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John E. Crews, PhD

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National Institute on Disability and Rehabilitation Research: Support of Capacity Building in Rehabilitation Research.
Ruth Brannon, MSPH, MA

Department of Veterans Affairs: Support of Capacity Building in Rehabilitation Research.
Mindy L. Aisen, MD
Rehabilitation Medicine Summit
Building Research Capacity

EXECUTIVE SUMMARY

The advancement of medical science depends on the production, availability, and utilization of new information generated by research. A successful research enterprise depends not only on a carefully designed agenda that responds to clinical and societal needs, but also on the research capacity necessary to perform the work. Research that is likely to enhance clinical practice presupposes the existence of a critical mass of investigators working as teams in supportive environments. Unfortunately, far too little research capacity of that kind exists in rehabilitation medicine to ensure a robust future for the field. The “Rehabilitation Medicine Summit: Building Research Capacity” was conceptualized as a way of fashioning a long-term plan to foster the required developments.

OBJECTIVES

The general objective of the Summit was to advance and promote research in medical rehabilitation by making recommendations to expand research capacity.

More specific objectives were to: 1) bring together leaders in medical rehabilitation research to characterize current research capacity in the field and identify obstacles to expanding that capacity; 2) propose specific actions and mechanisms to enhance research and the development of capacity; 3) formulate an action agenda for use by stakeholders in medical rehabilitation to enhance existing research and training programs or to create new ones; and 4) stimulate federal agencies and foundations to support the needed elements of rehabilitation research and training. Although
the purpose of the summit was not to discuss a specific research agenda, the above objectives were considered in the context of five research categories: 1) basic science, 2) clinical research (including clinical trials), 3) outcomes research, 4) health services research, and 5) engineering and technology development.

RESEARCH CAPACITY: OPERATIONAL DEFINITION AND ELEMENTS

For the purpose of the discussions, building research capacity was defined as "a process of individual and institutional development which leads to higher levels of skills and greater ability to perform useful research." Five elements of research capacity were identified and used to guide the pre-Summit work and the Summit discussions. These included: 1) researchers (their training, mentoring, recruitment, and retention; the value of a career in research and incentives for research); 2) research culture, environment, and infrastructure (academic institutions, the creation and maintenance of core facilities, the role of chairpersons and deans, collaborations, institutional research administration and social culture, and policies governing incentives and job security); 3) funding (sources, advocacy for changing policies, peer-review procedures, funding mechanisms, grantsmanship and fundraising, timing of funding requests, and conflicts of interest); 4) partnerships with other disciplines and disability consumer groups (the purposes of these partnerships; choices of research topics, disciplines, and consumer groups; modes of participation; and potential conflicts of interest when partnering with industry); and 5) the metrics of research capacity (quality and quantity of the pool of available researchers, the productivity of their research, and its impacts).

METHODOLOGY

Several important activities took place before the Summit convened. The Program Committee had extensive discussions about existing research capacity. Key bibliographic references were identified on the topic of building research capacity and made available to all participants. A special article on the history of rehabilitation research was commissioned. Recognized experts were invited to write articles on each of the five elements of research capacity to serve as a basis for discussion during the Summit. These articles were peer-reviewed and five additional experts wrote detailed responses to them. The Research Committee of the American Academy of Physical Medicine and Rehabilitation (AAPM&R) conducted a survey of researchers in the field to identify problems of research capacity and their potential solutions. Several funding agencies submitted reports of their efforts to build research capacity. Finally, participants were given access to a Website where all key information, including the articles mentioned above, was posted.

The Summit consisted of keynote lectures, paper presentations, and small-group working sessions that took place in Washington, DC on April 28 and 29, 2005. Invited participants included leaders in the field, senior and junior researchers, department chairs, deans, research directors, professional organizations (12), government agencies (10), disability consumer groups (6), and multiple medical specialties (7). For the group discussions, the participants were divided into ten small groups, ten participants per group, making sure that different points of view were represented in each group. Each element of research capacity was discussed independently by two different groups that were charged with identifying problems, solutions, and recommended actions. Their reports were integrated before the Summit’s final session, which was devoted to presenting the reports to the larger group and to discussing additional recommendations. The following sections summarize the groups’ conclusions with respect to each of the five elements of research capacity. A more detailed summary of the problems, solutions, and recommended actions identified by the five integrated groups is included in the Research Summit Action Plan.

PROBLEM IDENTIFICATION

Researchers

Capacity building requires the development of a pool of well-qualified researchers. To accomplish this task, issues such as training, mentoring, and placing new investigators must be addressed, as must other issues concerning the recruitment and retention of established investigators. The ideal trainee must have a strong commitment to inquiry and the desire and skill to collaborate with others.

Defining the domain of medical rehabilitation research was singled out as being a paramount requirement for expanding research capacity. The field is inclusive by nature because it receives contributions from the physical, biological, psychological, engineering, and social sciences; hence, the difficulty in delineating it. This predicament is reflected in the different conceptual models that are frequently invoked in discussing the field, including the Institute of Medicine’s Enabling–Disabling2 model and the World Health Organization’s International Classification of Functioning, Disability and Health.3

Difficulties in developing, promoting, and retaining greater numbers of skilled rehabilitation researchers were highlighted as well. Far too few programs exist that provide optimal training in medical rehabilitation research. Reasons for the dearth of training opportunities include a lack of training funds from government agencies and private institutions, a paucity of program models for fostering interdisciplinary collaboration, a lack of appropriate mentoring coupled with standardized training curricula for preparing individuals to be competitive as researchers, and inadequate attention to promoting
the retention of minorities, women, and individuals with disabilities.

Research Environment, Infrastructure, and Culture

Research environment, infrastructure, and culture represent a matrix of complex factors essential for excellence in generating medical rehabilitation research, training, recruiting researchers, and in conducting research involving people with disabilities.

A major problem is the lack of recognition of research and scientific discovery as an institutional, organizational, and professional core value. In too many instances, scientific discovery is not an explicit priority in the vision and mission statements of clinical and professional organizations with national memberships. Consequently, the strategic plans of these organizations do not promote collaborative or interdisciplinary research, and they are not expressly supportive of the necessary investments in scientific training, the development of grant writing skills, or the mentoring of promising research faculty. The human and physical resources to accomplish these tasks are unavailable in many academic rehabilitation environments. Mechanisms to recognize research productivity in formal and informal evaluation and reward systems are frequently lacking as well.

Funding

Significant funding must be specifically assigned to building research capacity. However, the current economic environment is likely to result in flat or even reduced funding for medical rehabilitation research, at least in the near future. This unfortunate financial picture exists at a time of increasing need associated with the growing number of individuals with disabilities, and of unparalleled opportunities to improve their lives by means of new knowledge generated by research.

The biggest problem is lack of a coherent strategy for advocating the needed research support. Stakeholders in medical rehabilitation research are fractionated in their efforts to obtain larger expenditures. The austerity of the current funding environment underscores the importance of organizations bringing their advocacy efforts together under common goals.

The problem of generating adequate funding for medical rehabilitation research exists at three levels. At the federal level, the field lacks visibility as being a worthy object of support when strategic funding decisions are made. At the local level, only a handful of academic programs have the research infrastructure required to produce successful research, and very few new programs have been developed in the past decade. This partially reflects the fact that many academic medical centers invest most of their resources in expanding the ability of their extant programs to generate research funds, rather than in developing promising new programs such as ones in medical rehabilitation. Finally, at the level of individual researchers, proposed research too frequently lacks the quality to merit being funded. Additionally, some researchers fail to take advantage of existing opportunities for funding, simply because they do not know of their existence.

Partnerships

Partnerships with scientists in other disciplines, academic departments, and institutions, and with people with disabilities, among others, are vital to enhancing the capacity for conducting high-quality, meaningful research. Several factors have limited the development of those partnerships. Because of the diversity of stakeholders and stakeholder objectives, a common framework has been lacking upon which to build funding, policy, and programmatic and marketing messages regarding research. Nor have consistent efforts been made to ensure the meaningful participation of people with disabilities in the research process.

Metrics

Concerted efforts to enlarge the capacity of medical rehabilitation research must be complemented by an ability to assess that capacity over time to gauge progress. No constitutive definition of research capacity seems to have won broad endorsement in the health sciences literature, and little guidance exists for deciding on the metrics and measures for its principal domains. Notwithstanding the lack of precedence, the meaning of medical rehabilitation research capacity must be understood with precision if that capacity is to be rigorously and comprehensively assessed.

SOLUTIONS AND RECOMMENDED ACTIONS

Although each group worked independently on its assigned problems, many of the solutions and recommended actions identified by each group were quite similar. This section integrates the solutions and recommended actions.

Coalition

Several discussion groups suggested the formation of a coalition of professional groups and consumer organizations. This coalition would create a national agenda addressing the issues of funding, capacity-building needs, and public education and awareness. It would develop specific objectives and action plans regarding 1) funding targets for research and research training, 2) needed changes in funding agencies’ policies and practices, and 3) initiatives to educate the public about the importance and societal benefits of rehabilitation research, and it would coordinate efforts to address those issues.

Training

A high priority area is the training of new investigators. To accomplish this goal, training curricula need
to be created, and funding needs to be expanded for rehabilitation research training programs across disciplines and at multiple levels, including undergraduate students, students in professional training program, faculty, and department chairs. Special efforts should be made to recruit and train women, students with disabilities, and minorities.

Career Paths

Researchers need support at different stages in their careers. Current funding sources fail to provide the needed continuity of support as their careers evolve. To foster researchers’ development and their retention in the field, funding opportunities must be increased for predoctoral students, postdoctoral fellows, junior faculty, and established faculty transitioning into new investigative areas.

Partnerships to Conduct Research

To assure its scientific importance and clinical relevance, rehabilitation research requires both interdisciplinary and multistakeholder partnerships. Collaborations among researchers of different scientific and professional disciplines need to be promoted and cultivated. The required initiatives must come from individual researchers as well as from professional organizations that encourage joint scientific meetings and discussions of interdisciplinary research issues. Partnerships are vital, too, to assure that rehabilitation research is informed by the perspectives of its intended beneficiaries—people with disabilities, their family members, and rehabilitation practitioners. Principal investigators should implement Participatory Action Research (PAR), making it an integral part of medical rehabilitation and disability research. Greater emphasis should be placed on providing people with disabilities with the training and support necessary for them to assume leadership roles in rehabilitation research.

Infrastructure

Currently, only a handful of departments or centers have the research personnel, equipment, space, and support staff that constitute a strong infrastructure for medical rehabilitation research. Many more such programs must be established before the aggregate research capacity is commensurate with existing knowledge needs. Inevitably, that will require host institutions to invest in establishing new rehabilitation research programs or in strengthening ongoing ones. A growth strategy should be pursued concurrently to build intramural partnerships that facilitate access to the infrastructure available to colleagues in other scientific and professional disciplines.

Message to Funding Agencies

Funding agencies do not assign sufficiently high priority to medical rehabilitation research. Within the National Institutes of Health, this can be rectified by establishing an independent institute dedicated to rehabilitation research. Actions are needed as well to expand the participation of rehabilitation scientists in scientific review panels, and to generate more requests for applications that focus on interdisciplinary rehabilitation research. A farther-reaching possibility is creation of an independent agency for disability issues within the U.S. Department of Health and Human Services. Advocacy directed at federal agencies must be complemented by initiatives aimed at increasing support from private-sector sources such as third-party payers.

Rehabilitation Science Model

It is generally accepted that the field lacks a unified scientific model. A consortium of experienced researchers should be created to develop this model and to define the domains and boundaries of rehabilitation research.

Mission Statements and Strategic Plans

Scientific discovery is not always recognized as an institutional or organizational core value. Professional organizations should include research as an important component of their mission statements. This should be reflected in their strategic plans and used as a means to promote interdisciplinary and collaborative research.

METRICS

Both long-term and short-term perspectives are called for to meet the challenges of assessing medical rehabilitation research capacity. The long-term perspective highlights the definitional and operational challenges that must be addressed eventually if that capacity is to be rigorously conceptualized and comprehensively assessed. The short-term outlook emphasizes that some information gathering can and should begin immediately in the following four areas.

1. Rehabilitation Research Trainees

Information to be tracked includes the number of funded postdoctoral positions available in rehabilitation and the distribution of fellows across rehabilitation disciplines; the proportion of trainees who come through research training programs and who become researchers—full-time, part-time, or none; and the research products that the trainees generate, as well as their extramural and intramural levels of funding. Possible action steps include defining who is considered as a core rehabilitation professional, exploring and using existing methodology whenever possible, and enlisting the cooperation of funding agencies to collect and share this information.

2. Size of the Rehabilitation Research Cadre

Information to be tracked includes the size of academic departments relevant to medical rehabilitation (e.g., number of research fellows, filled and unfilled faculty positions) and the amount of time rehabilitation
professionals, broadly defined, spend in research (e.g., half-time or more, part-time, or none). Professional organizations should be enlisted to collect this information on a regular and standardized basis.

3. Productivity

The information to be monitored includes citations of published articles, extramural and intramural levels of research funding, and the types of research designs appearing in the rehabilitation literature. Action steps include specifying the kinds of articles and the journals to include, and searching by professional organization memberships, institutions, or by disciplines or countries. Professional organizations should be enlisted to collect this information on a regular and standardized basis, using existing methodology where possible.

4. Federal Agency Expenditures on Rehabilitation Research

Expenditures allocated to rehabilitation research in specific content areas should be monitored. A recommended action step is to identify agency contact points to secure these data on an annual basis.

CONCLUSIONS

The longer-term challenge is to reach a consensus on acceptable definition of medical rehabilitation capacity, and then to operationalize each of its key components. Domains that are likely to be encompassed in that definition include funding, qualified researchers, institutions, research training, research methods, an applicable knowledge base, an encompassing research agenda (including topics, their relative priority, and funding levels), knowledge translation activities, defined consumer demand and need, and political advocacy. Figure 1 is an attempt to organize those domains within a coherent framework. Each domain is assigned to one of three categories—the Research Agenda, Research Environment, or Researchers—or to the conjunction of two of these groups. Steps should be taken to refine that schematization along with the separate domains comprising it. Additionally, feasible means must be identified to 1) quantify each domain and 2) characterize its quality of achievement (against some standard or norm). It will be necessary then to establish the psychometric properties of the key indicators, e.g., their validity, reliability, and sensitivity.

A post-Summit, multiorganizational initiative is called for to pursue the agendas outlined above. Data-gathering efforts should be launched as soon as possible to characterize current research capacity as a baseline for assessing possible future gains. Those efforts should draw on findings of the Survey on Academic Leadership and Research Development conducted by the Research Advisory & Advocacy Committee of the AAPM&R, and be implemented by either 1) an ensemble of federal agencies supporting rehabilitation research, or 2) a consortium of rehabilitation-related voluntary organizations such as those represented at the Summit.

REFERENCES

### Table 1

**Rehabilitation Medicine Summit: Building Research Capacity**  
April 28–29, 2005, Washington DC  
**Final Action Plan**

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<th>Research Capacity Element</th>
<th>Researchers</th>
<th>Problem</th>
<th>Solution</th>
<th>Recommended Action</th>
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|                           | Hunter Peckham, PhD and Denise G. Tate, PhD | 1. Lack of definition of the domains of rehabilitation science | 1. Develop/evaluate proposed models of rehabilitation science (multidisciplinary, IOM, others). | 1. Convene a group of “conceptualizers” with inclusion from various stakeholders to examine different models and relate the outcomes to research training models.  
2. Develop a white paper or report that lists potential successful models of rehabilitation science based on the outcomes of this meeting.  
3. Participate in a rehabilitation consortium that would address the definition of rehabilitation science, including research training issues and implications for the field. |
|                           |             | 2. Lack of exposure to rehabilitation and rehabilitation research and need to create a research environment aligning recruitment practices to address insufficient number and quality of researchers | 1. Short-term undergraduate and graduate funding options such as summer programs for exposing nonrehabilitation researchers to rehabilitation research and rehabilitation scientists to new research trends.  
2. Extend research training duration under current training programs available by our current funding agencies. | 1. Ask organizations to problem solve how to more effectively highlight research through plenary sessions and invitations to cutting edge speakers.  
2. Encourage joint meetings on common scientific themes.  
3. Foster relationships with Schools of Public Health to expand training opportunities.  
4. Develop a “suite” of mechanisms for precandidates with potential to be trained in rehabilitation research to incorporate clinicians into research activities. |
|                           |             | 3. Lack of training funds | 1. Expand financial support for research training. | 1. Advocate for funds for research training—this might be best achieved through a joint coalition with special attention to career development avenues.  
2. Expand the rehabilitation research networks approach for specific research training in specific scientific domains including specific laboratories and research environments.  
3. Explore private donor relationships to support trainees’ stipends. |
|                           |             | 4. Lack of available program models fostering interdisciplinary collaboration | 1. Create venues for interdisciplinary collaborations across departments and universities. | 1. Require that existing training grants (such as the NIH T32 and K12’s) include a multidisciplinary training focus for research. |
|                           |             | 5. Lack of appropriate mentoring | 1. Create and develop guidance materials.  
2. Teach mentees how to select and use mentors. | 1. Emphasize the scope of mentorship and develop guidance materials (career advisement, scientific, and professional).  
2. Identify models of mentoring from other specialties and organizations (psychiatry, geriatrics, pediatrics, National Science Foundation Advance programs). |
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| 6. Lack of a standard scientific training curriculum                    | 1. Develop standard protocols for research and a related curriculum for training in rehabilitation research. | 1. Review current research training curricula and ensure that it includes clinical trials training.  
2. Utilize the consortium mechanism to review curriculum approaches to ensure the scientific mission of our disciplines. |
| 7. Lack of strategies for retention of vulnerable groups (women, minorities, consumers) | 1. Gain a greater awareness of problems that impede retention (i.e., rules for promotion). | 1. Establish a multidisciplinary task force to review these problems.                                                                                   |
| 8. Preparation of individual for her/his role (how to get researchers to be competitive?) | 1. Develop an adequate career path for retention of rehabilitation scientists. | 1. Establish special interests groups (SIG’s) related to developing materials and communicating strategies.                                                   |
| 9. Lack of critical mass of researchers                                  | 1. Develop strategies for bringing together a critical mass of researchers in our field. | 2. Develop joint appointments that promote career development.  
1. Support efforts to modify the way agencies list departmental and institutional funding so it will create incentives for collaborative research. |
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<tr>
<td>1. Lack of explicit prioritization of research in mission statements</td>
<td>1. Incorporate research into mission statements of rehabilitation entities and revisit relative position of research as a component of the mission.</td>
<td>1. National organizations to revisit the position of research in their mission statements.</td>
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<td>2. National organizations to develop sample mission statements for use by organizations and institutions.</td>
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<td>1. Professional organizations and individual institutions to develop strategic plans for targeted research areas and building coalitions.</td>
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<td>2. Identify and disseminate examples of successful strategic plans.</td>
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<td>2. Lack of strategic planning that supports collaborative and interdisciplinary research and is consistent with the resources and institutional culture</td>
<td>1. Develop strategic plans for targeted research themes.</td>
<td>1. Identify, utilize, and disseminate database of “research evangelists.”</td>
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<td>2. Develop database of successful researcher–clinician role models and successful research institutions.</td>
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<td>3. Publicly recognize research success in organizations.</td>
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<td>4 Develop cross-discipline articles and workshops on the topic of research culture to include in specialty journals and conferences.</td>
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<td>3. Beliefs, attitudes, and values that do not support research</td>
<td>1. Establish cross-discipline successful models.</td>
<td>1. Develop and disseminate models for providing monetary and nonmonetary incentives.</td>
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<td>2. Recognize institutions and organizations that have adopted successful models.</td>
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<td>3. Establish research incentive consultation teams.</td>
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<td>4. Inadequate incentives and rewards for research</td>
<td>1. Develop incentive and reward programs that incorporate research.</td>
<td>1. Increase career and faculty development programs (such as the NIH’s K12, K30, K02, K05, and K07 type awards). Develop partnerships with other entities to fund such programs. Encourage development and expansion of fellowship programs for senior faculty (such as NIDRR’S).</td>
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<td>2. Encourage institutions to recognize mentoring as a faculty responsibility; provide credit and incentives in faculty evaluation process for successful mentoring.</td>
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<td>3. Create task force to identity needs and existing research courses and workshops in the field. Identify most successful courses and sponsors. List courses and workshops on a web site. Develop list of faculty willing to serve as mentors with their area of expertise.</td>
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<td>5. Lack of scientific training, grantsmanship, and senior faculty to serve as role models</td>
<td>1. Increase training opportunities and number of senior investigators with successful research programs.</td>
<td>4. Develop funding (internal and external) to provide extended research experiences in high priority (hot topic) areas for students, residents and fellows or for senior faculty who want to retool.</td>
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| 6. Lack of infrastructure that supports collaborative and interdisciplinary research and is consistent with the resources and institutional culture | 1. Develop strategic plans to enhance local and national infrastructure. | 1. Professional organizations and/or foundations to establish a consultation model/service to help new or small departments develop research programs. PM&R Foundation to consider subsidizing consultation program.  
2. Identify, develop, and disseminate a database of successful models of organizational infrastructure including resources such as “toolkit” and Web-based resources. |
| 7. Chairs and faculty leaders often lack experience and skills in developing and maintaining successful research programs | 1. Create and/or expand training programs for faculty leaders. | 1. Professional organizations and foundations in rehabilitation should expand existing training programs for chairs and faculty to include more emphasis on research.  
2. Identify and publicize existing training programs for chairs offered by research intensive universities (e.g., program at Harvard) and organizations (e.g., AAMC).  
3. PM&R Foundation should develop program to subsidize faculty chairs attending leadership training programs.  
4. Identify and disseminate existing and potential models of leadership that promote rehabilitation research.  
5. Establish mentorship and coaching models to develop research leaders.  
6. Create a research development consultation team. |
| 8. Lack of visibility and identity limits opportunities for collaboration with potential academic and industry partners | 1. Enhance visibility and recognition in targeted arenas: academic, general public, industry, etc. | 1. Expand existing marketing plans and efforts to highlight research as well as clinical contributions to society.  
2. Invest in development of public relations program using professional consultants focused on current and potential future contributions of rehabilitation researchers in specific hot topic targeted areas. |
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<tr>
<td>1. Lack of advocacy for research support</td>
<td>1. Mobilize population(s) to advocate for rehabilitation research including people with disabilities.</td>
<td>1. Organize a summit for constituency organizations (e.g., NMSS, AARP, and others) to join efforts and support rehabilitation research.</td>
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<td>2. Form “Friends of Rehabilitation Research” campaign to highlight voters with disabilities living in your community.</td>
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<td>3. Emphasized demographics of disability.</td>
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<td>2. Lack of rehabilitation penetration in federal issues</td>
<td>1. Implement scientific review panels with expertise and interest in rehabilitation.</td>
<td>1. Request NIH dedicated rehabilitation permanent scientific review panel.</td>
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<td>2. Develop more research centers of excellence.</td>
<td>2. Issue a request for applications (RFA) for additional “Interdisciplinary Research Centers of Excellence.”</td>
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<td>3. Become more influential and engage NIH networks.</td>
<td>3. Organize meetings of leaders of rehabilitation organizations (a coalition) with the directors of NIH and other funding agencies.</td>
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<td>4. Consider a non-NIH Federal Agency to consolidate federal disability organizations in the Department of Health and Human Services (including more support for rehabilitation research).</td>
<td>4. Ask NIH to send out RFAs related to rehabilitation research across institutes as a development tool for capacity of less experienced researchers.</td>
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<td>3. Fragmentation of rehabilitation organizations and lack of coordination among organizations (PM&amp;R, PT, OT, Neuroscience)</td>
<td>1. Consolidation of rehabilitation organizations to create a focused voice on rehabilitation research.</td>
<td>5. Given disparity in Federal funding agencies for disability, consider legal opinion to pursue federal government for discrimination against people with disabilities.</td>
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<td>4. Lack of departmental resources for infrastructure in local institutions and medical schools. Recognition of financial resources rather than science</td>
<td>1. Center Grants for institutional infrastructure supporting rehabilitation research are needed.</td>
<td>6. Develop a group of accomplished researchers (Speaker’s Bureau) who would be willing to speak to funding agencies as needed to discuss research funding, training, and overriding issues.</td>
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<td>5. Quality of research and competitiveness of individual researcher (Do we walk the walk to get funding?)</td>
<td>1. Local institution must value individual researcher to be competitive.</td>
<td>7. Move beyond NIH to develop a Disability Agency in DHHS (incorporates medical, social, transportation, and other issues).</td>
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<td>6. We can better identify other funding sources</td>
<td>1. Identify other funding sources.</td>
<td>1. Get the AAPM&amp;R, AAP, and ACRM to develop a plan to coordinate the efforts of rehabilitation organizations.</td>
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<td>2. Create a united voice with participation of all organizations (PM&amp;R, neuroscience, Allied Health professions).</td>
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<td>3. Meet with AAMC representatives and leadership to advocate for encouragement, visibility, and funding in medical schools for rehabilitation research infrastructure.</td>
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<td>2. Consider new branding (hire professional consultants) of rehabilitation efforts to be more visible, consistent, inclusive, and emphasizing research.</td>
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<td>3. Look within ourselves and accept responsibility to be more competitive researchers and seek collaboration across disciplines.</td>
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<td>4. Teach the art of networking outside of our own department and grantsmanship.</td>
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<td>5. Conduct mock study section reviews “in house” to refine grants.</td>
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<td>1. Foundation for PM&amp;R, AAP, AAPM&amp;R, ACRM, and other professional organizations to develop web page listing of all possible resources (e.g., Paralyzed Veterans of America, National Stroke Association, Foundations, and others).</td>
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<td>2. Develop case studies of rehabilitation researchers who have been successful in obtaining funding.</td>
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<td>3. To develop a portfolio of funding options.</td>
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Table 4

<table>
<thead>
<tr>
<th>Research Capacity Element</th>
<th>Partnerships</th>
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<tbody>
<tr>
<td>Group Leaders</td>
<td>Rory Cooper, PhD and John Kemp, JD</td>
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<thead>
<tr>
<th>Problem</th>
<th>Solution</th>
<th>Recommended Action</th>
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<tbody>
<tr>
<td>1. There are diverse stakeholders and a lack of a common framework</td>
<td>1. Try to bring together the federal agencies, state agencies, professional societies, consumer organizations, foundations, and research institutions. Develop effective partnerships with and among these organizations.</td>
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<td></td>
<td>2. Try to bring together the diverse professional societies to agree upon key issues and strategies for areas of common interest. For example, those professional societies participating in this summit.</td>
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<td></td>
<td>3. Form partnerships with different Departments and Professions. Incorporate industry as part of the partnership where sensible. Work with state organizations.</td>
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<td></td>
<td>4. Much larger group needs to demand funding. Only through partnering with consumers (disability organizations, individuals with disabilities, advocacy organizations) can there be a large and effective enough group to increase funding. Organizations of people with disabilities need to be brought together.</td>
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<td></td>
<td>5. Educate foundations and other organizations about disability and medical rehabilitation research.</td>
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<td>6. We need to form partnerships to educate the public and public officials to remove social stigma of disability and to understand the value of research.</td>
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<td></td>
<td>1. Include “Relevance to the Consumer Population” and “Significance to the Consumer” as part of the grant process in every funding agency.</td>
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<td>2. Include educated consumers in the peer-review process.</td>
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<td></td>
<td>3. Provide incentives to investigators to include people with disabilities.</td>
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<td></td>
<td>4. Greater communication with consumers needs to be established. We need to institutionalize consumer driven research priorities, and we need to regularly and effectively communicate R&amp;D results to consumers.</td>
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<td></td>
<td>5. Partnering with groups that can provide necessary funds.</td>
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<td></td>
<td>6. Education of general public about the potential to ameliorate or live with a disability.</td>
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<td>1. Form a “Rehabilitation Coalition” to speak with a common voice. This would likely have to be issue or project focused. For example, to promote research and capacity building. The American Institute of Medical and Biological Engineering (AIMBE) or ITEM Coalition may be models to consider.</td>
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<td></td>
<td>2. Create Educational Programs to inform the various stakeholders: professional organizations and consumers, and to seek their support for rehabilitation research and research policy.</td>
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<td></td>
<td>3. Create educational programs for consumers and nonrehabilitation professional groups about the benefits and positive outcomes of rehabilitation research. For example, increased risk of cardiovascular disease among people with SCI.</td>
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<td>4. Establish an annual forum.</td>
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<td></td>
<td>5. Establish a national partnership body, comprised of:</td>
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<td></td>
<td>• Government</td>
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<td></td>
<td>• ICDR</td>
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<td></td>
<td>• Research regulation and reimbursement</td>
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<td></td>
<td>• For-profit sector</td>
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<td></td>
<td>• Venture capital</td>
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<td></td>
<td>• Pharmaceutical industry</td>
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<td>• Insurance</td>
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<td></td>
<td>• Voluntary consumer organizations</td>
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<tr>
<td></td>
<td>• Health</td>
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<tr>
<td></td>
<td>• Rehabilitation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Professional organizations</td>
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<tr>
<td></td>
<td>• Legislative organizations</td>
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<tr>
<td></td>
<td>• Academic community</td>
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<tr>
<td>2. Inadequate full participation of consumers in research and development</td>
<td>1. Develop training programs for people with disabilities (including family members) in order to promote meaningful participation in rehabilitation research.</td>
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<td></td>
<td>2. Expand scholarship opportunities within federal agencies and private foundations for people with disabilities.</td>
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<td>3. Create an awareness campaign so that consumers become knowledgeable about opportunities to contribute to research and development.</td>
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<td></td>
<td>4. Partner with consumer groups (AAPD, NCIL, etc.) and other health advocacy groups.</td>
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<td>5. Conduct research in public policy.</td>
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<td>6. Seek dedicated funding to enhance partnerships.</td>
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<td>7. Support a disability leadership summit on research.</td>
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<td>8. Train researchers and proposal writers how to tap into priorities and consumer expertise.</td>
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<td>9. Encourage PI’s to implement participatory action research.</td>
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<tr>
<td>Problem</td>
<td>Solution</td>
<td>Recommended Action</td>
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<tr>
<td>3. Lack of relationships with payers results in discrimination towards</td>
<td>1. Partnerships with reimbursement organizations (for example to show</td>
<td>1. Have discussions with payers prior to the research projects.</td>
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<td>people with disabilities</td>
<td>that the 75% rule is flawed there are cost implications and community</td>
<td>2. Request the IoM to look into the 75% rule and the “In the Home Rule” again to prevent people from being shuffled off to nursing homes.</td>
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<td>participation issues. This dialogue needs to be inclusive of more groups</td>
<td>3. Promote a “call for research” to determine the best “rehabilitation processes and structures” and the possible impacts of proposed policy changes.</td>
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<td></td>
<td>of people with disabilities).</td>
<td>For example, what are the best combinations of rehabilitation services and settings to achieve optimal (acceptable) outcomes for people with various impairments?</td>
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<td>2. Dialog with CMS and other health care providers about provisions of</td>
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<td>specific services for people with specific disabilities (in the home</td>
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<td>rule).</td>
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<td></td>
<td>1. Have discussions with payers prior to the research projects.</td>
<td>2. Partner with institution to develop an infrastructure for rehabilitation research.</td>
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<td></td>
<td>2. Request the IoM to look into the 75% rule and the “In the Home Rule”</td>
<td>3. Conduct research in the mechanisms by which treatments work—basic science.</td>
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<td></td>
<td>again to prevent people from being shuffled off to nursing homes.</td>
<td>4. Special incentives for new investigators.</td>
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<td></td>
<td>3. Promote a “call for research” to determine the best “rehabilitation</td>
<td>5. Partnership with patients to create cohorts for long-term follow-up.</td>
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<td>processes and structures” and the possible impacts of proposed policy</td>
<td>6. Mentoring, developing a presentation to give to medical students to encourage rehabilitation research.</td>
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<td>changes. For example, what are the best combinations of rehabilitation</td>
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<td>services and settings to achieve optimal (acceptable) outcomes for</td>
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<tr>
<td></td>
<td>people with various impairments?</td>
<td></td>
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<tr>
<td>4. Lack of rehabilitation research capacity and rigor</td>
<td>1. Partnering with other relevant disciplines (medical specialties,</td>
<td>1. Leadership training for department chairs.</td>
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<td></td>
<td>allied health professionals).</td>
<td>2. Partner with institution to develop an infrastructure for rehabilitation research.</td>
</tr>
<tr>
<td></td>
<td>2. Funded networks with adequate resources.</td>
<td>3. Conduct research in the mechanisms by which treatments work—basic science.</td>
</tr>
<tr>
<td></td>
<td>3. Partnership with patients to create cohorts for long-term follow-up.</td>
<td>4. Special incentives for new investigators.</td>
</tr>
<tr>
<td></td>
<td>4. Increasing rehabilitation exposure to medical students.</td>
<td>5. Partnership with patients to create cohorts for long-term follow-up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6. Mentoring, developing a presentation to give to medical students to encourage rehabilitation research.</td>
</tr>
</tbody>
</table>

