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LETTER TO THE EDITOR

ICF, THEORIES, PARADIGMS AND SCIENTIFIC REVOLUTION. RE: TOWARDS A UNIFYING THEORY OF REHABILITATION

Graham et al. (1) remind us of the current lack of, and need for, a comprehensive theory of rehabilitation. They also suggest that the framework of the World Health Organization's (WHO) International Classification of Functioning, Disability and Health (ICF) (2) might provide elements of such a general theory and be of help in formulating more specific hypotheses. I am in total agreement with these general statements. However, some clarification of terminology, and further reflection on what a theory is and how it can be distinguished from research that deductively tests or inductively generates theory might be useful.

While I agree with Whyte (3) that a *theory* formulates general postulates with implications that go beyond empirical findings or examples on which the generation of the theory may be based, some further explication of the term may be useful. A model may thereby be understood as a visualization of theory, but if it is understood in this way it cannot be the theory itself.

There is no unifying definition of what a theory is. Most of the definitions provided by philosophy of science, however, agree on particular elements that a theory comprises (4, 5). First, a theory is comprised of statements about the world. These statements are formulated in sentences. Secondly, there are different types of sentences: (*i*) definitions; (*ii*) hypotheses; and (*iii*) axioms. Definitions can be nominal or operational. While the former is just a linguistic transformation in the form "A is B, C", the latter makes claims about empirical indicators of nominally defined terms and their measurement. Hypotheses, in turn, relate defined terms in "if then" or "all are" sentences. Axioms are assumptions about the reality that are fixed and not going to be empirically tested. Thirdly, there is also some agreement on the idea "that a science can succeed only if it can fail" (6). There should be at least some elements of the theory, i.e. the hypotheses, that are falsifiable or refutable by empirical testing (7). Theory is not verifiable, since all relevant cases can never be examined, particularly because of the presence of time, i.e. nobody knows the future. However, a general statement in "if A then B", "all A are B" or "B is a function of A" form can be falsified by (a basis sentence about) one observation of A and *not* B (8). If one tries to falsify a theory with an appropriate research design and there are no or not enough observations falsifying the theory, we say that a theory or hypothesis is confirmed. If a hypothesis is confirmed on many occasions, we might call it a law (4). There is some discussion about the lack of falsifiability of the core of many theories (8, 9), i.e. the assumptions about the world or axioms. Nonetheless, we might, for this purpose, define a theory as a set of sentences about the world that comprises definitions, axioms, and hypotheses, of which the last should be falsifiable through empirical testing.

Science is, furthermore, a social enterprise. That means that through the nowadays global exchange of theories and research findings dominant paradigms might be established in particular disciplines. According to Kuhn (8) a paradigm is a thought pattern common to a particular scientific community, including legitimate research questions, terminology, taken for granted assumptions (axioms), and patterns of interpretation of data. In normal science the scientist is "not an innovator but a solver of puzzles, and the puzzles upon which he concentrates are just those which he believes can be both stated and solved within the existing scientific tradition." (8) The generation of theories and their empirical testing happens most of the time within established scientific paradigms. There can be one dominant or multiple paradigms in a scientific discipline.

As far as rehabilitation theory is concerned, the ICF may be regarded as a new paradigm, and the move from the International Classification of Impairment, Disability and Handicap (ICIDH) to the ICF may be regarded as a paradigm shift or scientific revolution. The ICF attempts to reconcile two contrary scientific paradigms that had been established previously in disability and rehabilitation research: the individual or health consequences model of disability, and the social model of disability (2). It is indeed a scientific revolution that, for instance, the influence of environmental factors on disability is nowadays taken for granted by the international disability and rehabilitation research community, although no best evidence exists for this claim (10). The ICF introduction and appendix (2) set out further definitions, and explicit, as well as implicit, hypotheses about functioning and its determinants. So, the ICF includes some theory or set of hypotheses about human functioning that may be useful for a theory of rehabilitation. For example, the ICF claims that two persons with the same health conditions can have different levels of functioning due to contextual factors comprising environmental and personal components. In other words, it is hypothesized that the impact of health conditions on functional status is mediated and or moderated through contextual factors, which could be further specified (11) and can be empirically tested, e.g. through regression modelling of ICF-based data (12). Another example is the more implicit hypothesis that environmental barriers have (*ceteris paribus*; i.e. all other conditions being equal) a negative, and facilitators a positive, influence on functioning. Empirically, that must not always be the case (13); people who face barriers may be able to overcome them and people may not face barriers because they avoid them. Thus, based on empirical data these hypotheses could again be specified further, taking into account personal factors (14) and thus questioning the *ceteris paribus* condition. Apart from hypotheses and definitions, there are also axioms in the ICF that are taken for granted and

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not supposed to be empirically scrutinized, e.g. that functional status can be classified, qualified, and measured.

Thus the ICF may be seen as a new paradigm for rehabilitation and disability research, but also, more specifically, as a first step towards a general theory of functioning within this paradigm.

