences on one hand and their close relation with the cutting edge of the basic sciences

on the other are uniquely positioned to promote and capitalize on critical areas of advanced science, including, for example, stem cell research, biomechanics and nanotechnology (8). Accordingly, the field has a high potential for funding in the context of the current funding environment.

Professional rehabilitation sciences

Professional sciences in rehabilitation medicine study how best to provide care. They therefore have primarily practical aims. They integrate the knowledge generated by the basic and applied fields for the continuous improvement of care provision in a particular setting. The professional rehabilitation sciences encompass the development, evaluation and implementation of professional standards and guidelines, rehabilitation quality management, scientific education and training of professionals in rehabilitation, and the rehabilitation team (11).

To achieve their goals, professional disciplines often use an approach called development rather than research. Research in the professional sciences thus resembles what is called research and development in industry. Development describes the process of translating knowledge into procedures.

Research in the professional rehabilitation sciences may benefit from current conceptual descriptions of the rehabilitation professions based on the unifying conceptual model of the ICF (13). In this regard, the definition of the medical specialty PRM may serve as a case in point (18). The professional rehabilitation sciences may also benefit from a more explicit specification of research areas and methods, for example in the context of the definition of the contents of curricula teaching scientific methods relevant to the professional rehabilitation sciences complementing practice-oriented training programs (20).

CONCLUSION

Human functioning and rehabilitation research can be organized into 5 distinct scientific fields. 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. The biosciences in rehabilitation aim to explain body injury and repair and to identify targets for biomedical interventions. 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 biomedical rehabilitation sciences and engineering study diagnostic measures and interventions suitable to minimize impairment, including symptom control, and to optimize people's capacity. 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.

While the organization of human functioning and rehabilitation research in distinct scientific fields is useful in many ways, it is important to recognize that any distinction is always somewhat artificial. Since all distinct scientific fields are dedicated to the area of human functioning and rehabilitation, they are not only distinct but also related. Good research is conducted on a continuum ranging from basic and applied to the professional sciences, and researchers are moving along this continuum (21). A typical example is the development of interventions. In theory and sometimes in reality, interventions to influence functioning are developed based on knowledge generated by the basic sciences. However, the applied biomedical rehabilitation sciences and engineering often develop interventions based on observations by the professional sciences. While they may choose to investigate the intervention mechanism in collaboration with the basic sciences, they may initially study their safety, efficacy and clinical effectiveness. Also, the insights generated by the basic sciences are often directly relevant to the professional disciplines. For example, the understanding of human functioning as investigated by the human functioning sciences provides key knowledge to the rehabilitation professions for the assessment of patients' functioning.

For the naming of the 5 distinct scientific fields we consistently used the plural. This is certainly appropriate for an umbrella term such as rehabilitation sciences, which refers to integrative rehabilitation sciences as well as to biomedical rehabilitation sciences. Instead, one may prefer the singular for integrative rehabilitation science and not as used in our paper the plural integrative rehabilitation sciences.

The terms used to name the distinct scientific fields according to the chosen structure are tentative and subject to an international discussion. We therefore encourage people to submit commentaries to the *Journal of Rehabilitation Medicine* specifically on: (*i*) the distinctions used to develop the structure for the organization of rehabilitation research and the chosen structure; (*ii*) the identification and outline of the distinct scientific fields within this structure; and (*iii*) the taxonomy used for the 5 distinct scientific fields.

The organization of rehabilitation research in distinct scientific fields is instrumental for the development of governmental and private funding opportunities and to stimulate the creation of rehabilitation research facilities, interdisciplinary university centres and national and regional collaboration networks (22) and training programs (20).

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