IOM, Institute of Medicine; NIH, National Institutes of Health; NIDRR, National Institute on Disability and Rehabilitation Research; PM&R, Physical Medicine and Rehabilitation; AAMC, Association of American Medical Colleges; NMSS, National Multiple Sclerosis Society; AARP, American Association of Retired Persons; ACRM, American Congress of Rehabilitation Medicine; ICDR, Interagency Committee on Disability Research; AAPD, American Association of People with Disabilities; NCIL, National Council on Independent Living; DHHS, Department of Health and Human Services; PI’s, Principal Investigators; CMS, Centers for Medicare and Medicaid Services; VA, Veterans Administration; CDC, Centers for Disease Control and Prevention; AHRQ, Agency for Health Care Research and Quality.
<table>
<thead>
<tr>
<th>Problem</th>
<th>Solution</th>
<th>Recommended Action</th>
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<tbody>
<tr>
<td>1. Lack of a consensual definition of “research capacity”</td>
<td>1. Define the construct by delineating its essential components, some attractive candidates being funding, qualified researchers, institutions, research training, research methods, an applicable knowledge base, an encompassing research agenda (including topics, their relative priority, and funding levels), knowledge translation activities, defined consumer demand and need, and political advocacy.</td>
<td>1. Submit the array of domains to an intensive review to assure that is reasonably comprehensive and free of redundancies.</td>
</tr>
<tr>
<td>2. Lack of conventions for deciding on metrics and measures for many of the domains</td>
<td>1. Attain consensus on feasible ways to a) quantify each domain and b) characterize each domain’s quality of achievement. Then establish the psychometric properties of the key indicators, e.g., their validity, reliability, and sensitivity.</td>
<td>1. Devote the post-Summit, multiorganizational strategic planning effort in part to deciding how to implement the necessary empirical work, both the psychometric development of indicators and their application in a data gathering effort to characterize baseline research capacity.</td>
</tr>
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<td>3. Lack of a database describing current research capacity as a baseline for assessing future gains</td>
<td>1. Create a database describing current research capacity as a baseline for assessing future gains.</td>
<td>1. Develop the database, drawing on the AAPM&amp;R/RAAC Survey on Academic Leadership &amp; Research Development, on behalf of either 1) a possible effort to coordinate federal agencies supporting rehabilitation research, or 2) a consortium of rehabilitation-related voluntary organizations such as those represented at the summit.</td>
</tr>
<tr>
<td>4. There may be too many specific domains, making it potentially unrealistic to capture them all in a database</td>
<td>1. Organize the domains by identifying a subset of underlying ones.</td>
<td>1. We developed a Venn diagram comprised of three “super domains” that relate directly to the four other focus-group topics (cf. PowerPoint slide).</td>
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<tr>
<td>Table 6</td>
<td>Indicators of Research Capacity Building</td>
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| 1. Rehabilitation Research Trainees | 1. Number of funded postdoc positions available in rehab (NIH, NIDRR, VA, CDC, AHRQ, and other national funding agencies) and the distribution of fellows across rehabilitation disciplines.  
2. Proportion of trainees who come through research training programs who become researchers: full, part time, none.  
3. Average research products by research trainees in rehabilitation including citation of research products and extramural & intramural levels of funding. |
| 2. Size of rehabilitation research cadre | 1. Define who is considered as a core rehabilitation professional.  
2. Explore and use where possible existing methodology.  
3. Enlist cooperation of funding agencies to collect and share this information. |
| 3. Productivity | 1. Enlist professional organizations to collect this information on a regular and standardized basis.  
2. Secure data from the AAP Annual Survey. |
| 4. Funding | 1. Define the articles and journals relevant to include.  
2. Could search by professional organization membership, institutions, discipline, and by country.  
3. Enlist professional organizations to collect this information on a regular and standardized basis.  
4. Explore and use where possible existing methodology. |
| 5. Funding | 1. Enlist friends of rehabilitation to identify agency contact points to secure these data on an annual basis. |
It is really a pleasure for me to be here. I come to this meeting in part because the topic is so important and in part because the organization of the meeting struck me as so sensible and necessary at this time. But I also come as an outsider. I am not a person who is immersed in the field of rehabilitation medicine. I engage the topic from the perspective of an interested outsider. It is in this spirit that I want to share with you a few reflections and to say something about the work at the Institute of Medicine that I think bears on the interests of this group and on the work that you will be doing over the next 2 days.

The two key ideas that animate this conference are the concept of research and the subject of rehabilitation medicine as a topic of research. Oftentimes, when we think about research, we think about priorities for research, and we imagine resources for research being in some sense in competition with resources for care. We think about the dollars, time, and effort required for patient care in comparison to the resources needed for research or education. What I would like to suggest is that the tradeoff is not about research vs. care. The tradeoff is care today, with today's ability and technology, vs. care tomorrow, with improved abilities and technology. And so, when we think about investment in research vs. investment in care, it is really a tradeoff of present care vs. future care. And all of the effort is ultimately directed to the same ends, to the improved function and care of our patients. It is only a question of how much of our resource do we devote to what we can do today and how much do we devote to what we need to do to improve performance in the future.

If you consider the field of rehabilitation at large and the burden of disability on individuals, families, communities, and societies, the discrepancy between the comparatively tiny amounts we are now investing on research vs. what we are currently spending on care seems vastly disproportionate. By any reasonable estimate, we are spending several thousand dollars on today's care for every dollar we are investing to improve care in the future. One way to approach the question that you will be talking about and thinking about in terms of making the case for financial support of research is to stress the need to learn what works and to improve our ability to do what we need to do for the future.
patients in the future compared with what we are already spending on care today. I think this is a very powerful argument, but the case has to be made.

To me, the notion of disability is relative in two very important senses. It is relative first to our expectation of a standard capacity, of what we mean by ability vs. disability, and second, disability is always relative to the environment in which we live and function, whether it as a child, an adult, a senior citizen, or in whatever capacity. Consider for a moment if most people had voices that could project at 100 decibels if they wished, the fact that I am reliant on this microphone would be a mark of accommodation to my inability to speak at the volume that most people could speak, and I could rightly be considered to have a “voice-volume” disability. Imagine for a moment if most people could perceive in the infrared or ultraviolet range, beyond the current visual spectrum. Would I not be disabled by being limited to vision only in what we now think of as the visual spectrum? If I cannot appreciate the beauty of music sounded at levels of frequency in the ultrasound range, which perhaps bats are able to appreciate, would I not be considered to have a hearing disability? If most people could literally leap buildings at a single bound, would not my reliance on the elevator be a mark of accommodation to my inability to speak at the volume that most people could speak, and I could rightly be considered to have a “voice-volume” disability. The point is that our expectation about what it means to be “abled” is premised on our expectations of what we ought to be able on average to accommodate.

Every part of our built environment is in fact an accommodation to the current level of ability of most people. We do not climb stairs, those of us who do, 4 feet at a time, so steps are not designed to be 4 feet apart in height. We do not manage to cross the street at a gait of 20 feet per pace, so steps are not designed to accommodate the current speed of movement. The whole point of universal design is to break down the old distinction between a “naturally designed environment” and an “accommodated environment” and rather to think more broadly about the way in which our environmental design matches the abilities of more people to function in that environment. This notion of enabling and disabling in connection to the environment is a very important principle.

Let me say a couple of words of background about the Institute of Medicine before I allude to some of our work that bears on the subject of this conference. The Institute of Medicine is a part of the National Academies, which have three elective components: the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The National Academies stand outside of government as a private, nonprofit entity. The organization dates back to the charter originally awarded by the Congress in 1863 to establish the National Academy of Sciences. Established from the outset to be independent of government, the charter describes the purpose of the Academy to provide advice to any agency of government “on any matter of science or art.” Now, the word art at the time, I hasten to add, meant the applied or practical arts, what we would today describe as technology. The key idea was that it would be in the national interest to have a group of leading scientists who would apply their knowledge in service to the nation. Originally, help was needed in the Civil War effort. Over the years, the various parts of the National Academies have covered the entire spectrum of science-based policy in our nation: in the environment, in areas of education, and, of course, in matters of health, among others.

The Institute of Medicine began in 1970 as a separate elective body within the complex of Academies. One of the powerful lessons we have learned over these several decades is that the Institute of Medicine often has its most powerful effect when we tackle a subject repeatedly, rather than in a one-off way. For example, the work that the Institute of Medicine has done on the quality and safety of health care began with a set of preliminary studies leading up to a landmark study on errors in medicine called “To Err is Human,” released 5 yrs ago. The following year, a report called “Crossing the Quality Chasm” laid out a blueprint for thinking about systemic change in health care to improve quality. And there followed more than a dozen reports on different aspects of improving quality. By returning again and again to different aspects of the broad topic of safety and quality, I believe we have had a greater impact on the thinking of legislators, on action by the professions, and on the choices of policy-makers in the public and the private sector.

The work of the Institute is carried out mainly through volunteer committees whose members are not compensated. This notion of voluntary service also dates back to the original congressional charter. Because many talented individuals are willing to perform this public service, we are able to assemble individuals from a range of disciplinary backgrounds to deal with the problem at hand. The committee volunteers may be drawn from the members of the Institute or from other experts. In 2004, approximately four out of five people who served on one or another of our report committees were not members of the Institute of Medicine.

In the area of rehabilitation and disability, the work at the Institute of Medicine dates back at least 20 yrs to a report in 1985 on injury in America. The
committee that produced this report was chaired by Bill Foege, who later became director of the Centers for Disease Control and who championed the importance of understanding injury as a public health concern. This report helped establish injury as a distinct, major health problem. The 1991 study called “Disability in America” made a similarly important contribution by identifying disability as a comprehensive and coherent field of inquiry. This highlights what is to me one of the great challenges to your field, to define and conceptualize it in a coherent way, because you are so diversely represented across a range of clinical conditions and types of expertise.

In 1997, the Institute of Medicine report called “Enabling America” stressed the idea that our concept of disability was intimately connected to the individual–environmental interface, that one could not talk about ability or disability without placing the individual in a particular environment. If you want to improve performance, you can work with the inherent and developed capacity of the individual, the patient, or you can work on improving the accommodation of the environment to the capacity of that individual. By focusing on the relationship between the individual and environment, a sensible research strategy followed, to strengthen either the patient or the environmental side of the equation, and particularly the two in concert. The report recommended three basic steps that still ring true today. First, we have to strengthen the underlying science both on the environmental side and on the individual patient side. Second, the interface between the individual and the environment, what they called the enabling/disabling process, can help organize a research and policy agenda. And finally, the report places special emphasis on the transformation of technologic advances into practical benefits.

There are several reasons why it is timely and significant for rehabilitation medicine and all those concerned with disability to come together around a common research agenda. First, there is hardly any field I can imagine which better exemplifies the value and importance of multidisciplinary collaboration in the solution of practical problems. If you think about it, the role of engineering and biomedicine as one example is so evidently necessary in coming to grips with the needs of individual patients and the environment–patient interface. Second, there is hardly any area, I believe, that is better positioned to promote and capitalize on critical areas of advanced science today, including stem cell research, biomechanics, nanotechnology, robotics, and much, much more. This is an opportunity for those concerned with the very practical improvement of people’s lives to join in partnership with those performing research at the cutting edge of science to hasten the translation of those advances into practical benefits. These collaborations between the bench and the field can both inform the nature of the basic science that needs to be done and enable patients to take faster advantage of advances as they come along. If you look at the roadmap for the NIH, many of the strategies of interdisciplinary research, of translational medicine, and of training scientist/clinicians who can move between the patient and leading edge research can be fulfilled by research in the field of rehabilitation medicine.

While this is a remarkably promising time to be thinking systematically, coherently, and aggressively about a research agenda, you also face a number of serious obstacles in making the case for research in the field. First, I think there is a problem of definition and understanding of what constitutes the field. How broadly or narrowly does it apply? Does it really span the full range of mental, emotional, and physical disability and rehabilitation? Does it really concentrate on everything from accommodating the educational needs of children to the rehabilitation of the patient who has experienced a stroke late in life and everything else in between? How does one gain a common perspective and ground from the range of clinical experts, let alone those outside of clinical medicine, to have a common framework for understanding what is in the field? Working against a coherent framework are the plethora of disease-based interests in our country, which are necessary and good for many reasons but which naturally stress a particular origin of a disability rather than a functional consequence of that disability. This is a huge challenge, I think, to sort out conceptually the range of included topics and to cut across the disciplinary and disease interests that reside in different parts of the research landscape but have to be brought together somehow.

Second, we have to recognize that even today, disability makes most Americans uncomfortable. People are uneasy around persons with disability and embarrassed about it. As a community concerned about disability, we need a consistent outreach and communication to the public so that more people will come to appreciate that there is a continuum of ability, that everyone has the opportunity and should have the right to live their lives to the fullest ability that we can, with our current technology, enable. And these basic ideas are hard when people’s initial reaction is a kind of wariness and embarrassment.

A third basic obstacle is that, in today’s environment, where so many government agencies and research organizations feel under tremendous pressure financially, the opportunity to raise new funding is going to be severely constrained. Part of
the trick in advancing the cause of physical medicine and rehabilitation is going to be thinking about how to apply a kind of jiujitsu strategy to take advantage of the directions, the trends, the ways we are now investing in research, to redirect and guide it to serve the purposes of your field. For these reasons, building on the connections to hot fields of basic research, making a persuasive case to the public, and being forthright about the gap between what we are investing in research and what are the potential payoffs over time are all going to matter a great deal.

From the vantage point of the Institute of Medicine, I am pleased that our reports have been able to contribute progressively to laying the groundwork for the field. I hope that you will offer your advice and guidance to us for future work, which we would very much welcome. I wish you every success and thank you very much for the privilege of speaking with you this morning.
Opportunities for Rehabilitation Medicine Research in Medical Schools

ABSTRACT

Key Words: Research Summit, Rehabilitation, Medical Schools

From the medical school standpoint, the opportunities for rehabilitation medicine research are both unprecedented and unlimited. Growing awareness that virtually everyone is touched by disability at some point in their lifetime coupled with greater visibility of some remarkable success stories are heightening the field’s profile overall. Further, with its many adjacencies to and synergies with other fields, rehabilitation medicine exemplifies modern science’s new demand for interdisciplinary and multidisciplinary approaches. As Institute of Medicine President Harvey Fineberg, MD, PhD, observed, it is a particularly opportune time for partnership and collaboration.

Before discussing these new research opportunities, as well as the strategies for exploiting them, I’d like to thank Joel DeLisa, MD, MS, Professor and Chair, Department of Physical Medicine and Rehabilitation, UMDNJ–New Jersey Medical School; Thomas E. Strax, MD, Professor and Chairman, UMDNJ–University Hospital; and others active in the Association of American Medical Colleges (AAMC) for their assistance. I am grateful to them for their expertise and for helping me learn in depth about the issues you confront.

Let’s begin with some of the challenges facing the research agenda for rehabilitation medicine. First, National Institutes of Health (NIH) funding to medical schools in this area has clearly been inadequate. In examining NIH reporting on the state of financing for physical medicine and rehabilitation (PM&R) medical school departments, I made some interesting discoveries. In 2003, training grants totaled only $1.1 million. Further, only six PM&R departments received over $150,000. Moreover, in 2003, NIH devoted less than $17 million in the aggregate to research labeled as “rehabilitation research” and provided only seven departments in the country with more than $1 million. These funding levels contrast with the $28 billion in federal support NIH received in 2004 and the approximately $26 billion it received in 2003. In other words, the amount of funding allocated for rehabilitation research has been smaller than decimal dust in terms of NIH support.

Additionally, the National Center for Medical Rehabilitation Research (NCMRR, within NIH’s National Institute of Child Health and Human Development), a major...
source of basic research funding in this field, was allocated $62.5 million in 2003. Where was this funding dispersed if it did not go to medical schools? Did it go to hospital departments or other organizations? This funding level is obviously a very meager base on which to craft a sensible research agenda, especially given the magnitude of the problems.

Additionally (and most likely directly related to the problem, although it’s clearly a chicken and egg phenomenon), trained investigators in the field are very few in number. For all I know, perhaps their entire number is in this room. But the paucity of training funds in tandem with the paucity of investigators has resulted in much too small a cadre of individuals devoting their professional careers to this field. Historically, and again from the medical school point of view, there’s no question that the PM&R departments and those interested in rehabilitation medicine have been on the margin when it comes to the mainstream interests of medical schools. This situation is particularly true of research-intensive medical schools, for a number of reasons.

One reason is that other fields have appeared more “sexy,” more on the cutting edge of biomedical research, and more responsible for some exciting new discoveries at the molecular and submolecular levels. This trend has captured the attention of most young people interested in science careers and explains why PM&R departments have not participated as actively in the academic research enterprise as one might hope.

And in listening to Dr. Fineberg, it occurred to me that the general aversion of our culture to persons with disabilities probably plays into the issue of reputation, status, and prestige of PM&R departments relative to other medical school functions.

However, PM&R is not alone, certainly in a qualitative sense, with regard to the plight clinical departments have faced with regard to research. Recruiting and retaining clinical investigators, in general, has been difficult, largely because there is too little time for research and because of the pressures clinical faculty face in their clinical roles, especially the need to generate revenues to support their salaries as well as their departments’ functions. In many instances, if not the vast majority, these pressures have eroded the time and intellectual space available for research. Finally, the movement of patients out of hospitals has meant fewer opportunities for students to encounter patients in such settings. And, at least as I understand the nature of rehabilitation medicine, access to patients in hospital settings is a critical part of learning. In fact, this decreased access may have limited the kinds of investigations that might otherwise have been conducted.

At the same time, however, there are enormous opportunities today for medical schools that we must recognize and build upon. First, there is truly a growing awareness of the PM&R field’s magnitude. More specifically, there is a recognition that disability is not confined to a small subset of marginalized individuals and that it touches virtually everyone. Or, stated differently, virtually every kind of medical problem engages disability at some point during an individual’s lifetime. Consequently, the possibilities that can be incorporated or conceptualized as part of rehabilitation research are virtually boundless. Recently, the popular press has been featuring some truly remarkable successes in rehabilitation medicine, many of them resulting from Iraqi War casualties.

As a result, there is now greater awareness that much can be done to rehabilitate those who have been physically and mentally affected by the war’s trauma. We ought to build upon and exploit the fact that these stories are now in the popular press and in the public mind and emphasize that rehabilitation medicine is something exciting and worth pursuing.

As Dr. Fineberg mentioned, a number of exciting frontiers (such as nerve regeneration and neuroplasticity) offer enormous opportunity for a major expansion of activity and advances in the field. Opportunities to assist those with sensory deficits (e.g., impaired vision and hearing) are simply phenomenal. Additionally, pharmaceutical aids to memory offer exciting possibilities for rehabilitation to those with dementing problems. How do we take advantage of these opportunities?

Notably, we are at a point in time when a significant shift is taking place in modern science. Increasingly, modern science is demanding and depending upon interdisciplinary, multidisciplinary teams of investigators. It seems quite unlikely that future advances, especially in this field, will be made by individual investigators working alone in their proverbial basements. Rehabilitation medicine, with all the adjacencies, synergies, and partnerships that can be effected with other scientific disciplines (e.g., pharmacology, information, sciences, physics, bioengineering) exemplifies opportunities for interdisciplinarity and multidisciplinarity. Until recently, many of these disciplines had been removed from the medical mainstream in general and your field in particular. Today, the rapid succession of advances being made in each of these fields makes them ripe for collaboration.

Bioengineering, with its many subdisciplines (e.g., orthotics, prosthetics and other assistive devices, neuroprosthesis, functional electrical stimulation, brain imaging), is a particularly attractive research partner. In fact, the imaging field as a whole is exploding with possibilities, and the chance to anneal with this growing science is certainly one of many paths to be pursued. Additionally, robotics and improved control of the environment in speech and language communications are two areas where our bioengineering colleagues can greatly help leverage the kinds of problems you can identify.

How can medical schools, as active participants
in this field, participate more fully in the success of rehabilitation research? And what are the strategies for success? First, we need an explicit marketing effort aimed at medical students. Such a marketing effort will ensure students are aware of the field’s cutting-edge research opportunities as well as society’s growing need to solve problems affecting more and more individuals. Additionally, we need to define the magnitude and extent of the research agenda and effectively communicate these research needs to students still in the formative years of deciding how to apply their creative energies.

I also wonder whether we can do more to address medical school admissions barriers for disabled students. While it may seem cynical to think about the issue this way, it is fairly self-evident that individuals who are in some way disabled will be more inclined to devote their careers to finding solutions involving rehabilitation than other students might be. As I’m sure you are all painfully aware, we are still laboring under a very strong bias against disabled students becoming future doctors. Dr. DeLisa has been urging me to impress medical school admissions committees about the capabilities, not the disabilities, individuals bring to the admissions process. If we were to address this agenda more aggressively, it would, among other things, lead to a larger potential cohort of individuals naturally inclined to pursue rehabilitation research.

In addition to marketing rehabilitation medicine to prospective students, we need to think about marketing to prospective faculty and potential research funders. Here, we clearly need to publicize the enormous advances being made, the kinds of opportunities that now exist, and the tipping point we have reached regarding the field’s future. We must emphasize that our PM&R departments need more built-in resources and that a major research agenda cannot be built upon a flimsy base of support. The absence of desired funding levels from NIH means that medical schools now have both the challenge and the opportunity to provide enough seed funding, or enough groundwork, for a research infrastructure that creates a nidus of activity. In turn, such activity will grow and be stimulated by an expanding research agenda.

The key point underlying these marketing efforts is the recognition that one plus one in rehabilitation medicine equals more than two. We must recognize the leverage available to us by annealing rehabilitation research to other areas already enjoying a good deal of recognition and a good deal of funding. In this fashion, we will be able to find ways of converting or torquing that activity toward rehabilitation needs. Partnerships in areas where there are clear adjacencies need to be actively targeted, and collaborative activities with our medical school colleagues need to be explicitly pursued. In other words, we need to look at medical school departments such as orthopedics, ophthalmology, otolaryngology, and neurology as obvious candidates for solving problems of mutual interest. And, we must think much more creatively about engaging the participation of other departments (e.g., engineering, physics, psychology, and other disciplines not previously sought as actively) in our university environments.

We also need to increase the base of research funding, and here, patients become natural allies. Patients who have benefited from rehabilitation research can be invaluable advocates, and we should have no hesitancy in recruiting and organizing patient advocacy groups.

As we work to increase the research funding base, we must also be cognizant of existing budgetary constraints. The notion of getting brand new money devoted to this field is daunting, but a strategic planning effort looking at the potential sources of federal support could be a very important strategy and one that we might want to ask the Institute of Medicine to think about more carefully.

I was persuaded to emphasize this point when I looked at the potential funding sources for rehabilitation research at the federal level. They are both numerous and substantial. As I noted earlier, the NCMRR, within the NIH’s National Institute of Child Health and Human Development, has been the principal source of research funding. But there are several other institutes that at least on the surface seem ripe for involvement in rehabilitation, such as the National Eye Institute, National Institute of Arthritis and Musculoskeletal and Skin Diseases, National Institute of Biomedical Imaging and Bioengineering, National Institute on Deafness and Other Communication Disorders, and National Institute of Neurological Disorders and Stroke. Outside the NIH, we have the Agency for Healthcare Research and Quality, which also has a mandate to pursue outcomes and effectiveness research. Additionally, the Department of Veterans Affairs (VA) clearly has a major interest in rehabilitation and is already devoting a good deal of resources to this area intramurally—that is, within the VA itself. Both the Department of Defense and the Centers for Disease Control and Prevention (CDC) also have an interest in this field.

As the saying goes, “there’s got to be a pony in there somewhere.” Efforts to increase support for rehabilitation medicine research are going to require some prospective, thoughtful, strategic thinking about how we can identify, within this very large, extensive mosaic of potential funding sources, opportunities to strategically devote more effort, more energy, and clearly more resources to this field. The prospects for rehabilitation medicine research, from the medical school standpoint, are more promising than ever. Today’s environment, the state of the science, and the state of public awareness together provide enormous momentum for us to move forward. Thank you.
Potential Role of the For-Profit Sector

ABSTRACT


Key Words: Research Summit, Rehabilitation, Economics, Business

I was in a taxi at 4:30 this morning, racing to get to the 6:00 shuttle, when I retrieved an e-mail that my son had sent the night before. He was also going to be in Washington today, a few miles away at the Department of Interior. He was there for the announcement that a bird, thought to have become extinct about 70 yrs ago, had been rediscovered in Arkansas. It seems an interesting contrast that he was going down to announce the rediscovery of what had been presumed to be an extinct species, the ivory billed woodpecker, and I was going to talk at a meeting on how to prevent a species from becoming extinct, the physician researcher.

Dr. Fineberg and Dr. Cohen have both told you how they felt like outsiders at the conference. For me, the term outsider is really an understatement. When I moved from Chair of Medicine to CEO of a hospital, I thought I had moved to the “dark side.” At least that’s what all my colleagues had told me. But when I left my position as CEO of a hospital to begin a venture capital fund, most of them didn’t know how to characterize it, and neither did I. It has turned out to be quite an interesting experience. I have now sat on all sides of the table, both asking for funds and distributing funds in various guises. Using my most recent perspective, I thought I would use the time that I had today to look first at what funding sources exist for academic departments in general, and for research in particular, and then focus on an area that you’re probably not used to thinking about, namely, the world of the entrepreneur.

Let me begin by looking at the potential sources of funds for clinical departments (Table 1). I have sat with chairmen of clinical departments for many years reviewing budgets and revenue opportunities. Clinical revenues are clearly the major source of available dollars. An individual department’s share of graduate medical education payments is often a point of disagreement between chairs of academic departments and the people who control those funds, usually CEOs of hospitals. This should be another important source of funding, but lack of knowledge on the amount and distribution of these dollars puts the clinical chairs at a disadvantage. Classical research funding from the federal government and its foundations and a portion of the overhead that accompanies these funds has, unfortunately, become a shrinking asset. The transfer of funds from the hospital for services provided is an often overlooked and sometimes difficult to negotiate asset. A clinical department’s share of the money that medical schools receive from tuition, grants, and state aid is another area for chairs to

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pursue. Philanthropy is an attractive alternative, although this may put you in conflict with your medical school or hospital because they're usually not happy to see individual departments going into competition with their own development departments. Finally, there are entrepreneurial activities.

In the typical academic health center, 90% of the available funds come from clinical care, and these are used for a variety of things. They can be used to cross-subsidize research and education, but after paying for operational expenses, there is usually not much left. Hospitals have very low margins, and those margins are shrinking as we speak. There are increasing burdens resulting from falling reimbursement and from uninsured or underinsured patients. There are, as well, the increasing costs of technology. As a venture investor, I see a technology revolution about to break loose, and I worry about the amount of money that much of this technology is going to cost. If we look just at some of the things that you are predicting in the field of physical medicine and rehabilitation, you can project that the costs for clinical care are likely to increase substantially. Although this new technology is going to hopefully be translated into better and more efficient patient outcomes, the cost of that technology is still going to make major impacts on budgets, further diverting funds away from research.

Revenues coming into teaching hospitals are fungible. This flexibility was always good for the CEO but often not as good for the chairs of departments. Money can be used to pay for hospital needs or for clinical faculty. It can go to primary care or specialty care. It can be used to subsidize the research effort. I think it's fair to say that not much of the money coming into institutions from clinical care is going to get diverted to research anymore, no matter how good are the institutional intentions.

Of all the sources of research funding (Table 2), the ones we focus most on are the National Institutes of Health and other federal programs. Dr. Fineberg and Dr. Cohen have suggested that physical medicine and rehabilitation is gaining increasing emphasis from this sector because of the increased needs but also because of new technologies such as cell- and tissue-based technology, or bioengineering.

There are also increasing numbers of philanthropies and individuals that have formed funds to support research. They're not all as well known as the Gates Foundation, but they're out there. It often takes having access to those people or finding a way of developing their interest in your specific area.

Finally, we come to the for-profit sector. This may involve funding for clinical trials, the licensing of technology developed by individual researchers, or the start-up of new companies. A significant problem with industrial funding, which many clinical departments have successfully used over the years to support both research and education, is the risk of conflict of interest. Increasingly, the academic establishment is rightfully concerned that industry money comes with too many strings attached and may lead to public perception problems.

Table 3 shows the amount of money invested in health-related research from these various sources in 2002. Most of these numbers are higher in 2005. The largest amount of dollars spent came from either the National Institutes of Health or the large pharmaceutical and biotechnology companies. They each spent between $20 and $30 billion a year on research. Whereas the big pharmaceutical and biotech companies used to spend most of this money on intramural activity, they are now beginning to look outside for investment. There used to be a lack of interest in anything “not invented

TABLE 1 Potential funding sources for clinical departments

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<thead>
<tr>
<th>Source</th>
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<tbody>
<tr>
<td>Clinical revenue</td>
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<td>Graduate medical education payments</td>
</tr>
<tr>
<td>Research</td>
</tr>
<tr>
<td>Hospital fund transfers</td>
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<tr>
<td>Medical school tuition, grants, state aid, etc.</td>
</tr>
<tr>
<td>Philanthropy</td>
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<tr>
<td>Entrepreneurial activities</td>
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TABLE 2 Research

<table>
<thead>
<tr>
<th>Source</th>
<th>Dollars (in Millions)</th>
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<tbody>
<tr>
<td>National Institutes of Health</td>
<td>23,559</td>
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<tr>
<td>Other federal sources</td>
<td>4,930</td>
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<tr>
<td>Pharmaceutical industry</td>
<td>29,400</td>
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<tr>
<td>Biotechnology industry</td>
<td>20,500</td>
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<td>Venture</td>
<td>5,358</td>
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<tr>
<td>University</td>
<td>6,553</td>
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</tbody>
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TABLE 3 Investment in health research in the United States in 2002

<table>
<thead>
<tr>
<th>Source</th>
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<td>University</td>
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here,” but this is changing as “big Pharma” puts more of their emphasis into marketing and sales and less into research. Thus, they are looking for ways to boost their pipeline of new products.