A theory of functioning is of utmost relevance for a theory of rehabilitation, but also goes far beyond this. Therefore, we proposed that Human Functioning Sciences be established as the broadest level of disability and rehabilitation research, being of utmost relevance to, but also going beyond, Integrative Rehabilitation Sciences. Human Functioning Sciences aim to understand functioning from the comprehensive perspective, while Biosciences in Rehabilitation start from a particular perspective focusing on understanding pathogenesis and regeneration. In turn, Integrative Rehabilitation Sciences apply theories and results of the Human Functioning Sciences to the area of rehabilitation with the potential to integrate biomedical and comprehensive perspectives. Biomedical Rehabilitation Sciences and Engineering are applied sciences from the biomedical perspective. Eventually, Professional Rehabilitation Sciences study the clinical delivery and evaluation of services, e.g. through multi-disciplinary teams, and thus concentrate on a narrower field of application (16, 17). In fact, this is in part descriptive and in part normative (we say how it should be done), but not a theory. All of the scientific fields that we propose in the area of disability and rehabilitation research should develop their own theories, but in an intertwined fashion, adding more specificity or granularity when moving from the broader to the more focused levels. For example, integrative rehabilitation sciences could develop and test the hypothesis that rehabilitation services are effective and cost-effective at the community level, i.e. the more rehabilitation services available the better will be the functioning and the lower will be the healthcare costs of that population. In that they may rely on a general theory of functioning and human functioning epidemiology and impact assessment. A typical hypothesis in Biomedical Rehabilitation Sciences and Engineering would, for instance, be that a new method of gait training produces better ambulatory outcomes, e.g. better performance in a circuit, than a traditional one, or that hippotherapy reduces spasticity. These hypotheses could again be based on biomedical theory trying to explain mechanisms of gait and spasticity and how these may be affected by intervention. Biosciences in rehabilitation might develop appropriate research designs to test theory about these mechanisms. Indeed, a rehabilitation intervention may be effective, but hypotheses about the underlying biomedical mechanism might, nonetheless, be falsified. A typical hypothesis of the Professional Rehabilitation Sciences would be that multi-disciplinary rehabilitation teams are cost-effective compared with single intervention delivery in reducing length of stay and improving functional status.

In order to be able to synthesize all of this a taxonomy of rehabilitation interventions would be extremely helpful (16) as well as a theory about intervention delivery and settings, e.g. specialized rehabilitation hospital vs community.

It is important not to confuse theories with their empirical testing or with their inductive generation (called heuristic or explorative research). Both of these often involve assessments of functional status in disability and rehabilitation research. Although, the ICF is not a measurement tool, but a classification, measurements of functional status and environmental factors can be translated in the language of the ICF (17) and scale values transformed into an ICF qualifier scale for cross-calibration (18). Then, in fact, functional assessments could be depicted in the way that Graham et al. (1) propose. This is, however, rather more descriptive than theory. As Graham et al. state it is the association structure of ICF categories that is the most interesting from the theoretical and empirical point of view. Many tools for modelling these, in order to build or test theory, are now available (12, 20). Graham et al. (1) seem to have had these association structures in mind when they constructed their figures. Apparently, they make the theoretical claim that removing steps in the home of persons with particular health conditions would lead to an, at least minimal, clinically meaningful change (improvement) in mobility, e.g. from ICF qualifier 2 to 1. They also appear to say that the environment, not the neuromuscular impairment, is the most important intervention target, i.e. the influence of neuromuscular impairment on mobility is strongly moderated through environmental factors. This simple theoretical model is depicted in Fig. 1.

The theory can be tested using various research designs. For example, patients can, in principle, be assigned to an experimental group that receives an adaptation of their home environment and a control group that does not. In addition, many observational designs are possible, e.g. studying the mobility of patients before and after adaptation of their home environment, or comparing groups of patients who have insurance coverage for home adaptations with those who do not. Based on the predicted minimal meaningful change and pre-defined levels of statistical significance, sample size calculations can be performed and so forth.

The expected clinically meaningful change can be depicted in a diagram similar to that provided by Graham et al. (Fig. 2). This kind of diagram would mean predictions about aggregate populations, i.e. probabilities, in functioning research and could at the same time be used for studying individual cases at the clinical level. New research and clinical questions may arise from this. For example: Why does a particular patient lag behind the outcome the aggregate model would predict after intervention?; What were the conditions moderating or mediating the effect of the intervention that seems to work on

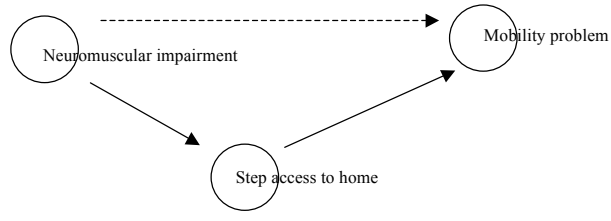

Fig. 1. Simple theoretical model using the example of Graham et al. The dotted line means an seeming association that may be found in bi-variate statistics, the solid lines signify the theoretical prediction.

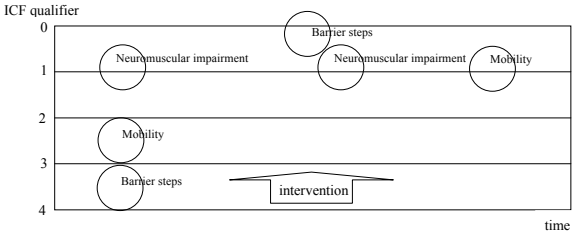

Fig. 2. Assessments before and after intervention.

the aggregate level?; Can respective sub-groups of patients be identified?; Is the prediction of the aggregate model better when we take into account the sub-group variables?

To sum up, rehabilitation has a new paradigm that is embodied in the ICF model. There are many implicit or explicit pieces of theory in the ICF and in many studies on rehabilitation. These should be made explicit and formalized in a set of hypotheses or mathematical functions in order to be able to aggregate and test them. To start with the ICF and disentangle definitions, hypotheses and axioms would indeed be a highly promising basis for a theory of rehabilitation. We already have many pieces of the puzzle; now we need to assemble them.

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