Other federal funding makes up about $5 billion, much of this coming out of the Department of Defense and the Veterans Administration. University funding was somewhere around $6.5 billion in 2002.

In 2002, the venture capital firms invested about $5 billion into the general area of health sciences research. The total amount of venture dollars that are invested every year has varied over the years (Fig. 1). The peak was in 2000, the infamous bubble, when the venture world spent over $100 billion investing in new companies, many of which don’t exist anymore. Much of that was in the areas of software, computer hardware, and telecommunications. At that point, the amount of money invested into medical technology was somewhere around 8% of the total. After the bursting of the bubble in 2001, there was a dramatic decrease in the total amount of capital invested from venture funds. But, there was no decrease in the amount invested in medical sciences, and in fact, there’s been a gradual increase in the amount as it is seen as a more likely successful area for private equity investors to place their money. Medical sciences now make up about 30% of the total amount of money invested by venture capital funds.

Within this area of investing, we can further subdivide investment into biotechnology, including drug development, medical devices, and health services (Fig. 2). The majority of these dollars are invested in the production of therapeutics because it is seen as the highest likely return. Medical devices are an easy area for venture capitalists to understand and therefore are a very popular investment sector.

How well do academic institutions in the United States utilize entrepreneurial funds for their own purposes? From 1999 to 2003, net license income has increased from $849 million to $1.3 billion. The academic world has clearly begun to look at funding from for-profit sources as a way of supporting their activities. The United States is not the only country involved in this effort and, in fact, perhaps not even the most aggressive. Europe, Israel, and more recently, Asia have become increasingly the venue for new company start-ups.

The distribution of venture investment and new company start-ups varies within the United States, correlating to some degree with the presence of academic institutions that have aggressively pursued this alternative source of funding. The largest concentration is in California, followed by the Boston area. Other places that have seen growth include New York/New Jersey, Pennsylvania, the Washington, DC, area, North Carolina, Florida, Georgia, Texas, and Washington State. Across the country, there are many areas that do not seem to have taken advantage of this source of funds as a way of funding research.

Part of the problem is that only selected universities and academic medical centers have really dedicated themselves to the pursuit of private dollars. This is mirrored in the funding and staffing of technology transfer offices. Four out of ten technology transfer offices in universities and academic medical centers in this country have fewer than five employees. Many of the staff have little or no experience in how to acquire dollars from outside the system to advance research goals. The University of California system, for example, has been very successful in the number of patents filed and license fees. Other institutions with similar research expenditures have not been as aggressive. This may be a function of a conscious effort to engage in research that they can generate license and invention revenues, or it may represent skill in converting the products of their research into commercializable products. The same variability of success can be seen in hospitals. Some academic hospitals focus on the development of marketable technol-
ology. They have a big technology transfer office and do very well in getting companies funded and in getting license revenue back into the institution for use in their research programs. Others, with similar research volume, don’t.

The ultimate expression of entrepreneurial activity is the creation of a company to exploit the technology (Table 4). Unfortunately, there are certain intrinsic conflicts between creating knowledge designed to be exploited commercially and creating knowledge in the classical academic way. This begins at the point of creation. The observation/invention represents the new companies assets, and this intellectual property needs to be protected. The classic approach of academicians is to make a discovery and write a paper. The approach of an entrepreneur is to make a discovery and bury it until he or she gets a patent. This later approach is often a problem for a potential investor trying to do due diligence because there is often no peer-reviewed information to look at. You find nothing because these people have been thinking from the beginning that there was a possibility of a real technology transfer into industry and therefore it’s kept very, very quiet.

Once you have a good idea, you need to incorporate as a company, develop a business plan, and then go out and get money to fund it. The business plan is a key step. Hopefully, your technology transfer office can help. The usual stages of funding are:

1. A seed investment by friends and family or interested individuals.
2. A private placement in which one or more venture capital firms provide funding in return for an equity and governance.
3. Commercialization by licensing, partnership, or on your own.
4. An exit during which the investors get to realize the value built up through a sale or public offering.

Nowadays, start-up companies can do a lot with minimal resources because much of the process can be outsourced. The product of the technology can be made by contract manufacturers and a clinical trial run by a clinical research organization. Virtual companies can get far along toward maturity before there is a need to fund much overhead.

There are a number of sources of money to fund technology development (Table 5). Certain foundations will give grants for the development of potentially commercializable technology. Small Business Innovation Research grants, given by the National Institutes of Health and by other federal funding agencies, are meant to encourage the development and commercialization of potentially profitable research. A source of early stage money used to start up many ultimately successful companies is the angel investor. This may be a wealthy patient or a friend or family member willing to make an investment at a low valuation. There are even organizations of angel investors looking for technology at this very early stage. If you have a decent idea and can write even a rudimentary business plan, many times these people will not only be a source of funding, but also bring much needed business expertise that can serve a company well during its later stages of development. As a company matures and requires more sizable financing, a company needs to work with professional investors, whether they be venture capital investors (who have a lot of money but also want a lot back in return in terms of ownership), strategic investments from drug companies, or other public and private companies that are looking for new technology.

**TABLE 4 Creating a company**

<table>
<thead>
<tr>
<th>Good idea</th>
<th>Incorporate as a company</th>
<th>Business plan</th>
<th>Seed investment</th>
<th>Private placement</th>
<th>Start-up to commercialization</th>
</tr>
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FIGURE 2 Total health venture investments (in millions of dollars).
Eventually, if the development makes it far enough, then people will look to realize the value that has been built through a sale or public offering.

What is required for a fundable company (Table 6)? The first thing is a doable technology that promises to lead to a product (drug, device, diagnostic, etc.) that will be saleable at a market-driven price for a profit. Investors are loath to look at plans that read more like a research project than a business plan. This is especially true because the big devaluation that took place in the early part of this decade. The product should be applicable to a significant size market, which I think is not a problem in physical medicine and rehabilitation, and certainly there ought to be a clear pathway to profitability. In the business of venture capital, the metric of success is profitability.

The university or hospital technology transfer office should be able to help you through the process, either using their own resources or by tapping into experienced people in the community. There are entrepreneurs that are willing to work with young companies to develop a business plan and to devise a plan for raising funds.

The factors that lead to success are clear. Good technology is critical. Expert management is almost as important. The founding scientist is usually not the right person to manage the company. There are people who make a career of developing an early stage company to a level of maturity and then moving on. It is also helpful to be in the right technology at the right time. I think Dr. Cohen is right that there is now a real interest in many of the areas that physical medicine and rehabilitation departments are interested and expert.

On the other hand, there are difficulties working within the academic environment. Investors tend to be wary of working directly with a university or an academic institution. Often times, there is a misalignment of motives and incentives between the scientist developing the technology and the university that owns it. In most academic institutions, there’s not enough space and money earmarked for the development of technology. There are potential conflicts between the institution’s economic goals, the academic goals, and the goals of a really serious entrepreneur. As I already mentioned, early publication of data to advance an academic career is often in conflict with the development of a robust intellectual property portfolio.

Finally, there are the inevitable conflicts between the entrepreneur and investor that have to do with things like valuation, ownership, and control. Academicians don’t like to give up control of their inventions or discoveries, whereas investors insist on control commensurate with their level of ownership. It is often difficult to explain why owning 100% of nothing is not as good as owning 10% of a $100 million company.

As I looked through the data that were on your Web site for the Summit, it struck me that there are a large number potential areas of research intrinsic to the physical medicine and rehabilitation community that would easily translate into kinds of companies that I see every day coming to me with business plans. The medical device, diagnostic, and therapeutic area is just ripe for exploitation in the area, and people are beginning to capitalize on it. Tissue engineering, prosthetics, neuroregeneration, pain management, rehabilitation, and the management of these patients and services are just some of the areas ripe for exploitation by the imaginative entrepreneur who can harness these various sources of both human and monetary resources to make major contributions to the field, while generating profits for themselves and their institutions.

In summary, there’s an increasing amount of new funding that has been raised by venture capital funds. They’re in your community, looking for good ideas and good technology, and they’re very willing to work with people to try and bring that technology along. The typical faculty member needs to make that mental shift from the classic academic way of thinking—write a grant, get funding, write a paper, and move on to the next project—to being a real entrepreneur. Although this is clearly not the correct route for many people, more and more academicians are beginning to tap into this area, and those who are successful at it have really been able to bring great value to themselves and to their institutions.
Development of Medical Rehabilitation Research in 20th-Century America

ABSTRACT


Key Words: Research Summit, Medical Rehabilitation Research, Development, History

When we look at the big picture, we might be surprised by the health and enablement achieved during the second half of the 20th century by many members of our nation’s disability community. The scope of the changes, when laid alongside the socioecological reality of 50 yrs ago, is a tribute to our nation in the 20th century. America dealt with the knowledge base of rehabilitation, the skills to cope with chronicity and disability, society’s readiness for fundamental changes in its vision and statutes, and the economic impact of disability on individual communities and the entire nation.

However, rehabilitation was not an early entrant to the fold of clinical departments in most American medical schools. Rehabilitation is a medical specialty that responds to people with disabilities, frequently conspicuous disabilities. Like other visible minorities, people with disabilities are marginalized and further disabled by society’s discrimination. There are ancient myths about the crippled and maimed who were feared and shunned by the larger society—the hunchback of Notre Dame and the Phantom of the Opera, for example. Medicine is drawn to the attractive fields that dwell in the land of high technology. Rehabilitation, on the other hand, seemed mired down with its patients who were considered second rate, or worse. All that is changing, and we are privileged to be part of the changes.

The winds of modernity have reshaped the model of health care. For example, in the last century, the physician-nurse team has grown to become a more interdisciplbar one. We have moved beyond the dictum that diagnosis informs cure to an increased understanding that whole-person diagnosis informs adaptive strategies for long-term altered function. We have evolved from heaping the costs of disability on the person with the disability to realizing that society has a role in accommodating and empowering the person as he or she, together with the family, faces disablement and financial catastrophe. In short, we are maturing as a nation.
Ancestors of today’s medical rehabilitation can be found thousands of years ago, such as a 3500-yr-old Egyptian stele showing a man, apparently with polio, using a long pole as a walking aid. Injuries in World War I stimulated the nation’s interest in a broader and more integrative approach to rehabilitation. Specifically, before the Great War, a large portion of the quantitative psychosocial research in the disability field related to assessment and measurement of disability and was largely confined to the vocational rehabilitation of industrial workers and soldiers. Around the time of World War II, health crises that grew from more war injuries and epidemics of poliomyelitis stimulated physicians, engineers, psychologists, and others in the burgeoning field of medicine and in the budding field of rehabilitation to move toward a more conjoined employ of medicine, technology, psychology, and social sciences, applying them to all aspects of disability in adults and children.

After World War II, with the advent of Medicare, Medicaid, and private health insurance, the healthcare system opened up to the general public and raised their expectations for services and miracles yet to come. Technology began a reaction of advances that provided diagnostic and therapeutic tools essential to rehabilitation, such as electromyography, engineered prosthetics, and electrically generated thermo therapies. Surgery blossomed with major advances in life-saving and function-improving techniques. Rehabilitation psychology research reexamined existing theories regarding adjustment to disability. Increased emphasis was placed on fostering coping strategies to promote community reintegration. These embraced a wide range of investigations, including vocational rehabilitation, social skills, sexuality and intimacy, recreation and sports, and advocacy skills. Recognition of the effects of disability on family members and caretakers and the development of strategies to improve functioning were also vital. In the post–World War II environment, disabled veterans wanted to return to the American dream and to the workforce. So too did the civilian workers. All these elements coalesced in the second half of the 20th century.

Three giant steps had prepared the ground. One was the enlightenment of the workman’s (sic worker’s) compensation laws that had their genesis in 1916 to protect federal employees. Since then, Worker’s Compensation has expanded to include many disease conditions, most civilian workers, almost all job categories, and all States. A second was the genius of Mary Switzer, director of the Federal-State Vocational Rehabilitation Program. She had abundant talents in legislation, economics, education, and health and welfare. Her efforts in 1954 helped Congress bring us Public Law 565, with its research and demonstration features and its mandate to fund and construct rehabilitation facilities across the nation. The third was fiscal and governmental assistance from the millionaire philanthropist, Bernard M. Baruch, who financed the establishment of the Baruch Committee on Physical Medicine. The Committee undertook three teaching and research centers in the country. In the decade of the 1940s, these centers graduated 57 fellows, seventeen of whom went on to become chairmen of academic departments. Consequently, after World War II, the three fundamental pillars of today’s rehabilitation were in place: technological advancement, leaders in Washington who passed enlightened federal laws, and a mechanism to organize and finance the preparation of physicians to investigate and practice rehabilitation.

With these as backdrop, another change evolved. Paul Magnuson, a general surgeon from Chicago who was instrumental in founding the field of physical medicine and rehabilitation, led the Veterans Administration (VA) from 1945 to 1951. In this capacity, he approved VA support for a national prosthetics research program through the National Research Council. Dr. Magnuson defined prosthetics broadly to include essentially all types of assistive technology, from prosthetics to sensory aides. In 1945, as the Battle of the Bulge was raging, the Surgeon General of the Army requested the National Research Council to convene a meeting to address the need for improved artificial limbs. Eighty individuals met in Chicago, and this meeting eventually led to the Committee on Prosthetic Research and Development within the National Research Council. This was the first United States federally funded agency that focused on rehabilitation engineering research. In 1948, Congress passed Public Law 729, which appropriated $1 million annually to the VA for a research and development program in prosthetics. This initial investment was the start of the Rehabilitation Research and Development section of the VA. The CRPD coordinated research, published documents, and promoted education. It also expanded its interest area beyond prosthetic limbs, an early example being the addition of a subcommittee on sensory aides in 1963. A Committee on Prosthetic Research and Development meeting was held in Annapolis, MD, in 1970 and led to the development of Rehabilitation Engineering Centers of Excellence. These centers were charged with defining rehabilitation engineering, improving the quality of life of persons with disabilities, performing research and development, collaborating with industry, making available new devices, educating students and professionals, and work-
ing collaboratively. In July of 1971, the secretary of the Department of Health, Education, and Welfare (HEW) convened a panel of experts to further define the need for Rehabilitation Engineering Centers and to give it visibility. Through lobbying efforts, the Rehabilitation Act of 1973 defined the Rehabilitation Engineering Centers and mandated funding to create the centers. The first Rehabilitation Engineering Center was established at Rancho Los Amigos, Downey, CA, in 1971 to work in the area of functional electrical stimulation. Today there are 22 Rehabilitation Engineering Research Centers, the successor to the HEW Rehabilitation Engineering Centers. Thus was born the field of rehabilitation engineering, defined as a total approach to rehabilitation that combines medicine, engineering, and related sciences to improve the quality of life of persons with disabilities.14

This period of rehabilitation research was remarkable for the cooperation between the VA and HEW. This cooperation was largely mediated by the Committee on Prosthetic Research and Development. But because the Committee on Prosthetic Research and Development exceeded its advisory role by advocating policy and pressing for funding, it was disbanded by the National Academy of Sciences (the successor of the National Research Council). However, before disbanding, the Committee on Prosthetic Research and Development held a series of annual meetings that eventually led to the creation of the Rehabilitation Engineering Society of North America in 1979. The Rehabilitation Engineering Society of North America encompasses virtually all interests comprising the field of assistive technology: clinical service delivery, research, new product development, legislation and funding initiatives, and consumer awareness and empowerment.

Several streams were converging to give impetus to disability research. Breakthroughs in biomedical and technological sciences described above changed the nature of work and community life. These breakthroughs provided the potential for longer and more fulfilling lives for a growing and restless minority in America, individuals with disabilities. Sharing the common features of minority status and social disenfranchisement, disability activists joined the disabilities rights movement that understandably drew strength from the civil rights movements for racial and ethnic minorities and from the women’s movement. Early disability research examined broad issues in disability viewed from the perspective of disabled persons as members of an underprivileged minority group15,16 who were devalued according to social stereotypes.17 These theories fostered research that examined the attitudes and behaviors of non-disabled persons toward disabled persons.18,19 Engel20 described the biopsychosocial model, and Moos21 described four integrative sociological factors: (1) disability including the social and physical environments, (2) the personal system, (3) mediating factors including adaptation, and (4) health status. Contemporary health, social, and economic forces fueled deinstitutionalization, independent living, and civil rights advocacy—by and for disabled persons. Other research dealt with more focused realms, such as wheeled mobility.22 As an example, in the wheelchair industry, little research and development were forthcoming after Everest and Jennings developed a folding wheelchair in 1932. Then, in the mid-1970s, wheelchair users themselves began experimenting with better wheelchairs. This experimentation started with the desire to improve sporting performance in wheelchair athletics. Innovators such as Marilyn Hamilton, the founder of Quickie, revolutionized wheelchair design and formed companies that had a greater research and development focus than their predecessors.

This slow but relentless sea of change created a flood of demand for federal and community resources, changes in architectural design, and a new awareness for access to the world that the able-bodied community took for granted.

1970S–1980S

Encouraged by these advances, rehabilitation grew with new ideas and attracted new players. In the 1970s, the confluence of demography, social need, and rehabilitation research generated new energies. For example, the interest in measuring human function became necessary, and the beginnings of a nomenclature emerged that later brought issues of human function into the system of international classification of disability. This effort to balance impairment, body function, structure, functional activities, and environment was eventually reflected in the International Classification of Impairment, Disability, and Handicap (World Health Organization)23 and its most recent revision, the International Classification of Functioning, Disability, and Health (World Health Organization, 2001).24 In later decades, this development led to predictions in resource utilization and expectations for treatment outcomes. It also guided agreements by third parties to be more open to paying for rehabilitation services.

Interaction among the many factors involved in disability helped move psychosocial researchers away from simplistic ideas of disability, personality, and adjustment. Instead, there was greater recognition of the complex interplay of these factors.25 For instance, depression in older persons may cause or exacerbate physical disability to a greater degree than hypertension, arthritis, heart disease,
and diabetes and may increase care taking and supervisory needs. The expertise of psychologists and social scientists helped focus rehabilitation on patient/client outcomes. The expertise of economists brought attention to the importance of cost and payment for health services. As rehabilitation was growing, it also was becoming more complex.

It became clear that environment plays a role in the decline of function. This realization was extended to a consideration of how learning theory could be applied in the rehabilitation environment through the application of the behavior modification principles of operant conditioning. The principles were developed in the laboratory and then applied to clinical problems confronting rehabilitation medicine. In particular, Fordyce demonstrated the application of single-case or small N experimental designs to clinical problems such as chronic pain, which were later validated by other investigators using a group design.

Animal models of operant conditioning have also been applied to the improvement of paretic limb function after stroke. Taub et al. applied constraint of the animal’s unaffected limb but did not train the affected limb. Their work has been validated by at least ten different groups of investigators. It supports the use of behavioral methods that may take advantage of neuroplasticity to increase function.

All these new rehabilitation theories and practices placed great pressure on the nation’s ability to afford the battle against disability, the benefits of neuroplasticity to increase function.

**POLITICS: EXPANSION INTO PUBLIC HEALTH AND PUBLIC POLICY**

In the public sector, early glimmerings of the tortuous and intertwined paths of service, education, and research appeared in federally sponsored rehabilitation. The paths could be discerned in the name given to the Federal-State Vocational Rehabilitation Agency started by Mary Switzer. It was called the Social and Rehabilitation Services and was placed within the HEW by the Rehabilitation Act of 1973. Its name predicted its mission and its future. In 1978, Congress took the next step. It realized Switzer’s vision, created the National Institute of Handicapped Research, a research institute in the public interest, and moved it from HEW to the Department of Education. In 1986, the Rehabilitation Act was further amended and the National Institute of Handicapped Research’s name was changed to the National Institute on Disability and Rehabilitation Research (NIDRR). With further amendments in 1992 and 1998, the institute was charged with a host of responsibilities: to benefit people with disabilities, to allow individuals to perform their regular activities in the community, and to bolster society’s ability to provide full opportunities and supports for people with disabilities. Research was directed at all ages and disabilities. NIDRR’s mission spanned research in employment, health, function, technology, access, independence, and community integration.

In bygone years, government sponsorship of rehabilitation research had been medical rehabilitation’s dependable angel, but the landscape changed after the establishment of National Institute of Handicapped Research in 1978 and changed even more in 1986 with its new name, NIDRR.

NIDRR’s role was thereby broadened. Its focus was to improve and coordinate services and transfer advances in technology to those who could use it. There was also to be an increase in opportunities for researchers who have disabilities or are members of minority groups. This was an expansive charge, a social charge, and the agency’s earlier emphasis on medical aspects of rehabilitation had to compete with the new mandates. After the Americans with Disabilities Act was passed in 1990, the NIDRR undertook a full-scale effort to square the real world with the promise of the Americans with Disabilities Act, which declares that individuals with disabilities are entitled to equal access to public accommodations, employment, transportation, and telecommunications. NIDRR’s mandate today recognizes these rights and society’s obligation to facilitate their attainment. Today, NIDRR is directed to generate scientifically based knowledge that furthers the values and goals of the disability community, rationalizes public policy, and meets the needs of service providers for knowledge on validated and improved practices.

In 1979 the Centers on Disease Control and Prevention published the first *Surgeon General’s Report on Health and Disease Prevention, Healthy People*, but there was little mention of disability. In 1980, a second report followed. Still, few health objectives were pertinent to the disability community. This deficiency was finally addressed in the *Healthy People 2000* publication and further addressed in *Healthy People 2010*. Progress has been spotty but measurable. More importantly, accountability for achieving the goals has been assigned.

In the 1980s, the nation’s disability community was extricating itself from the sickness model in part because the model did not encourage people with disabilities to participate in policy development by expressing their interests and needs. Leaders in the community were determined to participate in priority and budget setting processes and to help define healthcare services and delivery to their
community. As NIDRR moved further into its new roles, medical rehabilitation researchers and providers found their biomedical interests less able to compete with those of service, education, and advocacy. From the medical viewpoint, politicians and bureaucrats were now setting research priorities and redistributing resources. Adding complexity to the mood of the waning 20th century, many of the allied health disciplines, until then under the direction of organized medicine, gained increasing independence in their practices.

ESTABLISHMENT AND GROWTH OF RESEARCH JOURNALS

It is germane at this point to examine the parallel developments in rehabilitation’s scientific publications. Over the course of the first half of the 20th century, a series of apparently disconnected events occurred. Later, these events were to become joined in the creation of the journal we now call the Archives of Physical Medicine and Rehabilitation. In 1920, Dr. Albert A. Tyler of Omaha, NE, an enthusiast of medical electricity, formed, managed, and financed the Journal of Radiology. Members of the Radiology Society of North America, who were chafing under Dr. Tyler’s management of the journal, told him that he held too tight control of his journal. They were going to establish another and stop subscribing to his.

One week before Christmas in 1922, at Omaha’s Hotel Fontanelle, eight physicians sat down at dinner. By the time dessert arrived, they had agreed to form the Interstate Society of Radiology and Physiotherapy. In April of 1923 in Kansas City, Dr. Burton Baker Grover and others attending the fifth annual meeting of the Western Electrotherapeutic Association cordially invited everyone there to also attend their next meeting 5 mos later in Omaha. Five months passed, and in Omaha, 50 members of the Interstate Society of Radiology and Physiotherapy voted to change their name to the American College of Radiology and Physiotherapy.

One month later, on October 15, a Mr. Fischer, manufacturer of diathermy machines and devotee of medical electricity, financed and promoted an all-expenses-paid gathering in conjunction with the 1923 convention of the American College of Surgeons in Chicago. His intent was to promote his products with a stellar educational meeting to which he invited and financed lectures from such renowned people as Drs. Gustav Kolischer (president, American Congress of Rehabilitation Medicine, 1932–1933), Frederick W. H. Morse, Curran Pope (president, American Congress of Rehabilitation Medicine, 1924–1925), and T. Howard Plank. The meeting was held at the Logan Masonic Auditorium in Chicago and was a success. A total of 454 people attended from 29 states, Canada, India, and China. All attendees were invited to join the American College of Radiology and Physiotherapy. With a sufficient base assured, Dr. Tyler was spared the pain of losing his beloved journal. A society was formed that saved a journal, and after several name changes, the society became the American Congress of Rehabilitation Medicine. The journal also underwent name changes, becoming the Archives of Physical Medicine and Rehabilitation. Dr. Tyler later gave his journal as a gift to the College, and in 1933–1934, went on to become the 11th president of the American Congress of Rehabilitation Medicine.

That same Archives of Physical Medicine and Rehabilitation (the “Archives”), is now owned jointly by the American Congress of Rehabilitation Medicine and the American Academy of Physical Medicine and Rehabilitation. Until 1988 it was the principal, if not the only, journal for physiatrists and colleagues practicing medical rehabilitation. In that year, the Association Of Academic Physiatrists took editorial control of the American Journal of Physical Medicine and Rehabilitation, growing it to become a second major journal serving the several professional communities practicing rehabilitation in America. Perhaps it is true that evolution occurs in more than one locus at a time for it is also true that the American Journal of Physical Medicine and Rehabilitation evolved in a parallel way. It had been established in 1922 as the Archives of Occupational Therapy.

About 25 yrs ago, Edward Gordon reviewed 233 articles randomly chosen from 30 issues of the Archives between 1976 and 1980. He categorized them into six groups: (1) original new work, (2) synthesis of old work in novel ways, and (3) original contributions for old problems. These three groups accounted for only 14% of all the articles. He categorized the remaining 86% into (4) clinical or experimental work on old problems, (5) improvements in interventions and devices (in today’s pharmacotherapy, we would call it “me too drugs”), and (6) case reports of known conditions. The discomforting implication was that there was not enough fundamental, original, and groundbreaking research going on in rehabilitation.

One of this article’s authors (T. M. Cole) further explored this assessment. Using his own definitions and opinions of the central thrust of each publication, he categorized articles published in the Archives to comply with today’s focus on scientific research and compared 12 consecutive months’ content, September through August, 20 yrs ago, 10 yrs ago, and 1 yr ago. Interestingly, there are few variances to distinguish the three decades other than the recent increase in the category of outcomes research from 3% in 1983–1984 to 18% in 2003–2004, coincident with the re-
search-driven interest in that domain over the past two decades. To explore how articles published in the Archives compare with articles published in one of the nation’s elite medical journals, The New England Journal of Medicine, he tabulated the New England Journal of Medicine’s articles in the same manner and for the same twelve consecutive months 1 yr back (Table 1).

The comparison can be viewed only as suggestive because the roles and readership of the two journals are not comparable. But the direction of the content in each issue can be compared. Our journal is publishing research submissions in three of the categories in comparable proportions to the New England Journal of Medicine. The New England Journal of Medicine’s less emphasis on outcomes and health services research during a single 12-mo period may be different for reasons not pertinent to this article. Special focus journals deserve a separate comparison. The more focused journal, the Journal Of Rehabilitation Research And Development, may have a unique constituency and role in biomedical science. Its articles reflect a somewhat different distribution of publications (Table 2). Responding to a request, staff of the Journal Of Rehabilitation Research And Development categorized peer reviewed articles published in the last 5 yrs to comply with the categories tabulated above.

There are other journals that also take a focused approach in the manuscripts they accept for publication. Three examples are journals that address rehabilitation engineering: Assistive Technology (founded in 1989), Technology and Disability (founded in 1992), and Institute of Electrical and Electronics Engineers (IEEE) Transactions on Rehabilitation Engineering (founded in 1993). These three journals are dedicated to publishing research that advanced the science and clinical practices of engineers working in the field. By the middle of the 1990s, the field of rehabilitation engineering had developed a dedicated professional society (Rehabilitation Engineering Society of North America), a number of annual conferences, three peer reviewed research journals, and special interest sections within the various allied health and special education professional associations.

In his Walter Zeiter lecture to the Assembly of the American Academy of Physical Medicine and Rehabilitation and the American Congress of Medical Rehabilitation, Cole described a greening in the supply of and demand for rehabilitation facilities and services. Indeed, that greening occurred in the late 1980s and 1990s. Several entrepreneurs saw an opportunity to make profits in nursing homes and outpatient clinics. They created national chains of nursing homes that offered some elements of rehabilitation. Some bought and operated rehabilitation sections of hospitals or even entire hospitals. Smaller groups of medical and allied health practitioners started providing niche rehabilitation in storefront and shopping mall establishments that sprouted in most population centers, even many smaller villages and towns. Eventually, academic institutions warmed to the economic and academic opportunities of rehabilitation. Physicians graduating from rehabilitation residencies were attracted by offers of management and leadership, perhaps before they were ade-

| TABLE 1 | Distribution of article type over time in the Archives of Physical Medicine and Rehabilitation (Arch Phys Med Rehabil) and the New England Journal of Medicine (NEJM) |
|-----------------|-----------------|-----------------|-----------------|-----------------|
|                | Arch Phys Med Rehabil, % | NEJM, % |
| Physiology and mechanisms | 11 | 14 | 13 | 17 |
| Clinical, basic research | 64 | 71 | 60 | 63 |
| Outcomes research | 3 | 5 | 18 | 2 |
| Health services research | 13 | 6 | 7 | 17 |
| Technology/engineering | 9 | 4 | 2 | <1 |

<table>
<thead>
<tr>
<th>TABLE 2</th>
<th>Distribution of article type in 2000–2004 for the Journal of Rehabilitation and Research Development</th>
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<tr>
<td>2000–2004 Journal Of Rehabilitation and Research Development</td>
<td></td>
</tr>
<tr>
<td>Basic science</td>
<td>5%</td>
</tr>
<tr>
<td>Clinical research/trials</td>
<td>32%</td>
</tr>
<tr>
<td>Outcomes</td>
<td>30%</td>
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<tr>
<td>Engineering/technology</td>
<td>30%</td>
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<tr>
<td>Health services</td>
<td>3%</td>
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Data from Patricia Dorn, PhD, Journal of Rehabilitation Research and Development, personal communication, November 6, 2004.
quately prepared. Headhunters sought the services of established physiatrists for new or expanding institutions. Many players in this greening of rehabilitation rode the wave of opportunity as they integrated rehabilitation services into hospitals to qualify for one or another benefit or program certification. Acceptance, growth, dissemination, utilization, and profits from providing medical rehabilitation services and facilities were a tide not to be resisted. Greening, and profits, indeed!

However the development of research in medical rehabilitation languished far behind, almost in obscurity. From both practitioners and agencies that support the nation's sciences, there continued to be a lackluster effort to advance the many fields of medical rehabilitation science.

BUILDING MOMENTUM FOR REHABILITATION RESEARCH: THE 1980S AND 1990S

In 1985, the Institute of Medicine reenergized the medical focus on rehabilitation with its publication of Injury in America, a Continuing Health Problem. It issued a clarion call to include rehabilitation in the medical care of the traumatically injured hospitalized patient. However, there was financially based opposition to this direction. Why? Medical rehabilitation was vulnerable due to its commitment to the large and expensive interdisciplinary team. It seemed slow moving and did not respond efficiently with assessment and treatment services as demanded by third-party payers. Cost-containment convulsions were happening across the spectrum of health care in the western world. The federal government pressed ever more deeply into the relationships among patients, practitioners, institutions and payers. HMOs, PPOs, PPSs, and ADLs became household words. The business model was having its way.

The net result of this ferment was an escalation of the national cost and energy expenditure that continues to be a major dispute influencing the nation's fisc. In American society, there arose a clamor for more and more: more advocacy, more accommodations, more money for research, more money for training, more governmental assistance to pay for services. Yet in responding to the push and pull in this country, “more” did not mean a universal system of health care, either free or subsidized.

During the 1980s, the medical rehabilitation professional communities acknowledged difficulty fielding a cohort of competent researchers. Collectively, the communities undertook to educate their members with basic information about the nature of rehabilitation research and its sciences. Academicians began a long-overdue demystification of the world of research, research funding, grant writing, bridge building, and especially, introduction to the National Institutes of Health (NIH).

Others set out to deconstruct the generic term for research. They separated it into specific monikers for better understanding, for example: case reports, case series, observational studies, evidence based medicine, meta-analysis studies, randomized controlled trials, practical controlled trials, outcomes research, quality-of-life research, interdisciplinary research, and participatory action research, to name some. As the interdisciplinary nature of treatment programs has solidified, the research to test the programs' efficacy and outcomes has also become increasingly interdisciplinary. Notably, interdisciplinary and outcomes research have been fostered by NIDRR. This has increased the research quality and productivity of the rehabilitation field and is reflected in the increasingly interdisciplinary composition of the teaching faculty of rehabilitation medicine departments in academic centers. DeJong and Horn examined outcomes research and found that a barrier to its use is an inability to accurately characterize evaluations and interventions, especially inside the interdisciplinary team or when employing nonstandardized or customized treatments within the mix of comprehensive rehabilitation. They pointed out that we use aggregated packages in gross and complex settings. We have yet to disassemble the “black box.”

However, continuing to pull heavily in the other direction is the lack of extramural funding for rehabilitation. Physical medicine and rehabilitation departments rank 30th of 31 as reported by the NIH in 2002. Rehabilitation was allocated $15 million compared with other clinical specialties with related medical interests: neurology received $321 million, orthopedics $32 million, and family practice $37 million. Only psychology ranked lower.

It should be noted that one strategy used by some physical medicine and rehabilitation departments is to hire basic scientists to help them compete more successfully for NIH funds. Although migration away from one setting into another may not increase the total number of investigators in science, it does have three salutary effects: (1) benefiting America’s needs for an ever-expanding disabled citizenry by bringing into the rehabilitation milieu investigators who may not have previously understood and therefore not have been contributing to the advancement of rehabilitation-relevant research, (2) breakthroughs that result from previously nonexistent collaborations, and (3) stimulation for the generation of new insights and energies in the nation’s centers of academic rehabilitation.
COMING TOGETHER: GROWTH SPURT FOR REHABILITATION RESEARCH

Notwithstanding this progress, we have two more confounding hindrances: dissemination and utilization. There continues to be difficulty in moving new developments from the laboratories to the clinics and bedsides. Forces within academe drive investigators to write for their peers or those who promote their careers. There are three target groups for investigator-publishers: (1) fellow investigators with like interests, (2) fellow practitioners, and (3) consumers, clients, or patients. Articles written for fellow investigators lead more directly to advancement and recognition. But fellow investigators are not numerically the dominant practitioners who are in the daily position to convert clinical research into practice. What is the result? It is a hindrance to movement of research into practice. Realizing this, the NIDRR changed priorities in 1988 to disseminate information using formats that are accessible by individuals with disabilities. NIDRR also sought to improve the relevancy of rehabilitation research by increasing the input of families and individuals with disabilities in research planning, review of grant proposals, and research program implementation.46 One strategy used to respond to this need was participatory action research, another was to promote a socioecological perspective in research programs.47

Growing awareness helped to fill the breach between academics and service: (1) recognition that the field of medical rehabilitation remained underdeveloped, (2) clearly it had a potential value to the nation’s health, and (3) the research capacity in medical rehabilitation needed opportunity, assistance, and funding.

As the 20th century was drawing to a close, the NIH stepped onto the stage. For many years, rehabilitation academicians had tried unsuccessfully to find support for their research at the NIH. Now there was another opportunity for rehabilitation practitioners to once again present their case to the NIH. In 1989, the NIH assembled a panel to explore its desire to comprehensively review needs and concerns of the rehabilitation research community. The report led to the “realization that although rehabilitation medicine is more than 50 yrs old, it was just now coming of age as a scientific discipline. . .”48

This was the resounding endorsement that advocates of medical rehabilitation research had sought for years. In 1990, the NIH invited >100 clinicians and researchers with expertise in a wide range of medical, biological, allied health and social sciences to Hunt Valley, MD. Theodore M. Cole, MD, and V. Reggie Edgerton, PhD, cochaired this gathering of experts. The Hunt Valley Report stated that this was a “sweeping survey of research needs, challenges and opportunities in rehabilitation medicine” and that “it provides the most comprehensive perspective on the diverse field of rehabilitation medicine research that has ever been undertaken.”49

In 1990, on the heels of the Hunt Valley Report, legislation established the National Center for Medical Rehabilitation Research (NCMRR) within the NIH. Medical rehabilitation finally had support under the aegis of the premier biomedical and behavioral research-supporting agency in the world. The new Center was provided with shelter and guidance; it was embraced by the welcoming arms and supporting structure of the National Institute of Child Health and Human Development (NICHD). The Center is now in its second decade, and it acknowledges that its research portfolio has two boundaries.50 The first is that over the entire breadth of NIH, the rehabilitation portfolio currently totals $350–400 million spread throughout several Institutes: National Institute of Neurological Disorders and Stroke, National Institute of Arthritis and Musculoskeletal and Skin Diseases, National Institute on Aging, National Heart, Lung, and Blood Institute, National Institute for Biomedical Imaging and Bioengineering, and the NIDRR and the Centers for Disease Control and Prevention, the Department of Veterans Affairs, and elsewhere in government-funded agencies. The second boundary is that, traditionally, the largest portion of NIH funds (50–75%) goes to unsolicited, investigator-initiated applications, not to capacity building activities.

Fortuitously, soon after the Center was chartered and began to take its first breaths, the National Academy of Science and the Institute of Medicine asked Pope and Tarlov to edit the timely book Disability In America: Toward A National Agenda For Prevention,51 published in 1991. Once again, attention focusing elsewhere reflected onto rehabilitation.

By 1990 disability had become a national priority, the door to the NIH opened, and rehabilitation entered. But accommodation was needed. First, it was decided that the missions of NIDRR in the Department of Education and NCMRR in the NIH are not the same. NIDRR should not be folded into the NIH or one of its units. However, should the NCMRR evolve to an independent institute or even an independent center within the NIH, separate from NICHD? That question is currently under review.

In 1997, the National Academy of Science and the Institute of Medicine again drew attention to rehabilitation with the published report, Enabling America: Assessing the Role of Rehabilitation Science and Engineering.52 The report pointed out
that the incidence and prevalence of people with disabilities continue to mount in parallel with increases in our ability to prevent deaths due to injury. The editors emphasized that strengthening rehabilitation research would help to alleviate costs of disability and thus place less strain on our national treasury while improving the quality of life for millions of Americans. They too were troubled to note that no focus for medical rehabilitation existed within the NIH until the establishment of the national Center in 1990.

It is now clear, even after its first decade, that the NCMRR’s mission is compatible with the overall NIH research and training missions. There are reasonable prospects for scientific and budgetary growth in rehabilitation research based on the increments in funding, visibility, recruitment, capacity building, and public awareness of the past decade. However, it seems equally clear that attention to this new entity is still inadequate to the scope of its mission. Further independence for the NCMRR is in the best interests of developing the research and training needs of a field that arguably deals with America’s greatest health problem, disability and its secondary complications.

1990S–2000S

Technology advances have always driven society toward modernization. Rehabilitation is true to that maxim, and rehabilitation engineering research is a clear demonstration of the phenomenon. The development of microprocessors and the personal computer led to the need for ubiquitous computer access and to the advances in augmentative communications devices. Continued engineering-based research involves programming personal digital assistants to serve as cognitive prostheses for individuals with acquired brain injury. Currently, Microsoft and Apple both build accessibility into their software. Voice recognition software is another area in which engineering research for general application has advanced the state of the science for the entire community.

Themes in rehabilitation engineering research are noteworthy. At the start, assistive technology designed by rehabilitation engineers was meant to be specifically for individuals with disabilities. The goal was closing the gap between the demands of a task or the environment and the capacities of an individual. More recently, Universal Design has been the call of the day. The goal of this movement is to incorporate the needs and abilities of the broadest population of users when designing consumer products or the built environment. An example of this is curb cuts that assist parents with strollers as much as individuals in wheelchairs. Currently, the trend is toward smart technology, which offers the promise of intelligent personalized assistances. Once again, this line of research can help the individual with a disability and the busy individual who is trying to manage multiple tasks at the same time.

The importance of engineering in all of medicine was demonstrated with the formation of the National Institute for Biomedical Imaging and Bioengineering within the NIH. Although much of NIH-funded rehabilitation engineering research will come through the NCRR, the National Institute for Biomedical Imaging and Bioengineering is likely to be an additional source of funding into the future.

NIDRR

NIDRR remains the largest source of support for rehabilitation research and banners a very diverse catalog of topics receiving NIDRR funds. NIDRR lists areas of research in its most recent 5-yr report ending in 2003. These include:

- Employment outcomes: economics, federal, state, and community employment programs and accommodation, technology, education, and ergonomics in the work environment.
- Health and function—medical rehabilitation: health and wellness programs, service delivery, short-and long-term interventions, systems research, and new and emerging disabilities. Also included in this category are the model burn injury projects, model spinal cord injury systems projects, and the model traumatic brain injury projects.
- Technology for access and function: systems of public technology, the built environment, orphan technologies, and universal design practices.
- Independent living and community integration: managing personal life, participating in community life, fulfilling social roles, sustaining self-determination, and minimizing physical or psychological dependence. Also included in this category are issues of community integration, consumer direction and control, independent living, and development of innovative methods to measure achievement.
- Associated disability research areas: crosscutting knowledge areas linking disability statistics, outcome measures, disability studies, rehabilitation science, and international activities.
- Knowledge dissemination and utilization: these ensure the widespread distribution and usable formatting of practical scientific and technological information to reach diverse and changing populations and to present research results in different and accessible formats.
• Capacity building for rehabilitation research and training: supports advanced instruction for researchers and service providers, training for consumers in applications of new research and technology, and training consumers to participate in research efforts.

NIDRR’s training mission is long and storied. Many physiatrists who have led the field of physical medicine and rehabilitation first experienced rehabilitation in the 1960s and 1970s during medical school summer fellowships sponsored by NIDRR. For many years, the postgraduate training that turned physicians into physiatrists was funded by the NIDRR. In the field of psychology, the Princeton Institute attempted to settle on a definition of the field in 1959, helping to inaugurate a system of graduate training supported by the Office of Vocational Rehabilitation, later the Rehabilitation Services Administration. Within a few years, there were ten doctoral programs supported by the Rehabilitation Services Administration. From 1960 to 1970, the ten programs yielded approximately 116 PhD and 20 MA graduates at least partially funded by the Rehabilitation Services Administration fellowships. Fifty-eight percent of graduates were subsequently employed in colleges and universities, including medical schools, and in research institutes. Although a relatively small number of psychologists in the American Psychological Association’s Division 22, a rehabilitation-focused group, or graduates of Rehabilitation Services Administration–supported training initially identified themselves at the end of their training years as primarily researchers, many of them later became the core of academicians who were instrumental in developing increased psychological and social research capacity in medical rehabilitation.

NIDRR also promoted and funded the development and credentialing of rehabilitation engineers and technologists, those who deliver services to patients and clients. A mechanism was needed for verifying a minimum level of competence for practicing professionals. In 1994, the Rehabilitation Engineering Society of North America obtained a quality assurance grant from NIDRR and, in 1995, established a separate Professional Standards Board whose purpose is to develop standards of practice and certification for assistive technology practitioners. With the financial support of the NIDRR grant, the Rehabilitation Engineering Society of North America’s Professional Standards Board developed the assistive technology practitioner certification. One target group of this examination is engineers who, through this examination, can obtain clinical certification for the first time. The scope of content areas encompassed by the assistive technology practitioner certification includes wheeled mobility, seating, computer access, worksite accommodation, augmentative and alternative communication, and environmental control units (also known as electronic aids to daily living). After passing the assistive technology practitioner examinations, individuals with engineering degrees can sit for advanced certification as a rehabilitation engineering technologist. The net result of the maturation of the field of medical rehabilitation is that today it is rich with opportunities for a wide range of disciplines and levels of previous preparation.

NIDRR promotes its research mission through directly funding research activities, training future researchers, supporting existing investigators, and providing support personnel to the mission. These activities are:

1. Advanced Rehabilitation Research Training
2. Disability Rehabilitation Research Projects
3. Fellowship Training
4. Field-Initiated Projects (FI)
5. Knowledge, Dissemination, and Utilization Projects
6. Model Systems projects
7. Rehabilitation Research Engineering Centers
8. Rehabilitation Research and Training Centers
9. Section 21 Funding
10. Small Business Innovation Grants

On request, NIDRR supplied the authors with the information in Table 3 about its average funding levels, duration of grants, total investment for the past 8 yrs by program, number of grantees currently active, and funds allocated for capacity building.

NIDRR also listed its total Rehabilitation Research and Training funds for the past 10 yrs (Table 4).

NCMRR

Now in the middle of its second decade, the NCMRR has completed competition for four research networks that are focused on topics. Four million dollars per year will support multidisciplinary cores, information transfer, and pilot projects built on collaborations of three institutions with potential to connect with researchers in other facilities in the region. In the NCMRR’s ongoing research portfolio are sections addressing biological sciences, behavioral sciences, engineering, health services research, reimbursement research, and consumer information.

In fiscal year 2003, NCMRR’s research portfolio showed support for 265 grants ($65 million in funds) and had received 20% annual increases going into the most recent years, a rate that was significantly faster than its parent institute, the
NICHD. However, the budget for fiscal year 2005 shows no increase at all. Until recently, the Center has received a generous share of special opportunities, requests for applications, networks, and other set-asides. Current plans to reduce federal spending may be having a stunting if not withering effect for medical research in general and rehabilitation research in particular well into the future.

Basic to all NIH strategies is the ability to prepare more scientists to follow in the footsteps of those who preceded them. Therefore, NCMRR supports research training for a variety of professions and mechanisms: physiatrists, psychologists, physical, occupational, and speech therapists, neurologists, bioengineers, and basic researchers through individual fellowships, career development awards, and institutional training grants, among others. NCMRR’s research training efforts have produced the long-desired result. Below are the results of 13 yrs of NCMRR training and career development activities supplied October 2, 2004, as a personal communication by R. Nitkin, NCMRR.

**Departmental Training Grants (T32)**

Currently, the NCMRR funds 17 institutional training grants (T32) that support predoctoral and doctoral students (about 70% PhD, 30% MD). Institutional training programs in medical rehabilitation span the gamut from cell/molecular biology to bioengineering, to behavior, and to social and policy issues. During the first 13 yrs, these NCMRR programs have supported about 500-600 students at the predoctoral or postdoctoral level. Particular research studies occur at various recognized levels of analysis: pathophysiology, impairment, function, disability, and societal limitations. Although they are all represented, the first three have been most prevalent. Follow-up studies of these trainees suggest that more than three quarters have remained in research careers, often rising to faculty positions; a few have successfully competed for independent NIH research grants (e.g., R01s).

**TABLE 3** Average funding levels, duration of grants, total investment for the past 8 yrs by program, number of grantees currently active, and funds allocated for capacity building for the National Institute on Disability and Rehabilitation Research (NIDRR)

<table>
<thead>
<tr>
<th>Program</th>
<th>Average Amount per Year</th>
<th>Average No. of Years</th>
<th>NIDRR Investment (1997–2004)</th>
<th>No. of Current Grantees</th>
<th>Capacity Building/Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARRT(^a)</td>
<td>$150,000</td>
<td>5</td>
<td>$14,611,494</td>
<td>15</td>
<td>$14,611,494</td>
</tr>
<tr>
<td>Fellowship</td>
<td>$45,000–55,000</td>
<td>1</td>
<td>$3,602,328</td>
<td>10</td>
<td>$3,603,328</td>
</tr>
<tr>
<td>RRTC(^b)</td>
<td>$750,000</td>
<td>5</td>
<td>$244,812,097</td>
<td>43</td>
<td>$24,481,210</td>
</tr>
<tr>
<td>RREC</td>
<td>$900,000</td>
<td>5</td>
<td>$132,396,529</td>
<td>21</td>
<td>$5,793,026</td>
</tr>
<tr>
<td>Field Initiated(^c)</td>
<td>$150,000</td>
<td>3</td>
<td>$96,550,426</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>Model Systems</td>
<td>$355,000</td>
<td>5</td>
<td>$103,200,000</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>SBIRs</td>
<td>2.5% of NIDRR’s R&amp;D budget(^d)</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Section 21</td>
<td>1% of NIDRR budget</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) Indirect limited to 8%, may not exceed $150,000 per year.
\(^b\) Indirects limited to 15%.
\(^c\) May not exceed $150,000 per year.
\(^d\) In recent years, this amount has been $5 million dollars because of the New Freedom Initiative. All others have right to approved indirect rates, but amount is included in total per year.

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**TABLE 4** Total rehabilitation research and training funds for the past 10 yrs for the National Institute on Disability and Rehabilitation Research (NIDRR)

<table>
<thead>
<tr>
<th>Year</th>
<th>Title II (millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>$ 70,000</td>
</tr>
<tr>
<td>1996</td>
<td>$ 70,000</td>
</tr>
<tr>
<td>1997</td>
<td>$ 70,000</td>
</tr>
<tr>
<td>1998</td>
<td>$ 76,800</td>
</tr>
<tr>
<td>1999</td>
<td>$ 91,000</td>
</tr>
<tr>
<td>2000</td>
<td>$ 86,500</td>
</tr>
<tr>
<td>2001</td>
<td>$100,400</td>
</tr>
<tr>
<td>2002</td>
<td>$110,000</td>
</tr>
<tr>
<td>2003</td>
<td>$109,285</td>
</tr>
<tr>
<td>2004</td>
<td>$106,652</td>
</tr>
<tr>
<td>Cumulative total</td>
<td>$880,637</td>
</tr>
</tbody>
</table>

Data from Richard Melia, PhD, Director, Division of Research Sciences, National Institute on Disability and Rehabilitation Research, personal communication, October 6, 2004.
Individual Postdoctoral Fellowships (F32)

The NCMRR has supported an additional 20 postdoctoral fellows (mostly PhDs) through individual postdoctoral awards. The majority of these trainees has remained in research careers and is developing into a cohort of independent academic researchers. Most continue to publish in peer-reviewed journals, and a few are currently submitting NIH research applications.

Career Development Mechanisms (K01, K08, K23, K25)

Over the past 5 yrs, NCMRR has built overall research capacity in many disciplines, most of which are physicians or PhDs (314 out of 355 trainees), spending in excess of $37 million in 2004 on training. Twenty-eight percent of trainees hold dual appointments, thus demonstrating partnering abilities that strengthen relationships among institutions and disciplinary groupings. Career Development Awards are one of the bulwarks of scientific training, contributing scientists to many of the fields comprising medical rehabilitation. In 2000, NCMRR trained 19 fellows, spending $1.7 million. By 2004, 59 fellows had received training, at a cost of $4.7 million for this activity alone. The K series grants provide for a period of intense mentored research, either clinical or basic, to support the transition of clinical fellows into independent faculty careers. NCMRR applicants have had moderate success with this mechanism, generally in the range of 30–50%. Within the NICHD, medical rehabilitation is targeted as a special area of emphasis through the use of the K01 mechanism. This has allowed the NCMRR to support 16 PhD students seeking further training in rehabilitation research. An additional 20 NCMRR trainees were supported through the K08 and K23 mechanisms, which are designated for clinically trained individuals who seek further training in basic or patient-oriented research, respectively. Two additional NCMRR candidates received support through the K25 mechanism, which attempts to attract PhDs with engineering or quantitative backgrounds into biomedical research.

As a group, the NCMRR-funded K awardees have been productive researchers. Almost all of them have continued to publish in peer-reviewed research journals, some with several first-author publications already to their credit. About 90% have gone on to submit research proposals to the NIH using the R01, the R03, and other mechanisms, and seven have successfully competed for R01 grants, some more than one. Other K awardees have received major research support from other federal agencies (e.g., NIDRR and the Centers for Disease Control and Prevention) and from foundations.

Rehabilitation Medicine Scientist Training Program (K12)

The K12 mechanism, which has been used successfully to develop researchers in other medical specialties, supports a national network of established rehabilitation researchers to mentor clinically trained individuals in scientific research and academic medicine. The NCMRR K12 program has initially focused on the clinical specialty of physical medicine and rehabilitation. The NICHD K12 program supports a small number of physiatrists for 2–3 yrs of mentored research in a more basic science environment (generally outside their physical medicine and rehabilitation department), followed by continued support at the beginning of their physical medicine and rehabilitation faculty appointment. In the first decade, this program has supported almost 20 individuals. All have contributed to the research literature, in some cases with several first-author publications. Several of the graduates have received faculty appointments, and many are applying to the NIH for research grants, with some notable successes.

On September 30, 2003, the NIH Director laid out a series of far-reaching initiatives, a “roadmap” to optimize NIH’s entire research portfolio.60 It points to plans that cannot be done by any one institute. The plan needs multiple loci within the NIH to deal with issues that must be addressed. The “roadmap” has already brought forth rehabilitation Program Announcements61,62 seeking partnerships and capacity building for rehabilitation research infrastructure. One such Program Announcement sought to improve functional outcomes for basic, applied, and translational multidisciplinary research addressing rehabilitation or health maintenance of individuals with acute or chronic disease. Another sought applications for grants to build rehabilitation research infrastructure by providing access to expertise, technologies, and resources from allied fields such as neurosciences, engineering, applied behavior, and the social sciences.

Department of Veteran’s Affairs

As outlined earlier, the Armed Services have a history of interest in both the acute treatment of war-related diseases and injuries and in their chronic effects and the disabilities they produce. This is actualized through a nationwide system of VA hospitals and clinics that serve veterans and their families. As is true for nonmilitary healthcare institutions, the VA’s investment in medical rehabilitation in these facilities is both spotty and regional, depending on political conditions and aca-
demic alliances. However, it is clear that the VA has interest and commitment to furthering its rehabilitation research agenda to serve veterans. VA institutions house significant research facilities and employee research staff to work independently of or conjointly with regional academic medical centers and teaching institutions. Toward this goal, the VA has funded a variety of healthcare professional research training programs. In 2000–2004, 355 fellows and trainees received training in research appropriate to their professional degrees at doctorate, masters’ and baccalaureate levels (Patricia Dorn, PhD, personal communication, November 6, 2004).

Over these same years, the VA has invested over $150 million on rehabilitation-related research projects and career development lines, an average of approximately $30 million per year. Because the VA is mandated to develop partnerships with regional medical centers, >75% of trainees in 2005 will have dual appointments in both VA and academic institutions. During the past 5 yrs, the VA has awarded rehabilitation-related career development grants to 192 awardees, averaging 38 individuals per year.

**Online Learning Opportunities**

The Northeast Cognitive Rehabilitation Research Network\(^6\) (http://www.ncrrn.org/), funded by NCMRR, is an example of new Internet sources for learning about the methods and skills of scientific research. Within the past year, the NIH has funded several centers to work within regional consortiums and to be resources for connectivity to the academic and nonacademic fields of medical rehabilitation. Internet resources are increasingly providing branching links to related resources.

**NCMRR’s Plans For Its Future**

The future research directions that NCMRR is committed to are:

- Functional neuroimaging that has already made an impact on theories of rehabilitation.
- Pharmaceuticals that may control plasticity of the nervous system and influence the muscular system.
- Molecules that influence the growth of axons, artificial skin, cultured cartilage, growing new bone, and other replacement tissues.
- Neural prostheses to affect brain, vision, hearing, and bladder function.
- Biomimetic peptides to minimize inflammation and enhance acceptance of exogenous tissues.
- Micromechanical devices to assist in function after loss or damage by injury or disease.
- Simulation and modeling techniques as part of a wave of work to improve or run rehabilitative devices, techniques, orthotics, and surgical implants.
- Behavioral and cognitive deficits addressed through further work in learning and behavioral sciences.
- Lifestyle changes important to prevention of secondary disabling problems (e.g., diet, conditioning, and artificial intelligence).
- Computerized dynamic assessment, which holds promise for developing outcome assessment tools that can be rapidly and economically administered, have good test-retest reliability and are valid for a wide range of populations\(^6\).

Medical rehabilitation does not yet have a long research tradition. By its very nature there is there no defined focus on a particular organ, condition, age, or sex. However, there is a focus on function. Rehabilitative professionals have unprecedented opportunities to explore the biomedical, behavioral, and social basis for rehabilitative strategies. With an increasing population of individuals coping with various disabilities, it is our professional and social responsibility to respond with adequate research to validate approaches, optimize treatments, and incorporate new technologies and opportunities.\(^6\)

All scientific disciplines that are banded together under the rubric of rehabilitation, and all who support research in rehabilitation, might consider this mantra as a responsibility for the field:

- People with tomorrow’s disabilities must receive tomorrow’s models of health care.
- Clinicians of the future must offer more than that which they are already offering.
- Educators must have an abundance of new theories and skills to teach.
- Administrators must build organizations to advance the work so that it will not be lost.
- Advocates looking for novelty and alternatives must find innovation here.
- Today’s efforts must breed tomorrow’s fresh and new knowledge.
- Generating and documenting scientific progress will ensure that someone else will not have to reinvent medical rehabilitation.

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December 2005
Development of Medical Rehabilitation Research


Measuring Rehabilitation Research Capacity
Report from the AAPM&R Research Advisory Committee

ABSTRACT


There is considerable concern regarding the paucity of individuals pursuing biomedical research in general and rehabilitation research in particular. The Research Advisory Committee (RAC) of the American Academy of Physical Medicine and Rehabilitation (AAPM&R) accepted the task to explore the barriers to biomedical research careers for physicians and rehabilitation scientists and, in particular, those factors pertaining to successfully conducting rehabilitation research. Concurrently, the Foundation for PM&R was also exploring the related issue of building capacity for rehabilitation research and planning a Rehabilitation Research Summit to address this issue for the spring of 2005. The goals of the Research Summit included the identification of barriers to rehabilitation research and development of an active agenda to enhance research capacity. As such, AAPM&R and the Foundation for PM&R worked through the RAC survey to provide some key information that would help the summit leaders achieve their goals. This report presents portions of the survey related to research capacity and outlines the methodology of the data collection and analysis within the context of the capacity taxonomy framework as presented at the Research Summit, “Building Research Capacity,” held in the spring of 2005. This survey report provides quantitative information about researchers and academicians, their research environment, as well as their barriers and incentives for conducting rehabilitation research. Observations here provide a platform for future work in understanding the adequacy of the rehabilitation research enterprise, its appropriateness, and ability to meet societal needs for those with disabilities.

Key Words: Rehabilitation, Research Capacity, Metrics, Taxonomy, Researchers, Research Environment

There is considerable concern regarding the paucity of individuals pursuing biomedical research in general and rehabilitation research in particular. This concern has been expressed in deliberations and publications across the scientific community, including the National Institutes of Health (NIH), the Association...
funded, and frequently undervalued.3 Furthermore, the level of training for health professionals was fragmented, potentially underestimating the importance of rehabilitation research. Although understudied, preparedness and productivity of physiatrists in academic medicine has been explored to a limited degree. Webster et al.15 surveyed the research activities and perspectives of individuals completing a research enrichment program for physiatrists. The majority of respondents (85%) were in academic-based practice and at the assistant professor level (59%). Sixty-nine percent of the study respondents reported spending no time in research and 64% reported having no protected time for research. Despite self-reports of feeling well-prepared for research, high demand for clinical productivity, lack of protected research time, and lack of research funding were all identified as major barriers to research activity in this cohort of young academicians. The development of women in research careers was again highlighted in July 2002 when the AAPM&R had an opportunity to participate in a conference hosted by the National Academies of Science entitled “Achieving XXcellence in Science (AXXS).” Participants from the Office for Research in Women’s Health of the NIH, the informal consortium (AXXS), and professional societies were asked to return to their professional societies to explore ways to improve recruitment, retention, reentry, and recognition of women in science careers. They were also asked to review the role of women in leadership positions.

The Research Advisory Committee (RAC) of the AAPM&R accepted the task to explore the barriers to biomedical research careers for physicians and rehabilitation scientists and, in particular, those factors pertaining to successfully conducting rehabilitation research. At the heart of this discussion was how to appropriately measure the state of the field now and identify what is needed to grow the research enterprise. Among the factors frequently discussed was the disproportionately low level of participation of physiatrists in rehabilitation research, the inherent clinical nature of the specialty practice of PM&R, the paucity of skilled mentors, the small size of the specialty, lack of leadership, particularly women in leadership positions, lack of advocacy for research, and that research may be undersubscribed as a career choice.

Academic medical centers have become increasingly reliant on income from faculty practice plans to finance aspects of the academic mission such as teaching and research. This phenomenon has led to a decrease in the number of faculty hired on tenure track and an increase in the number of faculty hired primarily for clinical care and teaching on nontenure career tracks.4 The impact of these infrastructural changes in academic medical centers was illustrated in a 2000 publication of a survey of faculty at Virginia Commonwealth University (VCU) School of Medicine. This survey identified that half of the responding faculty were spending an average of 72% of their time providing patient care. These faculty with significant clinical responsibilities were more likely to be women, less likely to be professors, and less likely to be tenured or on tenure track.6 This survey also concluded that physician faculty who spend more that 50% of their time in clinical care have less time, mentoring, and resources necessary for development of research and other aspects of the academic mission. Although the general decline in the pool of available biomedical researchers and leaders in biomedical sciences is of considerable concern, the lack of women and women leaders choosing research careers is particularly ominous given that in the biosciences, women are one of the major sources for biomedical researchers. Unfortunately, although 50% of medical students are women, only a small percent of academicians and only 11% of all professors in academic medicine are women.7,8 Several publications have addressed the issues surrounding the opportunities for women and professional minorities and whether they have been proportionally and successfully recruited into biomedical clinical research careers.9–15

Professional societies, including the American Academy of Physical Medicine and Rehabilitation (AAPM&R), the Association of Academic Physiatrists (AAP), American Congress of Rehabilitation medicine (ACRM), and the Foundation for Physical Medicine and Rehabilitation, are also concerned because of the inadequate numbers of young and experienced researchers to advance the field of rehabilitation research. Although understudied, preparedness and productivity of physiatrists in academic medicine has been explored to a limited degree. Webster et al.15 surveyed the research activities and perspectives of individuals completing a research enrichment program for physiatrists. The majority of respondents (85%) were in academic-based practice and at the assistant professor level (59%). Sixty-nine percent of the study respondents reported spending no time in research and 64% reported having no protected time for research. Despite self-reports of feeling well-prepared for research, high demand for clinical productivity, lack of protected research time, and lack of research funding were all identified as major barriers to research activity in this cohort of young academicians. The development of women in research careers was again highlighted in July 2002 when the AAPM&R had an opportunity to participate in a conference hosted by the National Academies of Science entitled “Achieving XXcellence in Science (AXXS).” Participants from the Office for Research in Women’s Health of the NIH, the informal consortium (AXXS), and professional societies were asked to return to their professional societies to explore ways to improve recruitment, retention, reentry, and recognition of women in science careers. They were also asked to review the role of women in leadership positions.

The Research Advisory Committee (RAC) of the AAPM&R accepted the task to explore the barriers to biomedical research careers for physicians and rehabilitation scientists and, in particular, those factors pertaining to successfully conducting rehabilitation research. At the heart of this discussion was how to appropriately measure the state of the field now and identify what is needed to grow the research enterprise. Among the factors frequently discussed was the disproportionately low level of participation of physiatrists in rehabilitation research, the inherent clinical nature of the specialty practice of PM&R, the paucity of skilled mentors, the small size of the specialty, lack of leadership, particularly women in leadership positions, lack of advocacy for research, and that research may be undersubscribed as a career choice.
To explore these issues further, the RAC proposed the development and implementation of a survey to the AAPM&R Board of Governors. The survey was primarily targeted at physiatrists and researchers in the field of rehabilitation sciences and was designed to assess demographic information, previous training, the environment for research, and perceptions about their research skills and preparation for participating in research. In addition, questions regarding salary, career satisfaction, academic productivity, perceptions about diversity within the field, and rehabilitation leadership were also explored. Concurrently, the Foundation for PM&R was also exploring the related issue of building capacity for rehabilitation research and planning a Rehabilitation Research Summit to address this issue for the spring 2005. The Board of Governors of the AAPM&R and the Foundation for PM&R agreed that the survey proposed by RAC would provide some key information that would help the summit leaders and membership mutually achieve their goals. Subsequently, the RAC survey was funded by the AAPM&R such that it could be completed in time for the provision of a preliminary report for attendees at the Research Summit.

This report presents portions of the survey related to research capacity and outlines the methodology of the data collection and analysis within the context of the capacity taxonomy framework as presented at the Research Summit.

**METHODS**

**Survey Development**

Before developing this survey, several published surveys were reviewed and a literature search was conducted. In addition to a number of published reports, several unpublished institutional surveys, including those provided by AAMC, pertinent to professional development, research, and academic productivity, were examined for structure and format. Input regarding survey content, priorities, and goals was elicited from the RAC committee throughout the development process. Once an initial draft was constructed, additional feedback about survey content, format, and goals was obtained from leaders in the ACRM, AAP, and Foundation for PM&R, and the Research Summit Executive Committee to ensure their needs were addressed in the survey. A total of 212 questions were included in the survey, and question formats included multiple choice, Likert rating scales, fill-in-the-blank, and open-ended questions. Once the survey was completed, beta testing of both the paper and electronic versions of the survey was conducted with RAC members to obtain additional feedback on the usability and clarity of the instrument and format.

**Survey Sampling Procedures**

Both online and paper surveys were made available to people contacted to participate in this survey. All respondents were required to visit a Website to download a hard copy of the survey or to complete the survey online. To automate data entry and deidentification of data, utilization of the Web-based survey was encouraged through voluntary participation in a raffle for those completing the online version of the survey. A letter of invitation to participate in the survey was distributed through United States and electronic mailings. Valid electronic mailing addresses were available for approximately 42% of the population invited to participate. Three follow-up reminders to complete the survey were sent to everyone by postcard mailings and electronic mailings. Additionally, public announcements and generic reminders to complete the survey were made at professional conferences, including the 2005 AAP meeting. To ensure respondent confidentiality, personal identifying information associated with all electronic responses was not collected when submissions were uploaded into the database. Personal identifying information for individuals returning paper responses was not entered into the database.

**Study Population**

A total of 2130 individuals joined the AAPM&R, the AAP, and the ACRM were included in the contact list for this survey. AAPM&R members were contacted if they had documented involvement in one of 20 AAPM&R special interest groups. Additionally, individuals known to be involved in publicly funded rehabilitation research were contacted for participation. A total of 18.2% of those contacted responded to the survey. There were a total of 388 surveys collected. After removing unusable data forms (e.g., blank forms, forms submitted by retired practitioners or resident physicians), a total of 360 were used for analysis. Of those that responded, 70% held an MD or DO degree, 6.1% held both an MD/PhD, 17% held a PhD, and 6.9% held other degrees. For the purposes of this report, only individuals meeting the definition of researcher (n = 54, 15%) or academician (n = 132, 37%) were included for analysis.

**Respondent Categorization**

Survey respondents were initially categorized into three groups: researcher, academician, and other. Inclusion into the researcher group required the respondent to demonstrate significant research productivity in the areas of manuscript publication and funded research. A scoring system was developed by the authors, in conjunction with the RAC, to identify respondents with significant research
productivity. Respondents were defined as researchers if they received a score equal to or greater than 15, calculated through the following equation: \[ \text{score} = \frac{\text{total first/senior author original research publications for past 5 yrs} + (\text{percent funded research time} \times 0.1)}{100} \times 15. \]

For example, if a respondent had five first/senior author publications over the past 5 yrs and was 100% funded, the score equals 15 and the respondent was classified as a researcher. If a respondent had 10 first/senior author publications over the past 5 yrs and was 50% funded, the score also equals 15 and the respondent was again classified as a researcher. However, if a respondent had five first/senior author publications over the past 5 yrs and was 50% funded, the score equals 10 and the respondent was not classified as a researcher.

Academicians included anyone in an academic setting with a primary academic appointment (does not include academic-affiliated) who did not meet criteria for the researcher category. Individuals who did not hold a primary academic appointment but met the productivity criteria for the researcher category were still considered researchers.

Survey Information

In addition to demographic information, data regarding academic duties (including research, teaching, clinical care, mentoring, administration, and other service activities) are reported. Additionally, information regarding research environment and resources, research productivity, personal research skills, personal research resources, and barriers to conducting research are reported. Information about the role of national societies in serving the research needs of rehabilitation practitioners and scientists are reported, and data regarding job satisfaction and leadership roles are presented for both researchers and academicians.

Taxonomy of Research Capacity

The Summit leaders identified several focus areas to address and assess research capacity: researchers, research environment, funding, partnerships, and metrics. As a product of the Metrics subcommittee meeting, a taxonomy structure for identifying and measuring research capacity was constructed.

The Summit Metrics subcommittee created a taxonomy structure for several subdomains that represent three overarching aspects of research capacity: research agenda, research environment, and researchers (Fig. 1). The corollary notion to developing this taxonomy was that the processes used, the products created, and the professional and societal impact yielded though expanding and improving these capacity domains would be both a mirror and a measurement of effective capacity-building. Central among the candidate domains to measure were funding, training, and knowledge translation. The concept of identifying and developing valid qualitative and quantitative measures to measure capacity was emphasized, and measures for a variety of research settings, including measurement on the micro- as well as the macroscopic scale, were discussed. To provide some initial and objective assessment of current research capacity in the field of rehabilitation medicine and science, results from this survey are largely presented and discussed within this taxonomy framework. Specifically, each question included in this report was reviewed by the authors and linked to a specific category and theme presented in the metric. This deconstruction process allowed us to more objectively assess the nature and extent to which the survey measured current research capacity in rehabilitation research.

Statistical Approach

Descriptive statistics, including means, medians, percentages, and standard error of the means, are reported as appropriate. Means of each group are reported with medians in parentheses, except where noted. The number in each group (n) used for each analysis is shown in the corresponding tables. Mann–Whitney nonparametric analysis was used to compare differences between the two groups for all continuous and Likert (ordinal) scaled data. Chi-squared analysis was used for categorical data. Yates’ correction for continuity is reported for 2 × 2 tables. A P value of 0.05 or less was considered statistically significant. All data analyses were conducted using SPSS version 12 software.

RESULTS

General Characteristics

Demographic information about respondents meeting criteria for researcher and academician...
are listed in Table 1. A total of 77.7% of the respondents meeting criteria for researcher held a primary academic appointment. Researchers were somewhat older than academicians (49.2 ± 1.24 vs. 45.4 ± 0.72 yrs). A considerably larger proportion of the researcher population was male (74.1%) compared with academicians (54.2%), and the vast majority of both academicians and researchers were white. Compared with academicians, a larger proportion of the researcher population was non-MD/DOs. A total of 82.9% of the researcher population with a primary academic appointment held a rank of associate or full professor, and 40.0% of the academician population held either of these ranks (Table 2). Researchers have been at their current rank slightly longer than academicians (6.25 ± 1.01 vs. 5.60 ± 0.45 yrs) and worked slightly more hours than academicians (56.6 ± 1.43 vs. 54.9 ± 1.12 hrs). Neither of these variables was significantly different between the two groups. Researchers spend significantly more of their total time engaged in research activities (53.3% vs. 18.3%; P < 0.001). The majority of research time is spent conducting federally funded research for both groups. Academicians spend significantly more time in clinical activities (47.6% vs. 17.3%; P < 0.001) and teaching (14.4% vs. 8.4%; P < 0.001). Seventy percent of institutions for researchers and 83.3% of institutions for academicians offer a tenure stream. However, a significantly higher proportion of researchers have positions inside the tenure stream compared with academicians (67.5% vs. 36.4%; P = 0.001).

For those with academic appointments, Table 3 lists the primary reasons why respondents chose a career in academics. The primary reason for researchers entering a career in academics was the research opportunities available (88.1%), whereas the primary reason for an academic career for academicians was the opportunity to be a part of an academic center (60.3%). For those in an academic setting, 97.4% of researchers stated their ultimate goal for an academic rank is full professor, which was a statistically greater percent (P > 0.001) than the 65.6% of academicians who also wanted to attain this rank.

**Training**

There were no significant differences between researchers and academicians with respect to number of years of postdoctoral training (0.74 ± 0.19 vs. 0.50 ± 0.12 yrs; P = 0.113). Interestingly, 67.3% of researchers and 78.8% of academicians had no postdoctoral training. Similarly, there were no significant differences in the number of years of research-intensive fellowship training (0.77 ± 0.20 vs. 0.69 ± 0.14 yrs; P = 0.327). Both researchers (44.5%) and academicians (35.5%) engaged in several other alternative types of formal research training (Table 4), including additional graduate training, the National Institute for Disability and Rehabilitation Research's Research Enrichment

<table>
<thead>
<tr>
<th>TABLE 1 Demographics of respondents</th>
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<td>Variable</td>
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<tr>
<td>-------------------------</td>
</tr>
<tr>
<td>MD/DOs</td>
</tr>
<tr>
<td>76.1% (n = 274)</td>
</tr>
<tr>
<td>Academic-affiliated</td>
</tr>
<tr>
<td>Private practice</td>
</tr>
<tr>
<td>VA</td>
</tr>
<tr>
<td>Other</td>
</tr>
<tr>
<td>Non-MD/DOs</td>
</tr>
<tr>
<td>23.9% (n = 86)</td>
</tr>
<tr>
<td>Foundation</td>
</tr>
<tr>
<td>Industry</td>
</tr>
<tr>
<td>Other</td>
</tr>
<tr>
<td>Percent of MD/DOs that are PM&amp;R Board-certified</td>
</tr>
<tr>
<td>Degree</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Gender</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Race</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Mean age</td>
</tr>
</tbody>
</table>

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Program (REP), the AAP’s NIH funded K-12 Rehabilitation Medical Scientists Training Program, other NIH-funded career development (K-series) awards, and NIH-funded Institutional Research and Training Agreements (IRTA). Other types of additional training included VA training awards (Rehabilitation Research and Development award, Associate Investigator award), institutional research training programs, and AAP conference courses. There was no overall significant difference between researchers and academicians \( (P = 0.235) \) for participation in professional research training programs.

**Researchers**

Survey respondents answered several questions about their personal research skills (Table 5). In general, researchers felt more equipped than academicians with respect to most of the research skills evaluated. However, although there were no significant differences in how respondents in each group felt about their basic science skills, both groups felt these skills were inadequate, with over 56% of the population responding that they had inadequate or no skill. Academicians as a group also felt they had inadequate abilities to perform quantitative statistics, inadequate understanding of grant funding sources, inadequate translational research skills, and inadequate statistical approach and design skills. Despite rating themselves better in most categories, researchers also felt less qualified in performing quantitative statistics, translational research skills, and statistical approach and interpretation skills.

**TABLE 2** Demographics for respondents in full academic appointments*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Researcher ((n = 41)^*)</th>
<th>Academician ((n = 126))</th>
<th>(P) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is your current academic rank?</td>
<td>Instructor 0.0%</td>
<td>4.0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Assistant 17.1%</td>
<td>51.2%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Associate 36.6%</td>
<td>25.6%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Full 46.3%</td>
<td>14.4%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other 20.3%</td>
<td>4.8%</td>
<td></td>
</tr>
<tr>
<td>How long have you been at your current academic rank?</td>
<td>6.25 yrs</td>
<td>5.60 yrs</td>
<td>0.877</td>
</tr>
<tr>
<td>What is your ultimate goal for academic rank?</td>
<td>Instructor 0.0%</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Assistant 0.0%</td>
<td>1.6%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Associate 0.0%</td>
<td>22.4%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Full 97.4%</td>
<td>65.6%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other 2.6%</td>
<td>10.4%</td>
<td></td>
</tr>
<tr>
<td>Institution offers a tenure stream</td>
<td>78.6%</td>
<td>83.3%</td>
<td>0.642</td>
</tr>
<tr>
<td>Position is inside the tenure stream</td>
<td>67.5%</td>
<td>36.4%</td>
<td>0.001</td>
</tr>
<tr>
<td>Currently tenured (years tenured)</td>
<td>52.6% (8.2 yrs)</td>
<td>16.1% (9.9 yrs)</td>
<td>0.000 (0.202)</td>
</tr>
<tr>
<td>Number of hours working per week</td>
<td>56.6 hrs</td>
<td>54.9 hrs</td>
<td>0.352</td>
</tr>
</tbody>
</table>

* Questions in this table were only answered by those in an academic setting. Therefore, the \(n\) value for researcher was a subset of the total respondents in this classification.

**TABLE 3** Respondents’ two main reasons for choosing a career in academics*

<table>
<thead>
<tr>
<th>Reason</th>
<th>Researcher ((n = 41)^*)</th>
<th>Academician ((n = 126))</th>
</tr>
</thead>
<tbody>
<tr>
<td>88.1% Research opportunities</td>
<td>60.3% Being a part of an academic center</td>
<td></td>
</tr>
<tr>
<td>50.0% Being a part of an academic center</td>
<td>44.3% Teaching opportunities</td>
<td></td>
</tr>
<tr>
<td>40.5% Teaching opportunities</td>
<td>42.0% Research opportunities</td>
<td></td>
</tr>
<tr>
<td>9.5% Infrastructural resources</td>
<td>18.3% Patient mix/population</td>
<td></td>
</tr>
<tr>
<td>4.8% Location of employment</td>
<td>14.5% Location of employment</td>
<td></td>
</tr>
<tr>
<td>2.4% Patient mix/population</td>
<td>9.9% Infrastructural resources</td>
<td></td>
</tr>
<tr>
<td>2.4% Other</td>
<td>6.1% Other</td>
<td></td>
</tr>
<tr>
<td>0.0% Salary/compensation</td>
<td>3.8% Salary/compensation</td>
<td></td>
</tr>
</tbody>
</table>

* This question was only answered by those in an academic setting. Therefore, the \(n\) value for researcher was a subset of the total respondents in this classification.
When evaluating respondent publication records and productivity over the last 5 yrs, researchers had significantly more first author/senior author original research articles published in peer-reviewed journals. (19.9 ± 1.63 vs. 2.6 ± 0.25; P < 0.001). For both groups, 38.2% of these publications have been in specialty journals other than rehabilitation. Additionally, researchers publish more book chapters and review articles as a first author (5.4 ± 0.66 vs. 2.7 ± 0.42; P < 0.001). The total number of career original research articles was significantly higher for researchers than academicians (55.3 ± 6.10 vs. 12.5 ± 1.53; P < 0.001), and researchers have published more recently (last publication 2.4 mos ago) compared with academicians (last publication 12.2 mos ago). Interestingly, 75.9% of researchers feel that their publication record is appropriate for their stage in their career, whereas only 39.7% of academicians felt this way.

Despite differences in perceptions about research skills and publication record, on a scale from 1 (strongly agree) to 5 (strongly disagree), most academicians and researchers (84.4%) recorded a response of strongly agree or agree when asked if they envision themselves conducting rehabilitation research over the next 5 yrs. However, researchers felt more strongly that they would be conducting rehabilitation research over the next 5 yrs compared with academicians (1.39 vs. 1.93; P < 0.001)

**Funding**

Researchers reported significantly higher departmental startup funding packages compared with academicians ($52,983 vs. 13,824; P = 0.004) for equipment and pilot studies. Despite these numbers, 55.5% of researchers and 72.8% of academicians reported that they received no startup funding for research.

Although 100% of researchers have applied for a grant, only 72.7% of academicians report submitting a grant application. Of those who have applied for a grant, researchers currently hold an average 2.14 ± 0.45 federally funded grants and $1,333,586 as a principal investigator, whereas academicians hold an average 0.30 ± 0.072 federally funded grants and $129,933 as a principal investigator. Additionally, researchers hold an average 1.80 ± 0.24 federally funded grants and $856,844 as a coinvestigator, and academicians hold an average 0.44 ± 0.13 federally funded grants and $86,858 as

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**TABLE 4** Research training programs

<table>
<thead>
<tr>
<th>Training Program</th>
<th>Researcher (n = 54)</th>
<th>Academician (n = 132)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Enrichment Program for Physiatrists (REP)</td>
<td>9.3%</td>
<td>10.6%</td>
</tr>
<tr>
<td>NIH Institutional Research and Training Agreement (IRTA)</td>
<td>0.0%</td>
<td>3.8%</td>
</tr>
<tr>
<td>AAP K-12 RMSTP Program</td>
<td>3.7%</td>
<td>4.5%</td>
</tr>
<tr>
<td>NIH K award</td>
<td>9.3%</td>
<td>1.5%</td>
</tr>
<tr>
<td>Graduate program (PhD/MS research)</td>
<td>3.7%</td>
<td>2.3%</td>
</tr>
<tr>
<td>Other</td>
<td>18.5%</td>
<td>11.4%</td>
</tr>
</tbody>
</table>

---

**TABLE 5** Respondents’ opinion with respect to their own research skills*

<table>
<thead>
<tr>
<th>Personal Research Skill</th>
<th>Response &gt;3†</th>
<th>Researcher (n = 53)</th>
<th>Academician (n = 129)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic science techniques</td>
<td>56%</td>
<td>3.52 (4)‡</td>
<td>3.83 (4)</td>
<td>0.164</td>
</tr>
<tr>
<td>Performing quantitative statistics</td>
<td>55%</td>
<td>2.60 (3)</td>
<td>3.39 (4)</td>
<td>0.000</td>
</tr>
<tr>
<td>Grant funding resources</td>
<td>52%</td>
<td>2.00 (2)</td>
<td>3.22 (3)</td>
<td>0.000</td>
</tr>
<tr>
<td>Translational research skills</td>
<td>48%</td>
<td>2.54 (2)</td>
<td>3.51 (4)</td>
<td>0.000</td>
</tr>
<tr>
<td>Grant writing skills</td>
<td>43%</td>
<td>1.77 (2)</td>
<td>2.96 (3)</td>
<td>0.000</td>
</tr>
<tr>
<td>Research mentorship</td>
<td>41%</td>
<td>1.83 (2)</td>
<td>2.99 (3)</td>
<td>0.000</td>
</tr>
<tr>
<td>Research team management</td>
<td>39%</td>
<td>1.98 (2)</td>
<td>3.05 (3)</td>
<td>0.000</td>
</tr>
<tr>
<td>Statistical approach and interpretation</td>
<td>37%</td>
<td>2.42 (2)</td>
<td>3.07 (3)</td>
<td>0.000</td>
</tr>
<tr>
<td>Research publication skills</td>
<td>29%</td>
<td>1.73 (2)</td>
<td>2.67 (3)</td>
<td>0.000</td>
</tr>
<tr>
<td>Human subjects research regulations</td>
<td>22%</td>
<td>2.10 (2)</td>
<td>2.40 (2)</td>
<td>0.072</td>
</tr>
<tr>
<td>Research design and methods</td>
<td>16%</td>
<td>1.77 (2)</td>
<td>2.45 (2)</td>
<td>0.000</td>
</tr>
<tr>
<td>Research presentation skills</td>
<td>16%</td>
<td>1.71 (2)</td>
<td>2.34 (2)</td>
<td>0.000</td>
</tr>
<tr>
<td>Research ethics</td>
<td>5%</td>
<td>1.58 (1.5)</td>
<td>1.80 (2)</td>
<td>0.127</td>
</tr>
</tbody>
</table>

* Scaling for question: excellent = 1, good = 2, adequate = 3, inadequate = 4, no skill = 5.
† The percent of respondents that recorded a value of 4 (inadequate) or 5 (no skill).
‡ Mean values reported with median values in parentheses.
a coinvestigator. Researchers report having an average of 12.1 ± 1.30 yrs of federal research funding, while academicians report an average of 5.28 ± 0.78 yrs of federal funding over the course of their careers. For both researchers and academicians, NIH is the primary grant funding source (57.4% and 17%, respectively) and NIDRR is the second most common source of funding for both groups (37% and 8%). Other less common sources of federal funding reported by researcher and academicians included the Centers for Disease Control and Prevention (9.3% and 2.3%), the Veterans Administration (11.1% and 6.8%), and the Department of Defense (1.9% and 0.0%).

Researchers, on average, hold more private/institutional grants (1.5 ± 0.65 vs. 0.51 ± 0.09) and grant dollars ($98,396 vs. $21,946) as a principal investigator compared with academicians, and they also hold more private/institutional grants (0.33 ± 0.13 vs. 0.15 ± 0.06) and grant dollars ($104,891 and $13,606) as coinvestigators. Although the numbers are modest for both groups, researchers hold more pharmaceutical grants (0.35 ± 0.14 vs. 0.17 ± 0.05) and grant dollars ($49,647 and $10,833) when compared with academicians. When considering all sources of grant funding, researchers report that 43.1% of their salary is grant-funded, and academicians report that 14% of their salary is grant-funded.

Research Questions and Knowledge Base

Table 6 reports the general types of research that respondents conduct and the primary population or topic under which the research falls. Most people reported that their research involves material and information obtained from human subjects as well as direct patient contact. However, a minority of research conducted by both groups is reported to be basic science in nature. When evaluating the most commonly researched areas, 15.8% of respondents report conducting research related to brain injury, 15.4% report conducting musculoskeletal research, 14.2% report conducting stroke research, and 12% report conducting research in women’s health. Some of the least represented fields include research on osteoporosis and cardiopulmonary rehabilitation.

Research Environment and Partnerships

Research Resources

Table 7 reports how respondents feel about the resources associated with their current position. Types of questions address environment as well as partnerships primarily in the form of collaborative research relationships. In general, researchers felt more positive about most of the resources associated with their position when compared with academicians. However, researchers still felt that departmental startup funding as well as access to graduate students and residents were inadequate. Interestingly, over half of academicians and researchers believe that departmental startup funding, graduate student and resident, laboratory space, and protected research time is inadequate in their departments. Although both groups generally feel that their institution and department values research, they also believe that the majority of members in their department do not conduct sig-

<table>
<thead>
<tr>
<th>TABLE 6 Types of research conducted</th>
<th>Researcher (n = 54)</th>
<th>Academician (n = 121)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research includes human subjects or materials/information obtained from human subjects</td>
<td>98.1%</td>
<td>96.7%</td>
</tr>
<tr>
<td>Research involved direct patient contact</td>
<td>96.3%</td>
<td>89.3%</td>
</tr>
<tr>
<td>Research considered to be “basic science” in nature</td>
<td>18.5%</td>
<td>12.4%</td>
</tr>
<tr>
<td>The primary population your research serves or emphasizes:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amputee</td>
<td>5.6%</td>
<td>0.8%</td>
</tr>
<tr>
<td>Brain injury</td>
<td>22.2%</td>
<td>13.2%</td>
</tr>
<tr>
<td>Cardiopulmonary</td>
<td>1.9%</td>
<td>2.5%</td>
</tr>
<tr>
<td>Geriatrics</td>
<td>3.7%</td>
<td>7.4%</td>
</tr>
<tr>
<td>Health services</td>
<td>14.8%</td>
<td>5.0%</td>
</tr>
<tr>
<td>Musculoskeletal</td>
<td>16.7%</td>
<td>14.9%</td>
</tr>
<tr>
<td>Neuromuscular disease</td>
<td>3.7%</td>
<td>5.0%</td>
</tr>
<tr>
<td>Osteoporosis</td>
<td>0.0%</td>
<td>0.8%</td>
</tr>
<tr>
<td>Pediatrics</td>
<td>3.7%</td>
<td>10.7%</td>
</tr>
<tr>
<td>Spinal cord injury</td>
<td>1.9%</td>
<td>8.3%</td>
</tr>
<tr>
<td>Stroke</td>
<td>14.8%</td>
<td>14.0%</td>
</tr>
<tr>
<td>Women’s health</td>
<td>9.3%</td>
<td>13.2%</td>
</tr>
<tr>
<td>Other</td>
<td>1.9%</td>
<td>4.1%</td>
</tr>
</tbody>
</table>
significant research, are not productive in research, and do not have external grants.

**National Societies**

Respondents were asked to comment on how much they agreed or disagreed with how their national organizations viewed research from a variety of perspectives (Table 8).

Respondents tied to the ACRM were the ones who most strongly felt that their organization values researchers and uses research-based presentations at its meetings. Respondents linked to the AAP were the ones who most strongly felt that the organization provided adequate avenues for research training and venues for research collaboration and partnerships. In contrast, the AAPM&R scored the worst in each of these categories.

**Salary, Satisfaction, and Incentives**

Table 9 compares salaries of full-time MD/DO researchers and academicians to survey respondents (full-time MD/DOs) who reported being in private practice. Median salaries were lowest for academicians and highest for private practitioners. Additionally, in Table 10, salary was broken down by academic rank for researchers with academic appointments and compared with academicians. Median salaries for each group at a given rank were similar. Interestingly, 61.9% of respondents overall reported that their department has a financial incentive program for clinical productivity, whereas only 26.7% of respondents report having an incentive plan in their department for research productivity.

Table 11 discusses the rank order in which respondents find different components of their job satisfying. With the exception of administration and service, researchers and academicians significantly differed in what aspects of their jobs they felt were most satisfying. Research and mentoring were most satisfying for researchers, whereas clinical activities and teaching were most satisfying for academicians.

**Leadership**

Fifty percent of the researcher group has received at least one national award in recognition of his or her research, and 18.9% of academicians report receiving a national award recognizing their research work. A considerably higher percentage of researchers compared with academicians report serving on any type of federal scientific review board (75.9% vs. 26.5%). Additionally, there were significant differences between researchers and academicians with respect to number of departmental leadership positions (e.g., dean, chairperson, research director, residency director, clinical service director) (1.46 ± 0.17 vs. 0.98 ± 0.09; \( P = 0.012 \)) as well as the number of national committees served (4.56 ± 1.16 vs. 1.7 ± 0.25; \( P < 0.001 \)).

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**TABLE 7** Respondent opinion with respect to current position resources

<table>
<thead>
<tr>
<th>Resource</th>
<th>Researcher ((n = 54))</th>
<th>Academician ((n = 130))</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Departmental startup funding</td>
<td>70%</td>
<td>3.20 (3)†</td>
<td>3.83 (4)</td>
</tr>
<tr>
<td>Departmental subsidized protected research time</td>
<td>69%</td>
<td>2.94 (3)</td>
<td>3.77 (4)</td>
</tr>
<tr>
<td>Research assistant support</td>
<td>68%</td>
<td>2.47 (2)</td>
<td>3.84 (4)</td>
</tr>
<tr>
<td>Access to graduate student support for research</td>
<td>67%</td>
<td>3.09 (3)</td>
<td>3.71 (4)</td>
</tr>
<tr>
<td>Laboratory space</td>
<td>63%</td>
<td>2.58 (2)</td>
<td>3.84 (4)</td>
</tr>
<tr>
<td>Department honors protected research time</td>
<td>61%</td>
<td>2.94 (3)</td>
<td>3.54 (4)</td>
</tr>
<tr>
<td>Access to resident support for research</td>
<td>58%</td>
<td>3.45 (4)</td>
<td>3.40 (3)</td>
</tr>
<tr>
<td>Access to professional development mentor(s)</td>
<td>45%</td>
<td>2.33 (2)</td>
<td>3.06 (3)</td>
</tr>
<tr>
<td>Secretarial support</td>
<td>41%</td>
<td>2.83 (3)</td>
<td>3.15 (3)</td>
</tr>
<tr>
<td>Access to statistical support</td>
<td>37%</td>
<td>2.33 (2)</td>
<td>2.75 (3)</td>
</tr>
<tr>
<td>Access to PhD collaborators</td>
<td>36%</td>
<td>1.72 (1)</td>
<td>2.72 (3)</td>
</tr>
<tr>
<td>Access to MD collaborators</td>
<td>32%</td>
<td>2.23 (2)</td>
<td>2.78 (3)</td>
</tr>
<tr>
<td>Access to interdepartmental collaborators</td>
<td>30%</td>
<td>1.94 (2)</td>
<td>2.62 (3)</td>
</tr>
<tr>
<td>Access to interdisciplinary collaborators</td>
<td>25%</td>
<td>1.92 (2)</td>
<td>2.66 (3)</td>
</tr>
<tr>
<td>Office space</td>
<td>17%</td>
<td>2.13 (2)</td>
<td>2.48 (2)</td>
</tr>
</tbody>
</table>

* Scaling for question: excellent = 1, good = 2, adequate = 3, inadequate = 4, not available = 5.
† The percent of respondents that recorded a value of 4 (inadequate) or 5 (not available).
‡ Mean values reported with median values in parentheses.
chaired (2.21 ± 0.85 vs. 0.55 ± 0.11; \( P < 0.001 \)), or held an officer position (1.08 ± 0.30 vs. 0.513 ± 0.09; \( P = 0.012 \)) in the last 5 yrs.

The number of departmental/institutional committees served in the last 5 yrs did not differ between groups, but researchers chaired significantly more departmental/institutional committees than academicians (3.02 ± 1.14 vs. 1.42 ± 0.21; \( P = 0.004 \)). Researchers were much more likely to review for multiple professional journals (4.70 ± 0.38 vs. 1.63 ± 0.19; \( P < 0.001 \)) and were more often an editor of a journal (0.90 ± 0.19 vs. 0.23 ± 0.06; \( P < 0.001 \)).

**Barriers to Research Productivity**

Respondents were asked their opinion with respect to potential barriers to research productivity. Questions spanned a broad range of metric categories evaluating researchers and the research environment and are presented in Table 12. Although researchers reported many of these questions to be significantly less of a barrier to research productivity than academicians, both groups (70%) considered demand for clinical productivity the largest barrier to research productivity. Greater than half of respondents identified department subsidized research, administrative support, availability of startup and external funding, and department honoring protected research time as being significant barriers to research productivity. Part-time status and previous leave of absence were rated by both groups as the least significant barriers.

**Assessment of Current Research Capacity**

After reviewing each of the survey questions included in this report and categorizing them ac-

### TABLE 9 Current total salary including incentive pay*

<table>
<thead>
<tr>
<th>Practice Setting</th>
<th>Mean</th>
<th>Median</th>
<th>Minimum</th>
<th>Maximum</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Researcher</td>
<td>$201,053</td>
<td>$176,000</td>
<td>$120,000</td>
<td>$350,000</td>
<td>19</td>
</tr>
<tr>
<td>Academician</td>
<td>$163,817</td>
<td>$155,000</td>
<td>$46,000</td>
<td>$300,000</td>
<td>89</td>
</tr>
<tr>
<td>Private practice</td>
<td>$227,093</td>
<td>$200,000</td>
<td>$68,000</td>
<td>$900,000</td>
<td>54</td>
</tr>
</tbody>
</table>

* Only full-time MD/DOs included.
According to the metric identified in the methods section (Fig. 1), numbers of questions represented in each area of the Venn diagram were summed and presented in Figure 2.

This graphic nature of the data presented details the capacity domains most and least represented with this survey report. A total of 102 questions from the survey are included in this report. As expected, the majority of questions reflected aspects of the research environment. Additionally, several questions relevant to researchers were included in the survey. Table 13 outlines survey content captured within each of the major themes of the metric. Although several questions within the themes of research environment and researchers affected aspects of the research agenda, this theme was the least represented in the survey. Notably, the survey did not focus on consumer needs or political advocacy.

**DISCUSSION**

The Research Summit organizers identified five focus areas appropriate for exploration that were likely to contribute to a better understanding of current research capacities, strengths, and deficiencies. These five focus areas included researchers, research environment, funding, partnerships, and metrics. The Summit Metrics subcommittee created a taxonomy structure for several subdomains that represent three overarching aspects of research capacity: research agenda, research environment, and researchers (Fig. 1). Because the RAC survey was constructed before the development of this taxonomy framework, we chose to review and identify appropriate questions in our survey related to research capacity assessment and then link them to the appropriate overarching theme identified by the Summit Metrics subcommittee. This approach helped to assure the congruence between the goals of the survey and the summit. When reviewing survey questions from this perspective, it is apparent that the majority of the survey questions on research capacity aligned with the areas of researchers and research environment. Although research funding was assessed within the framework of this survey, no attempt was made to delineate the adequacy or appropriateness of current funding for rehabilitation research. In addition, we asked no specific questions about the adequacy of the rehabilitation research enterprise as a whole. Our inherent bias before constructing the survey was that the current capacity for rehabilitation research is inadequate to meet the needs of the disability community.

When evaluating the results of this survey, several potential limitations with respect to study design and generalizability should be considered. Despite the fact that we polled a cross-section of rehabilitation professionals and scientists, only a small number of respondents met criteria for researchers, and the majority of respondents were physiatrists. The distinction between academician

<table>
<thead>
<tr>
<th>Component</th>
<th>Researcher</th>
<th>Academician</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research</td>
<td>1.39 (1)†</td>
<td>3.06 (3)</td>
<td>0.000</td>
</tr>
<tr>
<td>Mentoring</td>
<td>2.64 (2)</td>
<td>3.31 (4)</td>
<td>0.004</td>
</tr>
<tr>
<td>Teaching</td>
<td>3.48 (3)</td>
<td>2.53 (2)</td>
<td>0.001</td>
</tr>
<tr>
<td>Clinical activities</td>
<td>4.00 (4)</td>
<td>1.91 (1)</td>
<td>0.000</td>
</tr>
<tr>
<td>Administration</td>
<td>4.35 (5)</td>
<td>4.66 (5)</td>
<td>0.374</td>
</tr>
<tr>
<td>Service (include committees)</td>
<td>4.85 (6)</td>
<td>4.93 (6)</td>
<td>0.818</td>
</tr>
</tbody>
</table>

* Scaling: most satisfying = 1 to least satisfying = 6.
† Mean values reported with ranking in parentheses.
and researcher was defined using a productivity metric, which was established by the RAC committee before data analysis based on our knowledge and personal experiences within our home academic institutions and with tenure and promotion criteria. The literature is sparse with respect to describing academic and research productivity standards across the medical and biomedical science disciplines.23,24 Despite this, we felt it necessary to define what could reasonably be considered by these professional peer groups as significant research productivity to determine what portions of the rehabilitation community are successfully contributing to the rehabilitation research enterprise and which groups are more likely to encounter barriers when participating in rehabilitation research. However, our definition of this productivity metric was arbitrary and may be subject to change as understanding and perspectives about capacity needs and goals develop.

Despite potential limitations with the definitions of researcher and academician, the results indicate that the group defined as academicians responded differently to many of the questions compared with researchers. Historically, “academicians” are viewed as a principal group that leads the research enterprise within the medical disciplines and trains the next generation of researchers. Yet, the results of this survey suggest that a large group of rehabilitation professionals in academic settings do not meet the established research productivity criteria, report that they are ill-equipped for research, experience more barriers to performing their research, have little funding, and are unsure about how to effectively obtain funding. In addition, skills in basic science, statistics, and translational research, all increasingly necessary requirements for conducting contemporary biomedical and related research, are decidedly missing from their skills portfolio. A lack of proper research training and exposure early in the careers of respondents may ultimately contribute to poor skill

<table>
<thead>
<tr>
<th>Potential Research Barrier</th>
<th>Response &gt;3†</th>
<th>Researcher (n = 53)</th>
<th>Academician (n = 129)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand for clinical productivity</td>
<td>70%</td>
<td>3.10 (4)‡</td>
<td>4.11 (5)</td>
<td>0.000</td>
</tr>
<tr>
<td>Department subsidizes research</td>
<td>61%</td>
<td>3.06 (3)</td>
<td>3.66 (4)</td>
<td>0.005</td>
</tr>
<tr>
<td>Research administrative support</td>
<td>59%</td>
<td>3.08 (3)</td>
<td>3.61 (4)</td>
<td>0.012</td>
</tr>
<tr>
<td>Availability of startup or pilot study funding</td>
<td>57%</td>
<td>2.94 (3)</td>
<td>3.53 (4)</td>
<td>0.007</td>
</tr>
<tr>
<td>Availability of external funding</td>
<td>55%</td>
<td>3.10 (3)</td>
<td>3.57 (4)</td>
<td>0.032</td>
</tr>
<tr>
<td>Department honors funded research time</td>
<td>52%</td>
<td>2.84 (3)</td>
<td>3.26 (3)</td>
<td>0.066</td>
</tr>
<tr>
<td>Skills with grant writing</td>
<td>50%</td>
<td>2.73 (3)</td>
<td>3.30 (3)</td>
<td>0.009</td>
</tr>
<tr>
<td>Knowledge of funding sources</td>
<td>50%</td>
<td>2.48 (2.5)</td>
<td>3.17 (3)</td>
<td>0.001</td>
</tr>
<tr>
<td>Appropriate mentorship</td>
<td>46%</td>
<td>2.67 (2)</td>
<td>3.24 (3)</td>
<td>0.012</td>
</tr>
<tr>
<td>Student/resident availability/interest in research</td>
<td>41%</td>
<td>2.70 (3)</td>
<td>2.94 (3)</td>
<td>0.226</td>
</tr>
<tr>
<td>Adequate research space</td>
<td>40%</td>
<td>2.71 (3)</td>
<td>3.10 (3)</td>
<td>0.084</td>
</tr>
<tr>
<td>Department recognizes research productivity</td>
<td>39%</td>
<td>2.31 (2)</td>
<td>2.64 (2)</td>
<td>0.143</td>
</tr>
<tr>
<td>Family/personal obligations</td>
<td>39%</td>
<td>2.64 (3)</td>
<td>3.16 (3)</td>
<td>0.008</td>
</tr>
<tr>
<td>Research methods skills</td>
<td>37%</td>
<td>2.71 (3)</td>
<td>2.95 (3)</td>
<td>0.236</td>
</tr>
<tr>
<td>Statistical support</td>
<td>35%</td>
<td>2.65 (3)</td>
<td>2.81 (3)</td>
<td>0.423</td>
</tr>
<tr>
<td>Research collaborators</td>
<td>30%</td>
<td>2.33 (2)</td>
<td>2.67 (3)</td>
<td>0.098</td>
</tr>
<tr>
<td>Interest in conducting research</td>
<td>26%</td>
<td>2.12 (1)</td>
<td>2.35 (2)</td>
<td>0.140</td>
</tr>
<tr>
<td>Research writing and presentation skills</td>
<td>26%</td>
<td>2.44 (2)</td>
<td>2.49 (2)</td>
<td>0.708</td>
</tr>
<tr>
<td>Adequate office space</td>
<td>22%</td>
<td>2.29 (2)</td>
<td>2.47 (2)</td>
<td>0.467</td>
</tr>
<tr>
<td>Part-time status or previous leave of absence</td>
<td>16%</td>
<td>2.08 (2)</td>
<td>2.07 (1)</td>
<td>0.728</td>
</tr>
</tbody>
</table>

* Scaling: not a barrier = 1, rarely a barrier = 2, minor barrier = 3, significant barrier = 4, major barrier = 5.
† The percent of respondents that recorded a value of 4 (significant barrier) or 5 (major barrier).
‡ Mean values reported with median values in parentheses.
sets reported and may negatively impact perspectives about conducting research. Although those respondents meeting criteria for researchers seem to be most satisfied with the research aspects of their position and better prepared and supported for research, they still often report problems in several of these areas. Furthermore, the infrastructure within the academic institutions and departments seems to be inadequate to support research for most respondents. For both groups, the primary barrier for research productivity was demand for clinical productivity. As a whole, departmental resources for pilot studies and administrative support as well as subsidization and honoring of protected research time were also major barriers. Partnerships and collaborations appeared to be less of a barrier. Moreover, there seems to be a disconnect between departmental value of research and the resources it provides and resultant productivity it claims for research. For example, respondents state that their departments and institutions value research, yet most programs lack a financial research productivity incentive program for their faculty but provide clinical productivity incentives. Additionally, very little is invested in the way of startup funding for faculty in either group. Historically, academic departments typically require research productivity for faculty promotion. The results of our survey suggest that the small group of researchers who were publishing and obtaining grant funding for research had higher academic ranks and attained more leadership positions. However, despite this recognition for research, poor resources and significant barriers suggest that other pressures may undermine the philosophic value placed on research productivity by departments and institutions. In short, a significant institutional culture shift at all levels with respect to training, support, protected time, research resources, recognition, and reward will have to take place before the majority of academics can make a significant contribution to rehabilitation research.

In addition to departments and institutions, the professional societies for the rehabilitation community should seriously reassess how they demonstrate their value for research. Although the other professional societies seem to do a better job than AAPM&R of supporting researchers and research collaborations, partnerships, and dissemination of research outcomes, all societies evaluated in this survey were found somewhat deficient. These data support the view that there is an opportunity for improvement and suggests that professional

<table>
<thead>
<tr>
<th>TABLE 13 Survey content captured within each of the major themes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Research Agenda</strong></td>
</tr>
<tr>
<td>Type of research conducted</td>
</tr>
<tr>
<td>Subject population that research serves</td>
</tr>
<tr>
<td>Research funding</td>
</tr>
<tr>
<td>Research training</td>
</tr>
<tr>
<td>Funding sources</td>
</tr>
<tr>
<td><strong>B. Research Environment</strong></td>
</tr>
<tr>
<td>Reason for entering academic environment</td>
</tr>
<tr>
<td>Percent effort spent in research activities</td>
</tr>
<tr>
<td>Type of research conducted</td>
</tr>
<tr>
<td>Institutional startup funding</td>
</tr>
<tr>
<td>Departmental/institutional value of research</td>
</tr>
<tr>
<td>Protected/subsidized research time</td>
</tr>
<tr>
<td>Student and resident research support</td>
</tr>
<tr>
<td>Research collaborators</td>
</tr>
<tr>
<td>Research staff support</td>
</tr>
<tr>
<td>Research space</td>
</tr>
<tr>
<td>National Society support of Researchers</td>
</tr>
<tr>
<td>Research dissemination</td>
</tr>
<tr>
<td>Development of partnerships</td>
</tr>
<tr>
<td>Researcher training</td>
</tr>
<tr>
<td>Demand for clinical productivity</td>
</tr>
<tr>
<td>Incentive and recognition for research</td>
</tr>
<tr>
<td>Research productivity</td>
</tr>
<tr>
<td>Department subsidized research</td>
</tr>
<tr>
<td>Availability of pilot study funding</td>
</tr>
<tr>
<td>Job satisfaction with research</td>
</tr>
<tr>
<td>Academic rank and tenure status</td>
</tr>
<tr>
<td>Number of hours worked</td>
</tr>
<tr>
<td>Academic leadership</td>
</tr>
<tr>
<td>Research funding</td>
</tr>
<tr>
<td>Research training</td>
</tr>
<tr>
<td>Funding sources</td>
</tr>
<tr>
<td><strong>C. Researchers</strong></td>
</tr>
<tr>
<td>Subject population that research serves</td>
</tr>
<tr>
<td>Publication record</td>
</tr>
<tr>
<td>Funding record</td>
</tr>
<tr>
<td>Grant applications</td>
</tr>
<tr>
<td>Funding sources</td>
</tr>
<tr>
<td>Personal research skills</td>
</tr>
<tr>
<td>Student and resident research support</td>
</tr>
<tr>
<td>Research collaborators</td>
</tr>
<tr>
<td>Research space</td>
</tr>
<tr>
<td>National Society Support of Researchers</td>
</tr>
<tr>
<td>Researcher training</td>
</tr>
<tr>
<td>Retention of researchers</td>
</tr>
<tr>
<td>Distinction for research</td>
</tr>
<tr>
<td>Scientific/peer review</td>
</tr>
<tr>
<td>National Society Support of Researchers</td>
</tr>
<tr>
<td>Research dissemination</td>
</tr>
<tr>
<td>Development of partnerships</td>
</tr>
<tr>
<td>Researcher training</td>
</tr>
</tbody>
</table>
societies would do well to investigate innovative methods to work collaboratively to support and promote the research enterprise on behalf of its members and the community with disabilities.

Conclusions About Current Capacity

This survey provides quantitative information about researchers and academicians and describes some barriers and incentives for conducting rehabilitation research. As such, these data may inform many of the issues of how to remove barriers, improve the research environment, and enhance research capacity for the discipline. Observations here provide a platform for future work in understanding the adequacy of the rehabilitation research enterprise, its appropriateness, and ability to meet societal needs for those with disabilities. These end points will be required to assess capacity, efficacy, and relevance of rehabilitation research.

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ABSTRACT


The field of medical rehabilitation, like all applied scientific fields, depends on research for advances in treatments and services. It is generally agreed that the evidence base that supports rehabilitation practice is inadequately developed.1–3 Thus, advances in rehabilitation research are needed not simply to move the “cutting edge” forward, but even to bring the evidence up to date with current treatment practice. This research, in turn, depends on the existence of a pool of qualified researchers conducting sustained investigations pertinent to rehabilitation topics.

Workforce surveys in the 1980s suggested that the pool of researchers in physiatry was small, and many academic faculty members in PM&R spent only a small percentage of their time on research.4,5 Productivity of PM&R departments, as judged by publication rates, was low, and the burden of publishing fell disproportionately on nonphysiatrist department faculty.6 Informal discussions since that time suggest that change has been minimal, although searches for published updates on this topic were not fruitful. Other rehabilitation disciplines share many of the same problems. For example, in physical therapy, relatively few academic faculty members have been principal investigators on federal grants,7 and a recent survey of physical therapy faculty revealed an average peer-reviewed publication rate of less than one article per year per faculty member, although there are signs that both of these indices are improving. Similarly, in occupational therapy (OT), many faculty members have not been required to hold doctoral degrees, few have obtained extramural funding, and the emphasis has been on teaching. A survey of British OT faculty revealed that, of the research published, 83% was unfunded.8 Here, too, there is suggestive evidence that this may be changing, with increasing numbers of doctoral-level faculty members, improved publication rates, and increased extramural support.9 Some of this improvement may have been spurred by a financial investment in research preparedness by the Occupational Therapy Foundation and the American Occupational Therapy Association.10 Recent favorable trends notwithstanding, the ongoing inadequacy of the evidence base supporting rehabilitation practice suggests a continued serious need to expand the research workforce.

Some of the obstacles to the growth of rehabilitation research are generic
WHY BECOME A RESEARCHER?

The fact that the field of rehabilitation desperately “needs” researchers does not automatically translate into a flow of individuals seeking research careers. What, then, motivates an individual to seek a career in research? For some, and perhaps many, the answer seems to be a passion or a sense that there is really no alternative.

Another attraction of a research career is the ability to map out one’s own direction and, assuming the resources can be found, follow one’s own path. As productivity pressures mount in the world of clinical service, the ability to creatively drive one’s own career direction may be seen as an even greater advantage.

There are also “market advantages” to a research career, and these are likely to build over time as more researchers enter the field. For those who want to work in an academic environment, a research track record is increasingly required to be competitive. One has only to look to other more “crowded” medical specialties to see that research-oriented fellowships are essentially required to obtain a desirable faculty position. This is, of course, offset to some degree by the development, in academic medical centers, of nonresearch hiring and promotion pathways for individuals who function primarily as clinicians. Still, for rehabilitation medicine and other rehabilitation-focused departments to remain viable in academic centers, they must be able to demonstrate a research portfolio, which cannot rest solely on their clinical faculty.

Thus, well-trained researchers are highly desirable recruits to chairs seeking to enhance their departmental position. A proven research track record provides powerful leverage in seeking such a position and negotiating adequate space, protected time, and other resources. As more competent researchers enter the field, this will drive the standards even higher and encourage more individuals seeking such careers to obtain the required training.

DEFINING THE DOMAIN

Many biomedical fields are organized around a specific organ system (e.g., cardiology, dermatology) or technology (e.g., biomedical imaging). The science that underlies such fields, therefore, can be defined in a fairly straightforward manner (e.g., molecular biology and physiology of cardiac muscle). As has been frequently noted, rehabilitation does not “own an organ system,” but rather involves an understanding of how the function and dysfunction of all organ systems relates to integrated individual and social function. Given the breadth of the domain of rehabilitation, identifying the scientific domain(s) that support it is very challenging. Almost any physical, biological, psychologic, or social science is potentially relevant to rehabilitation. Yet, no one can be adequately trained in all potentially relevant domains, and the contribution of each such domain to the overall field is small. Such a state of affairs is ripe for collaborative research. Yet, rehabilitation scientists are challenged to define what they bring to the collaborations as compared with what researchers from other disciplines may bring.

This has important implications for training and ongoing career development. Given the reliance of rehabilitation on many different scientific domains, training programs in each of those individual domains will not, in general, have a large focus on preparing their scientists to apply their skills to rehabilitation. Those few rehabilitation researchers who receive training in a particular scientific discipline, furthermore, will typically not find a critical mass of like-minded colleagues with similar training. Consider, for example, an individual with training in cognitive neuroscience seeking to apply this training to cognitive rehabilitation. This person will likely have few similarly trained colleagues in his or her academic rehabilitation department. Furthermore, he or she is likely to find few individuals in a national neuroscience professional organization working on rehabilitation problems and few individuals at national rehabilitation professional meetings with training in cognitive neuroscience. Thus, individuals with rigorous research training in a scientific discipline...
relevant to rehabilitation often find it challenging to find a critical mass of research colleagues.

Many rehabilitation researchers with clinical training tend to define their scientific domain in relation to a patient population (a “spinal cord injury [SCI] researcher,” an “amputee researcher”). However, on closer inspection, most rehabilitation patient populations do not map cleanly onto a single scientific domain. There is, for example, no unifying science of spinal cord injury. Rather, a person planning to study SCI might want to be an expert in neuronal regeneration, respiratory physiology, muscle metabolism, bone metabolism, sexual physiology, psychosocial coping, and so on. This situation is not unique to rehabilitation—researchers in cardiology could specialize in studying lipid metabolism or electrophysiology—but because the rehabilitation patient population is defined by functional loss rather than by specific impairments of an organ system, the decision about where to focus one’s scientific training will generally involve more choices. Furthermore, a researcher who chose, for example, to develop expertise in bone metabolism, to study SCI-induced osteoporosis and/or heterotopic ossification, might consider studying other rehabilitation populations (e.g., stroke, traumatic brain injury) in which his or her scientific training is equally applicable.

With this in mind, there are only a few scientific domains that offer skills relevant to a broad array of rehabilitation problems and populations. For example, training in epidemiology might equip one to study the demographics of and risk factors for a wide range of disabling conditions. Health services research training might facilitate the study of service delivery variations across various disability groups. Also, the emerging science of enablement/disability provides a conceptual model for understanding the interrelationships among impairments, activities, participation, and environmental barriers and supports, regardless of the specific condition. However, these three examples, although broadly relevant to the field, are less likely than more focused areas of scientific training to provide new treatment innovations. Moreover, although all rehabilitation researchers should be familiar with the conceptual framework of rehabilitation science, many rehabilitation researchers’ own work will make little direct contact with it. For example, someone working to understand the biochemical events that underlie paralysis-induced osteoporosis will be unlikely to simultaneously gather data on environmental supports for individuals with immobility.

The inability to define one or a small number of scientific domains that underlie all of rehabilitation practice is a fundamental challenge and one that offers no ready solution. However, there are a number of partial solutions that should be examined. We need, for example, to understand the optimal training candidate and curriculum for rehabilitation science training programs. These programs are relatively new and their ultimate impact on the field as yet unclear. The initial educational models of a number of such programs have, however, been described and raise several questions: Are such programs most useful for trainees who already have strong scientific training in a more focused discipline? Should their curriculum focus exclusively on theoretical perspectives on the “macro” issues relating function to environment? Do individuals who conduct research in focused scientific areas related to rehabilitation benefit from broader training in rehabilitation science, and does their research program follow a different course than those whose training is limited to the more focused domain?

Rehabilitation departments that support focused research efforts probably need to select one or a few foci to allow a critical mass of researchers with complementary skills to coalesce. Thus, a department that focuses on “applications of respiratory physiology to rehabilitation problems” may find it easier to assemble a critical mass than one that focuses on “stroke research.” Similarly, interdisciplinary research institutes that combine rehabilitation disciplines with other related basic science disciplines focused around a common scientific problem may be more realistic ways of organizing research and building research capacity than traditional departmental lines, because few (generally small) rehabilitation departments can afford to have the bulk of their faculty focusing on a single area.

DEFINING THE IDEAL TRAINEE

Like in all research fields, scientific success depends on an interaction between the traits of the potential researcher and the environment that nurture his or her development. Clearly, key attributes of a successful researcher are intelligence and inquisitiveness. Most successful researchers can identify themselves as having had a “mind for inquiry” from their earliest memories, although pivotal experiences and important mentors may have stimulated their specific career choices. However, these attributes alone are not enough to ensure success, particularly because research success increasingly depends on the ability to attract resources and collaborate with others. Thus, the ability to focus, to plan a long-term direction while focusing on short-term achievable steps, and the ability to interact effectively with others, and solve interpersonal and political problems are also highly important.

It has been suggested that rehabilitation may
attract fewer of such individuals than other fields because of the highly interactive team culture and humanistic orientation of the field, which some see as, in some sense, in tension with the focused and disciplined nature of the research endeavor. Perhaps there is truth to this, but one must keep in mind that there are social scientists and political scientists who apply a disciplined approach to complex problems of human organization. Equally important is the lack of role models for future generations. Given the current dearth of productive researchers in various rehabilitation disciplines, the most inquisitive students may not be exposed to the many fascinating questions available to study in rehabilitation, may not meet brilliant rehabilitation researchers with interesting careers, and may be drawn to other fields in which these opportunities and resources are more readily apparent. That is, who is attracted to the field depends, in large measure, on who is already in the field. One piece of evidence for this is that the most research-intensive rehabilitation programs seem to continually attract and train the most research-productive trainees.

The process of attracting excellent trainees, then, is intertwined with other strategies for enhancing capacity in the field. As the volume of research, research collaborations, and senior mentors increases, this is likely to have important effects on the volume of trainees seeking to enter the field. This is not to say that there are not specific recruitment strategies that would be productive, but merely that these need to build on the growing strengths of the field to provide effective training opportunities. In the short run, at least, one must acknowledge that there will be pockets of rehabilitation research strength distributed unevenly around the country. Thus, it may be most effective to try to attract the most talented trainees to those centers of strength where such role models and opportunities are already available.

DEPARTMENTAL SUPPORT

Basic science academic departments typically have well-developed career hierarchies that range from undergraduate to graduate students, to postdoctoral fellows, to instructors, to assistant, associate, and full professors. These are more than just titles indicating rank; they are social systems responsible for socializing the next generation of academicians in the field. Senior faculty typically have established laboratories that employ several postdoctoral fellows, train graduate and undergraduate students, have interdisciplinary collaborations, and produce grant applications, presentations, and publications. Thus, a junior graduate student has daily exposure to the career trajectory that he or she is likely to pursue, sees what is involved in the next step, and has the opportunity to participate in a milieu that transmits the “research culture” to the next generation. Implicit in this is the fact that senior members of the department got where they are by participating in the same socialization process.

In academic rehabilitation, because of the lack of a well-developed research culture, few departmental chairs themselves participated in such a socialization system. Thus, few have been able to create a research milieu that can transmit the necessary skills, attitudes, and expectations. Department chairs may not even have a clear and realistic sense of the type of training required to become a successful researcher, to achieve extramural funding, to develop interdisciplinary research collaborations and other critical themes. In addition, rehabilitation departments are increasingly having difficulty supporting researchers who are not yet self-sufficient in their funding. Even those with a sophisticated understanding of what is required to become a successful researcher may, in these difficult economic times, have difficulty assembling the resources needed to support their colleagues’ career development.

Over time, this problem of departmental socialization may lessen with the increase in the number of well-trained rehabilitation faculty members who have, in fact, had exposure to a research milieu during their own training. In the meantime, we will need to make use of career development milieus in other related disciplines for socializing our future researchers.

This approach, although necessary, is not without some risk. How do we ensure that rehabilitation scientists are not socialized into something else through this exposure to related fields? How do we maintain their interest in and commitment to the future of rehabilitation? Programs such as the RMSTP are one approach. These can offer a rehabilitation research career development milieu to supplement the more focused career development experiences that trainees participate in within related scientific fields. Our professional organizations can also provide a place for rehabilitation researchers to share their common experiences and goals, and to address the special challenges of developing a scientific career within a rehabilitation department.

MENTORSHIP

Appropriate mentorship is viewed as key to the development of a productive scientist. Whereas our formal training mechanisms view career development as a progression of discrete ranks with “independence” achieved on completion of postdoctoral training, in fact, scientific independence is a gradual transition that lasts well into the faculty
years. Indeed, true independence is no more a reality in scientific research (How many scientists have all the skills they need and make use of no collaborators?) than it is in human function (How many able-bodied individuals grow their own food and minister to their own healthcare needs?). Thus, the ideal mentor is someone conducting their own research in an area that is very similar to the area that the trainee wants to explore, and who is comfortable supervising closely in the beginning but providing increasing opportunities for autonomy over time. This training process is most analogous to apprenticeship, with the trainee learning not just the scientific domain, but how to manage a lab, how to get funding, how to negotiate with a department chair, how to supervise students, and so on.

Clearly, access to mentors is shaped by the two challenges discussed here. What scientific domain is most relevant in seeking a mentor to advance a rehabilitation career given all the potentially relevant domains? Also, can one look within one's own department for such a mentor or even seek optimal advice on an outside mentor from one's own departmental colleagues? In my work with RMSTP trainees, I have seen many individuals propose a mentor who is a good researcher working on topics rather far removed from the trainee's chosen direction. Such a mentor may certainly help the trainee to find solutions to his or her research problems, may provide critical reviews of grant drafts, and so on. However, the mentor may not be reading the same literature as the trainee, there may not be other graduate students and fellows working on similar research problems, and the mentor may have few ready-made solutions for the obstacles that the trainee encounters, all of which will dilute or delay the trainee's progress. Thus, ideally, a trainee should either work to find a mentor whose own research is a closer match to his or her own chosen path, or might choose to submerge his or her eventual research goals until a later time to benefit more fully from the milieu that the mentor has to offer.

Trainees in rehabilitation may also experience an excessively abrupt transition to independence because of the shortage of senior researchers in our field. It is not uncommon, after completing a postdoctoral fellowship, to be offered a position with research expectations in a department with little developed research. In fact, I have received inquiries to recommend RMSTTP fellows who might assume research director positions in developing departments immediately after completing their research fellowship. The junior faculty member may be flattered by the notion of being the most highly trained researcher in a department, but he or she would do well to remain in an environment where there are more senior researchers until later in his or her own career development. Early transition to independence may result in difficulty in obtaining funding and remaining productive and, ultimately, difficulty continuing a research program. Remaining in a research-rich milieu allows a more gradual transition from fellow to research associate on someone else's grant, to principal investigator on a small grant while continuing to participate in a more senior scientist's laboratory, to, ultimately, being in charge of one or more ambitious research projects. Only at this point does trying to establish a research program at a developing department make sense as a step in career development.

**FUNDING OF TRAINING AND ONGOING RESEARCH**

Research training and most forms of research are resource-intensive propositions. Thus, in most institutions, extramural support will be required to support the growth of rehabilitation research. In addition to providing necessary resources, the receipt of extramural funding is a marker of career success and scientific prestige, provides useful leverage with department prestige, and makes a researcher a more attractive recruit. A number of government funding agencies (e.g., NIH, NIDRR, VA) and private foundations (e.g., Robert Wood Johnson Foundation) have specific funding mechanisms for career development. Space precludes describing all of the different funding mechanisms and their requirements.

Broadly speaking, these training grants can be categorized as those that are awarded to institutions based on the strength of the training infrastructure and mentors available and where trainees apply to the institution vs. those that are awarded directly to the trainee, after he or she assembles a research and training plan that specify the mentorship arrangement. These career development mechanisms also vary in their relative emphasis on basic science vs. clinical research, the duration of support (generally 1–5 yrs), the stipend level, and the expectation of the proportion of time spent on research activities. Most, but not all, are restricted to doctoral-level trainees. In general, career development mechanisms that provide a longer period of support and a higher proportion of research effort are desirable, particularly for individuals whose prior training has been primarily clinical in nature and who, thus, require more support to become independent researchers.

Because of the typical salary difference between PhD- and MD-trained individuals, many of the available career development support mechanisms are unattractive to physician trainees based on salary support available. Some training mecha-
nisms, including the RMSTP, have recognized this problem and provided salary levels that are more competitive with starting academic salaries. Moreover, the NIH has made available special educational loan repayment funding to entice health professionals with doctoral degrees who have large education loans to enter research careers (http://www.lrp.nih.gov/about/). Although career development stipends may be an economic disincentive to further training, especially for physicians, this is true only so long as attractive “academic” jobs are available to individuals without such training. In some medical fields, research fellowships are essentially requirements for academic employment. There may still be an economic differential between private practice and academics, but the stark contrast in the type of work involved in these two environments puts them in somewhat less direct competition.

Once trained and supported by initial research funding, the challenge is to remain continuously funded. Virtually no researcher, no matter how qualified, is successful in every grant application. Consequently, most busy researchers apply for more grants than they can accept on the assumption that not all will be funded. This carries with it the risks of overfunding and gaps in funding. Overfunding may require the researcher to “buy” his or her way out of further clinical or teaching duties. Although this is not a problem in principle, it may be one in practice if there are insufficient clinicians or educators to take on the relinquished duties. Conversely, lapses in support require some source of bridge funding. Otherwise, a researcher with a short gap in funds may have to lay off skilled laboratory staff and/or to become fully occupied in clinical work, which may preclude the conduct of the pilot research necessary to respond to unsuccessful grant reviews. Ultimately, the researcher him- or herself may lose employment during a funding gap. Thus, retention of well-trained researchers requires innovative internal funding strategies to bridge inevitable funding gaps as well as advocacy with funding agencies to ensure that the success rate for grant applications is sufficient to motivate researchers to continue to apply.

Appropriate mentorship can help mitigate the funding problem by ensuring that a junior researcher learns approaches to successful grant writing and fiscal management. However, this will not eliminate completely the risks of over- or underfunding. Thus, the department chair or comparable employer of the researcher must have a strong commitment to flexibility of job description as funding levels rise and fall. He or she must also find ways to support funding lapses through departmental or institutional funds or risk losing a productive researcher in whom he or she may already have invested substantial resources. Department chairs need to have a sophisticated understanding of the economic realities of research funding, and how other departments and institutions respond to these problems, to be effective negotiators with the dean or comparable institutional official. Development efforts to raise private research funds or build a research endowment may also be required. In large institutions, these are not typically autonomous functions. Therefore, the department will need to persuade the dean that raising research funds for rehabilitation (or allowing the department to raise them with institutional encouragement) is an important priority.

Even in productive research environments, research and research training are generally money-losing activities. Training grants typically provide modest levels of indirect cost reimbursement. Even research grants that pay the institution’s full indirect cost rate do not typically fully cover the costs inherent in research because of such issues as salary caps that exceed the allowable payment levels, the need for bridge funding, the need to conduct pilot studies to develop a competitive grant application, and so on. Thus, from the perspective of direct research income, it is difficult to make a case for an active research program. However, there are less direct incentives for research and research training, including its role in preserving a department within an academic milieu and enhancing its status, attracting patients to an institution perceived to be at the forefront, the ability to attract philanthropic support, and, of course, the value of the mission itself.

OVERARCHING ISSUES

Successful research, increasingly, is an interdisciplinary team effort, as formally recognized in the NIH’s recent “road map initiative” (http://nihroadmap.nih.gov/interdisciplinary/index.asp). Consequently, a key issue for most researchers is the presence of a critical mass of like-minded researchers that can collaborate successfully. This has important implications for department chairs or others seeking to recruit and retain rehabilitation researchers. Those seeking to build rehabilitation research programs must either amass the resources necessary to recruit a nucleus of collaborators in a given content area or must develop viable linkages with other departments or institutions where such colleagues exist. Assembling several researchers with complementary thematic interests may provide the ideal path toward productivity in rehabilitation research. For example, if a department was interested in building up mobility research, they might recruit someone with a background in motor control and motor learning, someone else with an interest in muscle
metabolism and physiology, and another with training in biomechanics. This would allow a collaborative focus on movement problems and their remediation while maintaining distinct contributions for each collaborator.

A critical mass is also important for retention. Investigators with strong collaborative networks are less likely to leave (unless another institution “buys” the whole group), because those relationships are much more difficult to replicate than a physical laboratory. The presence of a critical mass of researchers also helps develop a departmental culture that respects and values research. When I was the only funded researcher in a clinical department, I often received comments from my colleagues suggesting that I was not “busy” or “working hard” because my work pattern did not look like theirs. The combination of a department chair committed to research, a critical mass of rehabilitation researchers, and a change in the climate within medical rehabilitation broadly, which understands the importance of research to the future of the entire field, will all be necessary to sustain the growth of a rehabilitation research culture.

CONCLUSION

Developing rehabilitation researchers is a critical component of increasing research capacity in the field. This must be understood not simply as the training of individual scientists to practice in the field, but as a cultural shift requiring changes in recruitment practices, departmental organization, finances, and interdepartmental and interinstitutional collaboration. Increased resources are being provided to train future generations of rehabilitation researchers, and as these individuals assume leadership positions within their institutions, they will be increasingly effective in transmitting the research culture to subsequent generations. However, a concerted effort by the whole field to recruit, place, and support young scientists will be required.

REFERENCES
Response to “Training and Retention of Rehabilitation Researchers”

ABSTRACT

Rymer WZ: Response to “Training and retention of rehabilitation researchers.”

Key Words: Research Summit, Training, Employment, Researchers

In response to Dr. Whyte’s position paper, I plan to argue broadly that we need to reevaluate and redefine the scientific objectives of our field as a means to establish goals for training and mentoring, as a means to increase our competitiveness for federal funding, and to guarantee continued growth and development of rehabilitation science as a strong and vibrant discipline.

Accordingly, I begin by reviewing existing academic models that could serve as models for rehabilitation research, drawing from the experience of other research-intensive medical disciplines.

I also propose a number of essentially novel scientific areas that could serve as organizing themes for our research and training programs in the future. In particular, I plan to focus on the themes of cellular, tissue, and organ adaptation; plasticity; and functional compensation as valuable core areas, whose findings are potentially applicable to rehabilitation of impairments in many different organ systems.

Finally, I propose several key steps that are necessary for implementation of a plan to build research capacity in rehabilitation science.

MODELS FOR SUCCESS

By most criteria, the United States’ medical research enterprise is the most successful in the world. It has been constructed largely in and around research-intensive medical schools that have essentially become research institutes with their primary mission focused on basic and clinical research. In these medical schools, basic science teaching activity has become progressively reduced (in terms of overall faculty effort and student contact time), and clinical service obligations for clinician scientists have often been parceled into modular components to maximize available investigator research time. This effort distribution has allowed basic scientists and investigator clinicians in the United States to achieve unparalleled levels of productivity and achievement.

As a result of this restructuring, the basic science investigator in a research-intensive medical school has become essentially a full-time researcher, and even the clinical investigator has often had his or her clinical time severely rationed. Typically, in many research-intensive clinical departments, a clinician investi-
cant level of administrative, teaching, and clinical service, making the daily academic life of such a faculty member quite arduous and difficult to maintain. Nonetheless, this general approach has historically been very successful, and it warrants close scrutiny as a prospective model for developing excellence in rehabilitation science. For a valuable, brief discussion of these issues, see Whitcomb.

Although this discussion focuses primarily on laboratory- or bench-oriented research programs, other models of research are also relevant and may be appropriate for many academic physical medicine, physical therapy, or occupational therapy departments. These alternative models could include experimental medicine approaches (focusing on mechanistic studies of disease), translational research programs, clinical trials groups, engineering applications, as well as researchers performing epidemiologic or other population-based studies.

**REHABILITATION SCIENCE: PREVAILING PROGRAMMATIC STRATEGIES**

In contrast, very few, if any, physical medicine and rehabilitation (PM&R) or physical therapy/occupational therapy departments (PT/OT) can claim successful implementation of a team-based, NIH-sponsored approach toward their research. Few if any have achieved a critical mass of funded investigators, and fewer still have established multidisciplinary teams or have developed appropriate core facilities. Very few allow funded clinical investigators to withdraw from clinical practice for a large segment of their time, as happens in peer research-intensive academic departments.

The reasons for these differences are complex and will undoubtedly be discussed at length in the Summit. However, in brief, there are constraints imposed by our clinical culture, by financial and space constraints in the development of a critical mass of investigators, by the limitations in scientific training and background of PM&R physicians and PT/OT faculty, and by limitations in development of appropriate multidisciplinary teams, including substantial numbers of appropriately trained PhDs.

Furthermore, there are few rehabilitation physicians or PT/OT faculty who have had appropriate extended research training. Postdoctoral research training is relatively rare in our area. Most postresidency fellowships are clinically focused and provide accreditation for specialty practice in areas such as sports medicine, pain management, spinal cord injury, or pediatric rehabilitation. Although some junior investigators will have applied for and received NRSA or K (career development) awards, this is far from the norm.

What is far more common is for PM&R physi-
Physicians to be given a full-time or almost full-time clinical load, or sometimes to be offered 4 to 6 hrs/wk, at most, for research activities. There is usually limited mentoring and guidance, limited core research facilities, and very few role models for such research-oriented physicians to emulate. For physical and occupational therapy faculty, there may be clinical service obligations, but there are routinely substantial teaching requirements that are not easily avoided.

CAN WE CLAIM A UNIQUE SCIENTIFIC BASIS FOR OUR FIELD?

Simply put, our field claims no unique area of science as its own. (See also the commentary from John Whyte.) The prevailing explanation for this is that we operate in an inherently multidisciplinary and interdisciplinary area that has no mandatory link to specific organ or tissue impairment. Furthermore, the clinical objectives of our field focus on functional restoration and, ultimately, on reduction of impairment and disability rather than on rectification of abnormal organ or tissue pathology.

I would like to now strongly question the utility of this model, because I believe it imposes severe limitations on the growth and success of our field, especially in the context of NIH funding. Although it is certainly true that the NIH has developed a much broader view of its mission, especially in regard to focusing on clinical outcomes and therapeutic evaluation methods, with appropriate emphasis on societal impact as well, the most intensive and successful areas of NIH-sponsored research almost all have well-defined connections to one or more areas of basic science.

So, for example, the most successful research programs in internal medicine and related specialties are in areas such as cardiology, endocrinology, neurology, gastroenterology, and nephrology. In each of these areas, there is an extraordinarily rich scientific base and a framework from which a great deal of research evolves. Indeed, in the most research-intensive medical schools, the clinical researcher may be performing basic science research at a level comparable with that of his or her colleague in an adjacent basic science laboratory.

Our field (of rehabilitation science) is not alone in this lack of a well-defined basic science base. There are a number of other fields of medicine in which a close link to a basic science area is also not well established. For example, pediatrics has been constrained by an enormous breadth of mission in that the field addresses disorders of all organ systems and of almost all bodily components with the primary constraint being the age of the subject. Similarly, family practice, obstetrics and gynecology, and, in many respects, psychiatry are also limited by a lack of a well-defined basic cellular, tissue, or organ science base.

Nonetheless, it is my assertion that our field should review and select the most appropriate basic research themes and integrate them fully into our research and teaching as far as possible. Furthermore, I believe that rehabilitation does have an emerging core set of scientific tenets, which our clinical programs can build on.

SO WHAT IS OUR SCIENCE?

I submit that our science should become the study of adaptation, plasticity, and functional compensation of tissues, cells, and organs in response to disease or trauma.

Adaptation refers to rapid changes in tissue properties that can partially restore function within minutes or hours. (Examples include changes in cortical sensory maps after amputation of a limb or after peripheral sensory loss.)

Plasticity refers to structural changes in tissue (such as the formation of new synaptic connections or nerve fiber growth in the nervous system) that solidify functional recovery.

Functional compensation refers to the development of alternative strategies for recovery of function such as learning to use different muscle or movements to overcome persistent motor impairments.

Almost all the things that are done clinically as part of rehabilitation treatments reflect the intent to understand the degree of cell, tissue, and organ impairment, to establish what are the limits of recovery of organ and tissue function, and to determine whether there are compensatory responses available to offset these impairments. Furthermore, based on many recent discoveries, there are fundamental opportunities emerging to change tissue and organ structure and function in a controlled manner using the mechanisms of cellular, tissue, and organ adaptation and plasticity.

These opportunities are especially prevalent in neurologic disorders such as stroke and spinal cord injury; however, similar approaches are emerging in relation to bone and cartilage recovery after injury, for muscle and ligament damage, and for cardiac and pulmonary impairments as well.

SOLUTIONS

Define the Model of Academic Research That We Can Use Most Effectively

Is this model going to be a research-intensive NIH-sponsored model with appropriate reliance on NIH, Veterans Administration, or NIDRR grant support and team-driven facilities and training,
including core facilities and training programs? Such models require large-scale release of faculty time for research, imposing difficult scheduling and financial demands on departments and hospitals to sustain their clinical activities.

Alternatively, is the model going to be a clinical trials industry-sponsored model in which strength in experimental design and statistics, clinical trials management, and implementation of specific clinical instruments is the area of skill development? (Such clinical trials models can be difficult to develop and sustain because of the need to establish clinical trials experience and expertise. Furthermore, clinical trials are very expensive and difficult to get funded through the NIH, limiting their potential as engines of academic growth.)

Alternatively, Do We Choose a Different Model?

It is my belief that the only really strong academic research model that has been demonstrably successful comes from research-intensive NIH-sponsored clinical medicine, so if we choose to develop another path, we need considerable assurances that this path will work.

If we choose to follow in the path of research-intensive academic medicine, we will need to secure substantial new funds to bootstrap the growth of departments or centers to the point at which the number of skilled and competitive researchers reaches the necessary critical mass to be successful.

Choose Our Science

I would like to propose serious consideration of the theme(s) of cell, tissue, and organ adaptation; plasticity; and functional compensation as the fundamental scientific substrates underlying recovery of function in many disabling conditions.

In my judgment, these themes warrant a rigorous and thoughtful analysis, because they can potentially provide the framework for appropriate experimental studies, for clinical trials design, as well as for more integrative approaches to functional impairment and disability.

Develop Multidisciplinary Teams for Research, Training, and Mentoring

This multidisciplinary approach has developed energetically in many areas of medicine, as reflected in the recruitment of PhD scientists in clinical departments. In the last few years, the NIH Director, Dr. Elias Zerhouni has promoted the development of broadly based interdisciplinary research and training efforts in his NIH roadmap as an obligate step toward maximizing success in biomedical research.

Although the engagement of PhD researchers also happens in many PM&R and PT/OT departments, it is still not common to have permanent tenure-track or tenured researchers at the doctoral level closely involved with and integrated with the research programs. There are routinely issues of tenure guarantees, job security, pay equity, and role disparities that intervene, often limiting the potential for cohesive team development.

If our field of rehabilitation science is to be successful, we must draw on all available talent by forming strong mutually rewarding partnerships with basic science and engineering researchers and with other clinical disciplines as well. We cannot do it alone.

REFERENCES

ABSTRACT


Key Words: Research Summit, Culture, Environment, Infrastructure

I have been honored with the assignment of discussing research culture and research infrastructure in preparation for the Foundation for Physical Medicine and Rehabilitation Summit on Medical Rehabilitation Research. Perspective on this topic comes from my current position as Professor and Chair of the Department of Rehabilitation Medicine at the University of Washington. Our department has a strong research reputation, with more than $10 million of annual research funding from a variety of sources, including the National Institutes of Health (NIH), National Institute on Disability and Rehabilitation Research, Centers for Disease Control and Prevention, and other funding agencies. In the last 10 yrs, our core group of 60 faculty members have roughly tripled our total research funding.

The research culture and infrastructure in a department or institution is critically important to enhancing research capacity in physical medicine and rehabilitation (PM&R). Without a supportive culture and solid infrastructure, it would be difficult for even the most eager researcher to build an effective research program. Moreover, unless we continue to develop this support at multiple institutions, it will be a great challenge to improve PM&R research capability nationally. This article will discuss the components of core research infrastructure, the role of various personnel in establishing that infrastructure, and components instrumental in establishing a research culture in a PM&R department. The article will also cover research collaboration, administrative archetypes, and how PM&R research is different from other medical research fields. Finally, the article will review some proposed solutions for enhancing the research culture and infrastructure in PM&R, thus enabling an increase in rehabilitation research.

KEY ELEMENTS

There are a number of key elements required to establish a supportive research infrastructure in a department of PM&R. These include a variety of departmental personnel, nondepartmental institutional personnel, funding streams, and physical infrastructure.

Perhaps key among these requirements is a department chair who is interested and knowledgeable in research. (In this article, I discuss the department chair, but comments pertain equally to other research leaders, such as...
leader of a research institute.) The department chair does not necessarily need to be an active basic science researcher. However, the chair needs to wholeheartedly support the notion of building research capacity in the department and needs to have an understanding of what goes into recruiting, developing, and supporting strong researchers in the department. The chair needs to understand time and funding requirements for faculty involved in research and needs to be able to articulate the department’s research vision to the dean and other constituents of the institution. The chair’s values need to promote research at a level equal to or higher than clinical care and teaching because these other two elements can easily take up the faculty’s time, leaving no time for research. In particular, the chair needs to protect the faculty member from other demands that pull on him or her. At times, this even means protecting the researcher from himself or herself and the seductiveness of other nonresearch activities.

The institution in which the department of PM&R exists needs to have the appropriate infrastructure to enhance research in general. This means that the institution needs the mechanical components to allow investigators to efficiently prepare and submit research grants. This includes, among other elements, a smoothly functioning human subjects review, scientific review, and research compliance monitoring structure. There must also be well-defined processes (i.e., policies, procedures, and workflow) that help make the flow of research and the administration of research smoother. The institution should ideally have a funds flow mechanism to return some of the indirect costs to the department to support research grants. The institution must also understand the unique granting sources in rehabilitation medicine as compared with other medical fields. For instance, whereas NIH indirect rates are often 50–70% or more, the National Institute on Disability and Rehabilitation Research typically has indirect rates included in the total award, which can make for some difficult negotiations with the University’s Grants and Contracts Office, as the higher the indirect rate, the less the funds that are available for direct research expenses. Some agencies or foundations limit the indirect cost rate to a low rate. The institution needs to have a way to handle new space needs that are generated by new grants. Federal and foundation funding are not the only sources of research support. It is also important to acknowledge the role of local philanthropy, institutional financial support, product commercialization profits, and support from clinical operations in supporting research efforts. Each of these also have their limitations, however. Philanthropy, for example, is limited to the donor’s wishes. Clinical operations are now often not self-sufficient financially and cannot cross-subsidize research operations as much as they used to in the past.

In addition to the infrastructure to support grant applications and research, the institutional expectations need to include active research programs. This most commonly occurs at the institution’s Appointments and Promotions Council. In most strong research universities, expectations for a tenure-track faculty include significant and independent research programs. Although some institutions have increased the number of clinician-educator faculty (who have less research expectations), hiring a majority of faculty in this track can be problematic in terms of building research capacity. The institutional Appointments and Promotions Council needs to develop an understanding of rehabilitation research (preferably by having one or more members of the council from the department of PM&R). Moreover, the promotions criteria for the department of PM&R need to lay out the specific expectations for research achievements of its faculty.

At the departmental level, there needs to be support in addition to the chair. The chair alone, with the best intentions, cannot easily implement the infrastructure needs for a new researcher. Key among the personnel are the departmental administrator and a grants manager. The departmental administrator needs to understand that research grants are a high priority and that the funding from these grants is an important element to departmental funding. The administrator also should understand the specific regulations from funding agencies, reporting requirements for different funding agencies, and compliance issues with respect to funding. Many times, in larger departments, the departmental administrator will have a grants manager to deal with grants on a day-to-day basis. In our department for example, we have two individuals who serve as grants managers, covering both the initial applications and following budgets over time for active grants. These grants managers are financially supported in large part by return of indirect dollars from active research grants. These grants managers should develop an understanding of how to interact with funding agencies that are important to the department. There are different rules and regulations for NIH, National Institute on Disability and Rehabilitation Research, Centers for Disease Control and Prevention, and other agencies that are important to rehabilitation research. Small oversights can make a big difference in funding. As an example, in our own department, one of our investigators had to return over $50,000 in Centers for Disease Control and Prevention funds because we did not realize that no more than one no-cost extension was permitted by Centers for
Disease Control and Prevention rules (whereas this is permitted under NIH and National Institute on Disability and Rehabilitation Research rules).

The grants manager or departmental administrator also should be comfortable in working with a variety of faculty on their research grants. Some experienced investigators will need only minimal help. However, the new investigator will need a lot of hand holding to understand what goes into a grant application and how to bring a new grant application through the system. Considerable help will also need to be provided to a new successful grantee in terms of monitoring a budget post award. In addition to the management staff, the behavior of support staff is important in defining culture. Having administrative or office support who are both capable of, and agreeable to, handling all of the paperwork, “errands” (e.g., pulling patient files, typing institutional review board forms), and other administrative functions required for research is critical.

Physical space is often a limitation in the ability to obtain successful research grants and to build research capability. Most institutional space is assigned according to successful outside funding, particularly funding that carries full indirect costs. PM&R is at a disadvantage when obtaining funding from agencies that do not provide full indirect costs. In many cases, space does not seem to exist before a research grant is submitted. However, there are a number of options for the investigator and the chair to solve this problem. First, space can often be used more efficiently by investing in furniture, workstations, and the like. Moreover, part-time workers often do not need their own desk full time but rather can share office areas with other part-time staff. Second, in many cases, if onsite space is not available, the research grant can be written to include rent for offsite space, which may be more readily available. Third, often collaborators will have space available that the primary department does not, particularly for wet lab or basic science space. Finally, in some cases, one should simply go ahead and write the proposal as if space were available. Once a well-funded grant is received, it will be difficult for the institution or the dean to tell the investigator to return the grant because they cannot find space to support the research.

Mentors are a key component to building research culture and infrastructure. In our institution at the University of Washington, we have a structured mentorship program for junior faculty (assistant professor) or for new faculty coming on at a higher academic level. The mentorship guidelines are attached (Appendix). Mentorship is vital for development of junior faculty. Given the time and financial costs of recruiting new faculty, it is far better to devote resources to mentoring existing faculty rather than to take a chance on losing them and having to recruit new faculty. We have found that it works best for mentors to not be direct supervisors (e.g., clinical service chiefs or division leaders) for the newly hired faculty member but rather to be someone who the new faculty member does not directly report to. It is preferable to have this role be one of advocacy rather than one of evaluation. In addition, an orientation program for new faculty is extremely helpful. We have put together an orientation package in our institution that tells people how to get things done, such as how to have posters made, how to work through the human subjects review process, and how to submit new grants. This orientation package or program will vary from institution to institution. We have seen many a new faculty member flounder for lack of knowing who to go to or how to get things done.

The role of colleagues and collaborators for the new researcher is a vital one. This is in addition to any mentorship role that such colleagues may play. It is difficult for a new investigator, or even an established investigator, to work in a vacuum. Colleagues and collaborators are very helpful to encourage the new researcher, to provide additional input and knowledge base that the researcher does not have, and to enhance academic productivity of the new faculty member. Although mentors are assigned in our department, colleagues and collaborators need to be found based on common research interests. Such collaborations do not need to be only within the department and are in fact better if they cross into other departments or even other institutions. An additional advantage of collaboration is that one’s research investment is “diversified” so that if one research project does not work as well, the investigator may be able to team up with a collaborator and pursue a somewhat different path.

The residency program director and other divisions within the department also play a role in research development. First, they enhance the long-term research capability of the department in the field by recruiting and encouraging residents and students to pursue an academic career in PM&R. In addition, it is helpful if they understand the research expectations of a new faculty member so that the new person is not overloaded with teaching, clinical, or administrative responsibilities. Finally, the residency program director and others in the department can help to recruit residents and students to help the new faculty member with their research project. It does not help, however, if residents and students ask the faculty member to do something that is not in their area of interest. We have consistently encouraged our fac-
ulty members to only recruit students and residents to work with them on existing research programs and not to start off in a new direction because of a student or resident’s interest.

In terms of preparing a grant, support staff and statistical support are very important. Support staff to help type and format the grant and to make sure the proper paperwork is in order is vital, particularly as the grant gets down to the deadline. Statistical support is variable from institution to institution but is key for most successful grant applications. Statistical support is necessary to prepare power calculations and to establish a plan for analysis once a project is funded. The statistical support can be very expensive, and it is often preferable in larger departments to hire a part-time statistician to serve as a resource for faculty rather than hiring statistical support on an hourly basis. Usually, consulting services where graduate students provide input is not sufficient for this purpose. At the University of Washington, such a consult service exists, but there is no consistency in the consultation, and the support is not sufficient for writing an NIH-type grant.

Most new researchers will require time to collect pilot data before submitting a grant application. Pilot data are key to demonstrate to the funding agency that the experiment or study has a reasonably good chance of success and that the techniques can be carried out reliably. It also shows that subjects can be recruited. To collect pilot data, often start-up funding and free time need to be provided to the faculty member for a reasonable period of time. It is preferable if the faculty member has a definitive plan for how such pilot data would be collected rather than simply giving him or her time off to do whatever he or she wishes. At the same time however, it is unreasonable to expect that a faculty member can obtain external funding for a study when he or she has no pilot data to present as part of the application. Often, there are local university grants that can be applied for to obtain pilot funding. The University of Washington, for example, has a Royalty Research Fund that uses revenues from University patents to fund pilot projects. In addition, there are many small foundations that can be used to fund collection of pilot data.

Ultimately, the goal for an established investigator is to be able to secure extramural funding from agencies such as the NIH, National Institute on Disability and Rehabilitation Research, Centers for Disease Control and Prevention, or the National Science Foundation. This external funding is critical to allow a faculty member to carry out serious investigation. Unfunded research is no longer usually of sufficient quality to compete with other investigators. The funding allows for the principal investigator to pay coinvestigators’ time (which means they will put in more effort on the study) and allows the principal investigator to hire research assistants and people to actually do the data collection and analysis. It is usually unreasonable to expect a clinician to carry out all these activities without hired assistance.

Once funding is secured, the department or institution should have an established funds flow mechanism for indirect cost dollars. Usually, an institution will retain the majority of these dollars to cover facility costs and administrative costs. At times, dollars will come back to the home department or even to the individual investigator. At our institution, a small percentage of these are retained at the department level, which funds our grants manager and provides for other funding to support our research efforts. We do not return dollars specifically to the individual investigator. Although there are some advantages to providing indirect dollars directly to the investigators, the disadvantage is that it makes it more difficult to fund central research infrastructure for the department.

**ESTABLISHING THE RESEARCH CULTURE**

There are a number of ingredients necessary to establish a culture of research in an academic PM&R department. One initial consideration is whether the department has or wishes to have a vision or strategic plan for building research capability. My personal belief is that building a research program is qualitatively very different from building a teaching or clinical program in PM&R. The primary difference is that one can often train and recruit successful clinicians and teachers. However, a successful researcher needs to have a burning desire to become an independent investigator. The investment of time and energy is often above that required of clinical work and teaching, and it is only those working in the area of their own interest with a burning desire who will be successful. In this author’s opinion, it is probably best to envision a research program in very general terms and let that vision be flexible and swayed by the investigators that are ultimately recruited.

In many cases, it is not feasible to recruit someone with a specific predetermined research interest, but it is rather preferable to recruit the best faculty member one can find that fits in broadly with the general research interests of the department. In other cases, one can pursue a targeted area of research expertise if the pool of potential recruits is large enough. Sometimes a joint effort in collaboration with another department will be more fruitful in recruiting an individual with specialized research expertise or skills.

When building a research culture, the aca-
democratic department will want to take a long-term view rather than have expectations for short-term results. This means that departments will often have to invest in finishing residents or graduate students with the hope that they can be mentored and developed into successful independent investigators. There is of course always the possibility that some of these people in whom the department has invested will leave and join other departments or go into private practice.

Because collaboration among researchers plays such a big role in helping to facilitate research, it is very helpful for the department and for the department chair to promote interaction among researchers. The mentorship program mentioned above is one element of this interaction. Sometimes, informal interactions among researchers (i.e., discussions in the hallways) are some of the most important elements in helping researchers feel at home doing research.

Collaboration with faculty in other departments is especially useful when it brings in experienced researchers that can mentor less experienced faculty or when it brings new research techniques not typically used in rehabilitation research. In addition, research conferences should be encouraged and regularly scheduled. It is often preferable for these conferences to have faculty members present their early work before a finished product is completed. They might want to present ideas for research, pilot projects, or grants in which they are having trouble so that problems and areas of mutual interests can be discussed. At our own institution, we have a research conference once a month in which ongoing projects are discussed while problems are brought up for input. Often, such a research conference will be held before a grant is submitted.

Faculty meetings provide another venue for discussion of research projects. When one of our faculty members gets a grant, we ask him or her to present this briefly at a faculty meeting so everyone can hear what is to be done. Also, when grants are first submitted, we ask them to present what project is being proposed. When a grant is funded, this is announced in a faculty meeting so that the other faculty can applaud the faculty member’s success.

There are a number of other venues for discussing research programs. The important point is the higher the visibility of research discussions, the greater importance the faculty will understand is attached to it.

Recognition of research efforts of the faculty should be visible and continuous at multiple levels. In our department, research accomplishments are recognized in many ways. When a new faculty member becomes a principal investigator of any grant, he or she receives a special mug with gold letters that says “Rehabilitation Medicine Research.” New grants and significant research accomplishments are announced in our monthly electronic newsletter that is distributed to faculty members, staff, hospital medical directors, donors, alumni, and friends of the department. At faculty meetings, new grants are announced with pride, and the faculty member is asked to speak about their accomplishments. For many of the more significant research accomplishments, the department chair passes these on to Dean of the School of Medicine, who usually writes a brief note himself to the faculty member.

The University of Washington requires the chair of each department to meet regularly with each of the faculty. At these annual reviews, research accomplishments of the faculty are reviewed and discussed, as are plans for the next year and possible new research directions. Finally, research expectations are laid out in our appointments and promotions process. The criteria for appointment and promotion do, for some levels, require independent investigators.

Research efforts need to be supported by the department in a number of ways besides recognition and mentoring. As mentioned above, to collect pilot data and get that first funding, a significant investment is required for the faculty member’s time and for start-up funding. Typically, at the University of Washington, we would hire a clinician-scientist with 60% clinical responsibilities (40% time for research and teaching). We do not give new faculty members administrative or significant teaching duties or committee work for the first year, and sometimes longer. Most faculty members are provided with start-up funding. Start-up funding often comes from dowries from the Dean’s office during the new chair search. Time for initial research is often cross-subsidized by other faculty who were given the same opportunities when they started in previous years.

Efficiency of research, clinical work, and teaching are critical to the success of a new young investigator. Thus, it is very important to align the clinical work, teaching responsibilities, and research efforts of a faculty member as much as possible. Thus, if a research project relies on recruitment of patients the faculty member encounters every day in his or her clinical work, there is a greater chance of success. As an example, if a faculty member is interested in stroke research, it is best if his or her clinical work involves stroke patients as much as possible and his or her didactic teaching addresses stroke. Doing clinical work in one area and research in a totally different area is distracting and reduces efficiency of the faculty member’s time. Moreover, having students draw
the faculty member away from his or her own research efforts and into different research directions is usually not profitable.

When a new faculty member arrives from a different institution, it is important to introduce him or her to potential collaborators in the department or in the institution. Carefully listening to the new faculty member’s interests and knowing the institutional strengths will facilitate these introductions. As mentioned above, success in research requires a burning desire to become a strong investigator. The department chair or mentor cannot produce this desire, and it is something that is mostly innate. For those faculty members who do not have sufficient initiative to write or collect pilot data or find collaborators, the department chair needs to recognize this deficiency. If the burning desire is not there, the department cannot create it.

COLLABORATION

Collaboration for the successful researcher is important for a number of reasons, as mentioned above. First, it allows for greater complexity of research than would be available from a single investigator. Moreover, it allows the faculty member to develop new ideas or new techniques that he or she would not have alone. Because most research projects have successes and failures than others, it is very helpful to have collaborators to provide encouragement or to allow one to focus in another area if the first area becomes unproductive.

The key to a successful research collaboration is the presence of mutual scientific interests. If scientific interests are divergent, faculty members will feel that they are wasting their time collaborating with another investigator. Thus, it is often the function of the chair or mentor to help find research collaborations that would be synergistic for both parties.

Although introductions can facilitate collaboration, the strongest collaborations are usually developed at the individual faculty member level rather than by a department chair or administrator. Sometimes, interests can be very similar between the two collaborators, which is most common. Other times, research interests can complement each other. Collaboration can extend to a variety of other scientists, including not only others in the medical field, but also engineers, therapists, and basic psychologists, among others. For instance, we have had successful collaborations with orthopaedic surgery, anesthesiology, and psychology, all looking at pain, with each department bringing a complementary set of expertise and abilities. Sometimes, it is useful for a clinician to collaborate with a basic scientist, particularly if the basic laboratory results can be extended out into the clinic. As an example, we recently had a K12 fellow working in a molecular biology laboratory learning how to insert genes for dystrophin into mice and ultimately into patients with muscular dystrophies.

Problems can arise in collaborative relationships. It is often well to discuss potentials problem areas before specific problems arise. Most commonly, we have seen problems arise over authorship, authorship order, and ownership of research data. Generally, discussion of these policies beforehand will reduce the likelihood of severe problems later on.

ADMINISTRATIVE RESEARCH MODELS

In this author’s experience, there are two different departmental research models that are commonly in existence. In the classic research model, which is employed at the University of Washington, we generally expect faculty to be a “triple threat.” Essentially, we expect our clinician-scientists to be strong clinicians, excellent teachers, and strong independent researchers. In actuality, there are few faculty members who do extremely well in all three of these areas, but most of the time, faculty will excel in one or two areas, with solid but not stellar performance in the others. A different model, which is in use in other institutions, is to consider research as separate from clinical work. That is, to hire researchers (usually PhDs) to do the research and to have a separate role for clinicians. This model does have advantages in that the researchers can do research full-time, and some will be very successful. The down sides with this model are that one does not necessarily build leaders in PM&R, and such researchers may have a more restricted view of disability and rehabilitation than the triple-threat academician. In actuality, most academic PM&R departments probably have some hybrid of these models, with some PhD researchers doing only research and then some clinician-educators providing mostly clinical care and teaching.

REHABILITATION RESEARCH

Rehabilitation is substantially different from other areas of medical research in a number of ways. First, the outcomes from rehabilitation are usually substantially different and more difficult to measure than outcomes from acute surgical or medical interventions. Functional outcomes, for example, can be more difficult to measure than life or death, blood pressure, heart rate, or even pain. The functional measures useful for one disability may not be equally useful for another type of disability. Thus, outcome measures need to be carefully considered before a research project is started.

In addition to varieties of outcomes, patients are often quite different with respect to their specific disability and functional deficits. Thus, al-
though most patients with hypertension or myocardial infarction may be similar, patients with stroke or traumatic brain injury can have quite variable sets of impairments. Because these are so variable, it is more difficult to measure subtle changes in outcome when there is a large initial variance in function.

Although many other research fields test a single intervention, we have often utilized, in rehabilitation, multiple multidisciplinary interventions. The interventions are often individualized according to the patient’s needs and may vary in intensity, duration, and frequency. This is substantially different from a double-blind, randomized, controlled trial of a medication vs. an identical-looking placebo. It is also more difficult to investigate mechanisms of recovery in rehabilitation because we do not yet have a molecular basis of rehabilitation that can be examined in a basic science model.

These differences for PM&R research require a different outlook on rehabilitation research and use of different methods. Although we do not yet have a strong foundation in the molecular basis of rehabilitation processes, our field will move forward greatly as this understanding develops. Thus, we need to promote research that utilizes molecular biology, examines the influence of activity on outcomes after central nervous system injuries, and examines those cellular or molecular changes that accompany such interventions.

By far, the majority of rehabilitation research now focuses on clinical interventions and clinical outcomes. We may need to continue to be experts on measuring function and measuring outcomes and learn how to reduce our interventions into discrete quanta that can be uniformly and reliably tested. For example, rather than asking the question of whether an inpatient rehabilitation admission “works” for stroke patients, we need to be asking which individual components, when uniformly applied, are associated with an improvement in function. This is especially hard because interventions are often customized to the patient’s needs and because there are so many variables that ultimately contribute to function.

Because many of our patients benefit from assistive devices or technology interventions, much of our research benefits from collaboration with scientists in engineering and bioengineering departments. Strong collaborations here allow us to bring new advances in these other fields to the field of rehabilitation. Moreover, the scientists in these areas are well versed in experimental design and measurement, which can be brought to our field.

Finally, there is a need to advocate for greater expansion of the field of rehabilitation research. We are still in our infancy compared with other fields of health-related research. This will require advocacy both at a national level (e.g., NIH and Congress) and at the local level.

**PROPOSED SOLUTIONS**

To advance the culture and infrastructure for rehabilitation research, we need as a field to improve our ability to identify and grow potential researchers, to encourage collaboration with other departments and between institutions, to mentor our junior faculty, and to build core institutional infrastructure for rehabilitation research.

Identification of researchers needs to start at the student level. Medical students and students in allied health are best recruited early in their training, before they have decided on their career paths. Our colleagues in medical student education tell us that medical students make a “differential diagnosis” list of possible specialties in their first 2 yrs and then cross items off the list in their clinical years (rather than adding new possibilities). Thus, we need to get into the first and second year of medical school training with a number of strong role models and also have influence on our colleagues in the allied health disciplines within their first year of education.

Given the K12 program that is currently in place for our field, we have an excellent opportunity to recruit residents into research training. In our department, we have regular faculty meetings in which we discuss potential resident applicants to the K12 program. Once a potential K12 participant is identified, the department chair meets with that individual, describes the research training program and the benefits of an academic career, and tries to recruit him or her into this process. This follows through with a commitment to anyone who wants to do K12 fellowship research training after residency. We make every effort to keep such individuals on our faculty after fellowship training. Of course, the appropriate residents cannot be selected for training if we do not choose the right medical students for our residency program. We do emphasize the research capabilities of our department during resident interviews and indicate that ours would be an excellent program to attend if the individual has an interest in an academic career. Finally, junior faculty with an interest and drive to build a research career are encouraged early on and, when possible, set up with a mentor who is a more senior researcher.

Encouraging collaboration benefits almost all participants. We have tried to build collaboration between divisions in our department and between our department and others whenever possible. There are also a variety of instances in which collaboration between rehabilitation medicine departments in different institutions has been of benefit.
for multicenter trials. Such multicentered studies can bring in new investigators, giving them mentoring and partnerships that they otherwise wouldn't have access to.

Mentors play a key role in academic advancement for someone interested in a career in rehabilitation research. We are lucky at the University of Washington to have a number of successful senior researchers who can function as mentors. This program needs to be continually encouraged and mentors thanked for their work with the junior faculty.

Building and maintaining a core infrastructure will of course be key to facilitating research among our faculty. We need to continue to work with our deans and institutional leadership to expand research space (both dry lab and wet lab) and to obtain indirect research dollars to build our research mission. Moreover, there are many instances in which we need to convince our institutions to make an investment in pilot funding or use of a statistician, which would ultimately result in significant extramural funding. The American Academy of Physical Medicine and Rehabilitation Foundation may be another resource that can be called on to support the collection of pilot data.

Perhaps most importantly, we need to build a cadre of established researchers in our field who can then take leadership positions in our departments and lead the struggle to enhance our research capabilities at every institution.

**APPENDIX**

**Mentoring Program Guidelines**

The Department of Rehabilitation Medicine is committed to a mentoring program for new and junior faculty. The goal of this program is to provide an orientation for new faculty to the department and to the University, to ensure orderly growth and development of the new faculty member, to provide advice when needed, and at times to serve as advocate for the new faculty person. This program complements the Internal A&P Committee and annual faculty review, but does not replace either function.

The mentoring program will operate under the following guidelines:

1. There will be an orientation packet sent out to new faculty members before their arrival at the University. This packet will include information about the department, the University, and other information deemed appropriate for a new faculty member.

2. At arrival, the new faculty member will meet with the chair of the department and with the departmental administrator, the research/grants coordinator, and other selected departmental members as appropriate.

3. Before arriving, the chair will assign each new faculty member a mentor. Mentors and mentees will be assigned by the department chair based on the requests of the incoming faculty, the requests and time demands of the senior faculty, and the incoming faculty member's interests and perceived needs. The chair may assign a new mentor to the junior faculty member at his or her request or at the request of the mentor. In addition, within the first year after joining the faculty, each new faculty member will be encouraged to choose an additional mentor who may be more aligned in terms of research and teaching with the faculty person’s own program.

4. It will be the responsibility of the new faculty member to arrange a meeting with his or her mentor at least twice per year. A greater frequency may be needed at times. These meetings should focus on academic progress, including progress in clinical care, teaching, and research. Problems experienced by the new faculty member should be raised for discussion and possible solutions considered. When appropriate, the new faculty member should be directed toward the department chair for resolution of significant problems.

5. The role of the mentor and new faculty member should be one of an advocate rather than one of evaluation.

6. New faculty members will be asked to evaluate the mentoring process on a yearly basis.

7. Mentorship assignments may change from time to time as responsibilities or interests of our faculty evolve. Thus, a single mentor might not remain with the new faculty member indefinitely.

8. New faculty members at the assistant professor level should retain a mentor until promotion. New faculty members at other academic levels should retain the mentorship relationship for a minimum of 3 yrs.

9. The Annual Faculty Activity Report will include sections on participation in the Mentoring Program.
In this issue of the *American Journal of Physical Medicine and Rehabilitation*, the article “Research Culture, Environment, and Research Infrastructure” by Dr. Robinson is an excellent description of the critical elements that have been responsible for the exceptional level of success and accomplishment enjoyed by the Department of Rehabilitation Medicine at the University of Washington throughout the past several decades. As a case example of the pathway toward developing a successful research-oriented department of physical medicine and rehabilitation, it provides both general and specific suggestions that should be instructive and required reading for future chairs of physical medicine and rehabilitation departments and to many other concerned with this topic. However, to the extent that the University of Washington is a singular (and perhaps unique) example of an academic department of physical medicine and rehabilitation, there is a need to consider other existing models that exist within universities (e.g., schools of health-related professions, institutes of gerontology, centers for development disabilities) and associated with universities (e.g., academic medical centers, hospital-based rehabilitation research centers, free-standing or quasi–free-standing medical rehabilitation research organizations, and independent research institutes affiliated with universities or academic centers). Because I have been employed by several of these types of medical research entities, I would like to provide a few observations that build on the points offered in the article entitled “Research Culture, Environment, and Infrastructure.”

By way of introduction, it is also useful to recognize a few points in the recent American Academy of Physical Medicine and Rehabilitation survey on Academic Leadership and Research Development. In this survey of medical rehabilitation researchers, the majority of respondents rank ordered the following barriers to research productivity: (1) clinical productivity demands, (2) department not subsidizing research, (3) lack of available start-up funds, (4) inability to acquire or access adequate external funding, (5) research administrative support, and (5) departmental failure to honor funded research time, and (6) availability of suitable research mentor.

**KEY ELEMENTS**

In addition to the supplementary personnel essential to most grant-seeking organizations (e.g., departmental administrator, grants manager), there is often
an individual designated as the director of research. This individual may have research training as part of his or her PhD, MD, or MD and PhD background and will likely have some experience in successful grant preparation and administration. Such a person may possess a specific area of scientific expertise and serve as P.I. or Co-P.I. on several research grants and on research training grants. In addition, it is important for this person to be well versed in institutional review board, Food and Drug Administration, Health Insurance Portability and Accountability Act (HIPAA), and other appropriate federal guidelines and regulations. To the extent that some departments and other institutions cannot fiscally manage a separate grants manager position, this knowledge base becomes more essential to reside within the organization. The director of research should be in an excellent position to balance the scientific merits and cost–benefit of proposed research activities with the resources available within the department and institution that may effectively support the project. This individual serves an important function by mentoring more junior researchers in the research process, guiding investigators toward the most appropriate funding sources, and stimulating contributions to the scientific literature.

In certain organizations, the preparation of grants is materially aided by employing a grant writer, ideally one who has had previous experience in writing federal grants and who understands how to digest and translate highly technical scientific prose into proposals that will be readable and appealing to the study-section reviewers. This type of professional, though not in great supply, has been of great value to certain institutions, especially those without experienced researchers on staff. Another nonscientific but potentially important position that can help in the infrastructure of a research program is a publications editor or science writer. Such an individual may have previously been employed on the staff of science journals, hospital or university publications and communications departments, or perhaps as a freelancer. Given the less than stellar writing skills of some faculty, limited time availability, and competing priorities, such a position may enhance departmental research productivity as measured by peer-reviewed publications.

DEDICATED SPACE/ACCESS TO SUBJECTS/EQUIPMENT

Another key element inherent in the successful research enterprise is the availability of adequate space, often “dry labs,” to conduct applied research. Given the demand on space in most hospitals and academic health centers, this can be a significant obstacle to successful research. At the Rehabilitation Institute of Michigan, we attempted to model the successful general clinical research center approach funded by the National Institutes of Health, within our center by utilizing private endowment funds and creating a small four-bed clinical rehabilitation research unit. The unit included specially equipped rooms with 24-hr videotaping capability, a human performance laboratory, a motion analysis laboratory, specialized equipment, and a team of clinical rehabilitation research unit staff with specialty research training. At Kessler Medical Rehabilitation Research and Education Corporation, we have been fortunate to develop the research program in dedicated research space (20,000 square feet), which is primarily within the main rehabilitation hospital building, a short walk from the patient care units and therapy gyms. Within this space, we have built several laboratories with specialized equipment, such as several gait and motion analysis systems, specialized wheelchair-adapted equipment, body-weight–supported treadmill systems, a balance system, virtual reality driving equipment, near-infrared spectroscopy brain-imaging equipment, and visuospatial testing equipment. The space for our research laboratories is minimally adequate for a relatively larger rehabilitation research program. The costs for both space and equipment have been covered by a combination of local foundation funding and federal grants. This type of space and equipment capability is likely present in a relatively small number of rehabilitation centers. However, the importance of having adequate space and state-of-the-art equipment to perform rigorous medical rehabilitation research should not be underestimated.

One must also consider the frequently occurring problem of recruiting adequate numbers of research participants for studies. Despite impressive power analyses, the projected number of subjects (which may be convincing to some grant reviewers) may be difficult to achieve in reality. Having a well-developed mechanism and key personnel for subject recruitment (e.g., nurse coordinator) with strong links to clinical populations are essential elements for achieving adequate numbers of human subjects. Certainly, the conduct of clinical trials of any significant magnitude or developing a “model system of care” requires reliable and consistent methods of subject recruitment and follow-up postdischarge. This has become even more challenging in some settings with the advent of HIPAA.

INFORMATION TECHNOLOGY

One area that is increasingly important in building major research programs is the information technology function. Though sometimes an afterthought, the acquisition and retention of tal-
Among information technology specialists, who work closely with researchers in the development of sophisticated information systems, are critical in storing, processing, transforming, and securing research data to enable scientists to produce meaningful outputs for publication and dissemination. At Kessler Medical Rehabilitation Research and Education Corporation, we have invested heavily in this area and have been fortunate to have staff members who have advanced expertise in hardware, software, Internet, Web design, and Web programming. Research scientists readily appreciate the value of such personnel in supporting sophisticated technology and assisting in the development of unique systems that enhance confidentiality, security, and research dissemination. Within the past 5 yrs, we have incorporated major elements of information technology into many of our major grant applications. Again, although this level of information technology staffing may be beyond the scope or budget of some departments or research institutions, the key elements outlined in an information technology component should be considered in developing the infrastructure of a strong medical rehabilitation research program.

ESTABLISHING THE RESEARCH CULTURE

The issue of recruitment of researchers has been addressed in the article by Dr. Robinson, although I might sound a more encouraging note about faculty recruitment with predetermined research interests. Though it may be more often possible to recruit “the best faculty member one can find that fits in broadly with the general research interests of the department,” this view may be a bit narrow. In some specialty areas of rehabilitation medicine (e.g., traumatic brain injury, spinal cord injury), there are a number of physician fellowship programs (perhaps 10–20 in each category) that may be ideal for recruiting young research-minded physiatrists in a specialty area. In addition, the Traumatic Brain Injury and Spinal Cord Injury Model System programs have also been a venue for training early to midcareer physicians who become productive in subspecialty research. Finally, one should consider the nonphysician researchers who have historically been critical elements in the success of major academic physical medicine and rehabilitation departments, often with a PhD background in rehabilitation psychology or clinical neuropsychology, and also those individuals with advanced research training in physical therapy, occupational therapy, speech pathology, rehabilitation nursing, and rehabilitation counseling. Since the early 1980s and early 1990s, the National Institute on Disability and Rehabilitation Research and the National Institutes of Health have provided institutional research training grants (Advanced Rehabilitation Research Training Projects and T-32s), which have been producing some graduates who have made important contributions to rehabilitation medicine research and are on the faculty of major departments of physical medicine and rehabilitation and at freestanding rehabilitation hospitals’ research programs. A number of our most successful graduates have become our most productive researchers and have been successful in obtaining federal funding within the past 5 yrs.

Not to be overlooked in establishing a research-friendly culture within our educational and clinical programs are the following types of activities: (1) required resident/fellows research course, (2) required resident/fellow research project, (3) Annual Research Day that highlights internal research within the institution, (4) research fellowship didactic lectures, (5) visiting professor lecture series, and (6) participation in multicenter clinical trials or collaborative studies. Each of these activities, by itself or combined with others listed, can help create an environment in which research is viewed as an essential part of the culture.

RESEARCH INCENTIVES

Although issues involving recruitment of talented investigators is a key challenge for the field, the difficulties in retaining and incentivizing key researchers should not be overlooked. Beyond the tenure system, it is possible to establish a formal incentive program for scientific staff that may be linked to the achievement of organizational objectives based on such identifiable indicators such as number of peer-reviewed publications, new grants awarded, new grants submitted, amount of first-year funding, and amount of indirect costs received. Although it may be somewhat difficult to achieve total consensus on which of these indicators is most important and the relative weighting in the “incentive formula,” it can become an important mechanism for acknowledging the contributions of key staff. Nonmonetary incentives, such as travel, equipment, research assistants or graduate students, and space can also make a significant difference in having a research culture that is conducive to long-term retention.

REFERENCES


Funding for Rehabilitation Medicine
Building Research Capacity

ABSTRACT

T he ultimate goal of all rehabilitation and disability research is to restore function or prevent functional decline, thereby promoting community integration, independent living, and return to productivity. The field is challenged by difficulties in developing sensitive, reliable, and meaningful measures of medical rehabilitation outcomes that meet the needs of a variety of constituencies, including clinicians, administrators, regulators, consumers, payers, and researchers. Another challenge is the increasing number of rehabilitation patients with complex medical situations arising from the growing prevalence of multiple conditions and an aging disabled population.

FUNDING
The priorities for healthcare expenditures and research funding favor acute care, curative interventions, and biomedical research. In comparison, there is far less support for physical rehabilitation and disability, chronic illness, and rehabilitation research. With so much of the medical system focused on fixing problems or curing disease, relatively little attention is paid to alleviating pain or improving functionality. Research to address the treatment and prevention of secondary conditions, develop effective outcomes measurements, treat trauma- and violence-related injury, and evaluate health promotion initiatives is critically needed by the specialty field and its patients.

DISABILITY DEMOGRAPHICS
During the past 25 yrs, the percentage of people with disabilities in the United States has steadily increased from 11.7% in 1970, to 15% in 1994,\(^1\) and to 19.3% in 2000.\(^2\) This increase can be attributed to the aging of the population and life-saving advances in medical care that have resulted in more survivors of trauma who have persistent disability. Almost half of the affected individuals today have disabilities that affect their ability to perform activities of daily life. Of working-age adults, one out of eight has a condition that affects ability to work. The majority of individuals with disabilities (60%) describe their disability as somewhat or very severe.\(^3\) Despite the scope of disability, determining the cost to society is difficult. Disability is defined in different ways, which compli-
icates direct analysis. Expenditures for public programs that serve people with disabilities provide one means of estimating these costs. Annual expenditures total $86 billion for Medicare/Medicaid, $88 billion for Social Security, $40 billion for mental health programs, and $6 billion for vocational rehabilitation. In 1993, the National Institutes of Health (NIH) examined disability-related healthcare costs and estimated that the annual cost was $170 billion. Today, an estimated $300 billion is spent annually on care for Americans with disabilities, with traumatic brain injuries costing more than $37 billion and spinal cord injury estimated to exceed $6 billion. In the same year, Federal payments for disability services to Medicaid enrollees reached $44 billion. In fiscal year 2000 alone, the Medicare program paid nearly $29 billion to 5.4 million beneficiaries with disabilities. The disability demographics and the cost of disability are the impetus for funding rehabilitation research.

FUNDING ENVIRONMENT

General Foundation Funding Trends

Currently, there is inadequate funding for disability research. In 2002, only 3.2% of foundation dollars went to disability research. Moreover, the bulk of disability dollars is directed toward specific diseases or conditions rather than for benefit of the disability community as a whole. Far fewer foundation grants are available for physical disability than for mental and developmental disability. For example, in 2002, almost four times as many grants were approved for mental disability as there were for physical disability.

Public Funding

Determining the distribution of public rehabilitation research dollars is very difficult. The major sources of government funding—NIH, National Institute on Disability and Rehabilitation Research (NIDRR), Centers for Disease Control and Prevention (CDC)—do not disburse their funding primarily by condition or disability. They first establish general funding priorities, invite requests for proposals, and then evaluate submitted proposals based on scientific merit and perceived value to the medical and scientific community. Although some attempt is made to track general topic areas, many grants do not easily fit into any one category of disability or disease. The magnitude of the federal research enterprise in rehabilitation is conservatively estimated by the American Academy of Physical Medicine and Rehabilitation to be $800 million.

NIDRR

NIDRR is housed in the Office of Special Education and Rehabilitation Services (USERS), which is part of the United States Department of Education. NIDRR funds research in the areas of employment, outcomes, health and function, technology for access and function, independent living and community integration, and disability outcome measures (Table 1). Most of NIDRR’s grants fund research and training centers, model system centers, rehabilitation engineering centers, state technical assistance projects, field-initiated research grants, and institutional and individual training grants. NIDRR’s total fiscal year 2005 budget was $108 million (Ruth Brannon, personal communication, April 2005). In fiscal year 2004, the success rate for field-initiated grants was 6.7%.

National Center for Medical Rehabilitation Research

The National Center for Medical Rehabilitation Research (NCMRR) is housed within the National Institute of Child Health and Human Development at NIH. NCMRR was established to foster development of the knowledge base required to enhance the health, productivity, independence, and quality of life of persons with disabilities. To achieve its objectives, NCMRR supports research aimed at enhancing the daily functioning of people with disabilities. Secondary conditions of people with disabilities are emphasized. NCMRR aims to highlight these conditions to inform the broader scientific community so that disability research can incorporate the myriad advances in the biological, behavioral, and engineering sciences. In 2004, NCMRR funded more than $65 million in rehabilitation research, including regional rehabilitation research networks and a clinical trials network focused on traumatic brain injury. However, the budget increases for NCMRR in 2004 and 2005 are in the range of 1–2%, which is less than the increase for the National Institute of Child Health and Human Development. Table 2 shows the structure of the institutes and centers of the NIH that fund medical rehabilitation research and their funding mechanisms.

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<td>Advanced Rehabilitation Research Training Grants</td>
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TBI, traumatic brain injury; SCI, spinal cord injury.
Since 1990, the NIH has enjoyed funding increases that average about 9.7% annually, and that resulted in an appropriation of $27.9 billion in fiscal year 2004.\textsuperscript{11} For 2005, the Bush Administration proposed funding the NIH at $28.6 billion, an increase of 2.5%, or $700 million dollars.\textsuperscript{11} The fiscal year 2005 Omnibus spending bill provides $30 million through the National Center for Research Resources for extramural research facilities construction and renovation.\textsuperscript{12} According to the Bush Administration's preliminary projections, the NIH will receive an average annual increase of only 1.8% in the next 4 yrs, resulting in an appropriation level of $30.5 billion in 2009.\textsuperscript{13} Some lawmakers favor prioritizing other agencies, such as the National Science Foundation and the Department of Energy.\textsuperscript{11} Recent analysis of trends at NIH notes the following success rates for grants submitted to the National Institute of Child Health and Human Development (parent agency of NCMRR) from 1998 through 2003: R01 (NIH Research Project Grant Program) = 24.7%, R03 (NIH Small Grant Program) = 35%, K23 (Mentored Patient-Oriented Clinical Scientist Award) = 36.1%, K24 (Midcareer Investigator Award in Patient-Oriented Research) = 41.7%, and T-32 (Institutional Research Training Grants) = 39%. These include competitive renewals, continuation grants, and resubmissions. However, given budget limitations, it is expected that these levels of funding success may be diminished in the next few years due to lower ceilings on the “pay line” of highly rated grant applications.

A recent overarching initiative has been the “NIH Roadmap,” which provides a framework for bridging the gap between various NIH institutes, centers, and laboratories by promoting interdisciplinary, translational research partnerships. The three NIH Roadmap themes were designated as (1) New Pathways to Discovery, (2) Research Teams of the Future, and (3) Re-Engineering the Clinical Research Enterprise. A substantial base of funding has been established to support new funding initiatives in these areas, such as the following: Regional Translational Research Training (P20), Exploratory Centers for Interdisciplinary Research (P20), and Dynamic Assessment of Patient-Reported Chronic Disease Outcomes (U01). In addition, an emphasis on training scientists in interdisciplinary techniques has been incorporated into a number of the traditional NIH Research Training Programs, such as the K12 (Mentored Clinical Scientist Development Program Award), T-32, and R13 (investigator-initiated conference grants) mechanisms.\textsuperscript{14}

### Agency for Healthcare Research and Quality

The Agency for Healthcare Research and Quality (AHRQ), part of the Department of Health and Human Services, is the primary source of funding for research on healthcare quality and effectiveness. Disability and rehabilitation is one of the many areas of healthcare research that AHRQ supports. The agency’s 2004 budget was $303.7 million, 80% of which was earmarked for universities and research institutions.\textsuperscript{15} The AHRQ was almost dismantled in 1995, and funding for the agency has been essentially flat since 2002.\textsuperscript{15} Moreover, AHRQ funding earmarked specifically for patient safety was approximately $84 million in 2004. In its 2005 budget, the Bush Administration proposed funding the AHRQ at $304 million, an increase of $300,000, or \(<1\%\).\textsuperscript{13}

### CDC

The CDC includes two funding sources for physical medicine and rehabilitation research, the National Center for Injury Prevention and Control and The National Center on Birth Defects and Developmental Disabilities. The National Center for Injury Prevention and Control supports research on injury prevention, acute care, and rehabilitation. Funding opportunities include investiga-
DeLisa and Rosenthal


Christopher Reeve Paralysis Foundation

The Christopher Reeve Paralysis Foundation spends $8 million annually on spinal cord injury research. The Foundation favors innovative studies considered too unconventional to qualify for larger government grants. The Christopher Reeve Paralysis Foundation prioritizes studies that generate data that are needed to qualify for the support of larger funding agencies like NIH.

Muscular Dystrophy Association

The Muscular Dystrophy Association is the world’s largest nongovernmental sponsor of research seeking the causes of and effective treatments for neuromuscular diseases. The Muscular Dystrophy Association sponsors approximately 400 research projects annually. In 2003, the Muscular Dystrophy Association spent more than $21 million on research at university-based centers and at other research centers.

National Multiple Sclerosis Society

This society, the largest private sponsor of multiple sclerosis research in the world, spends more than $35 million on research annually. Funded research deals with treatment, prevention, and cure and with professional training and development. High-risk pilot grants are available, and a $1 million cash prize that can be awarded to a scientist whose research leads to a cure for multiple sclerosis is also available.

United Cerebral Palsy

In 2004, United Cerebral Palsy spent $250,000 on research, $324,000 on career development and $433,000 on professional and public information.

Other Private Funding

Most major rehabilitation centers in the United States have foundations that raise funds to support their research. Examples include the Henry H. Kessler Foundation, Craig Hospital Foundation, Mayo Foundation, the Institute for Rehabilitation and Research Foundation, and the Rehabilitation Institute of Chicago.

Funding Agencies and Directions for Growth

NIDRR, one of the largest funders of rehabilitation research, establishes priorities for areas in need of investigation. According to NIDRR, the new long-range plan may highlight the following themes: models, methods, and measures; programmatic research; and products and environmental adaptations. A key area requiring more investigation is the field of rehabilitation outcomes measurement. Although research in outcomes mea-
measurement has increased in recent years, more work needs to be done to develop valid outcomes measurements to support clinical effectiveness research.

**Relating Biomedical Research to Rehabilitation Outcomes**

A growing field of research is applying basic science knowledge to rehabilitation strategies to improve efficiency and efficacy. Researchers are looking at the cellular response of muscles to exercise and training among people with physical disabilities to maximize the benefits of therapy. Another example is at the genomic and proteomic level, which promises to yield important information about the causes and possible interventions regarding musculoskeletal pain.

**Programmatic Research**

This refers to research that provides information on medical rehabilitation interventions or disease categories. Medical and scientific researchers are establishing new avenues of research in cell regeneration, cell transplantation, neuroprotection, and neuroprostheses.

**Treatment and Prevention of Secondary Conditions**

Because of the serious consequences of secondary conditions in the disabled population, rehabilitation has placed more emphasis on the prevention and treatment of common medical complications like urinary tract infections, pressure ulcers, spasticity, seizure disorders, musculoskeletal injuries, joint degeneration, and respiratory disorders. Researchers are also focusing on health conditions that are more likely to affect individuals with disabilities, including complications due to comorbidities such as obesity, cancer, and heart disease.

**Aging with a Disability**

People with disabilities enjoy greater longevity because of advances in medical care; however, this increases their risk for chronic conditions associated with aging, such as heart disease, cancer, and sensory loss. The interaction of aging and disability is an area of increasing interest to researchers. As the population of people with disabilities ages, it is more important to study the effects of rehabilitation therapies on older individuals, particularly those with musculoskeletal impairments. We need to determine the effect on caregivers and family, especially those who are also advancing in age and the capacity to serve as caregivers. Although disabilities can affect sensory and motor functions, rehabilitation research has traditionally emphasized motor abilities. Sensory rehabilitation is an area that is receiving more attention from clinicians and researchers. Wellness and health promotion are strategies that are being applied to the population with disabilities. Nutrition and educational programs and primary care clinics are some of the models that have been developed. Little is known, however, about the efficacy of these various models.

**Products and Environmental Adaptations**

Disabilities often adversely affect how people interact with their environment, which affects the performance of activities of daily life. Researchers have explored the application of technological and design innovations and environmental adaptations to improve the quality of life for people with disabilities. Several technological innovations that show great promise include:

- **Robotic therapy devices.** These devices may allow for more effective outpatient and home care and may reduce costs associated with physical therapy and visits to rehabilitation centers.
- **New neuroimaging techniques.** Functional magnetic imaging, positron emission tomography, single-photon emission computer tomography, proton magnetic resonance spectroscopy, and other neuroimaging techniques are being applied to conditions that cause disability. Understanding of brain function in people with traumatic brain injury, spinal cord injury, multiple sclerosis, stroke, and other neurological disorders is essential to the development of effective, targeted therapies.
- **Computer adaptive testing.** Computers offer the prospect of more accurate and comprehensive functional assessment. The goal is to develop customizable, highly efficient tools for evaluating cognition, mobility, self-care function, and overall quality of life.
- **Neural prostheses.** Neural protheses can help address sensory and motor deficits. Electrical stimulation devices are being developed to help control respiratory and bladder and bowel function.

Assistive technology is an active research field that applies technology and engineering advances to solve problems in disability rehabilitation. Examples of assistive technology devices that may lead to improved quality of life for people with physical disabilities include more functional wheelchairs, improved cushioning, and voice-activated technology that can be used to operate computers, telephones, and other devices.
RECOMMENDATIONS FOR THE FUTURE

Adequacy of Funding

We have already noted the relative paucity of funding for large-scale medical rehabilitation research and the need to target both public agencies and private foundations with advocacy efforts. Establishing targets for funding levels is challenging, but it may be safe to say that a 50% increase in rehabilitation research funding over current levels is a goal to aim for within the next 5 yrs. The steps to reach this lofty goal are outlined below (Table 3).

Advocacy for Changing Policy

Verville and DeLisa\(^8\) raised the issue of creating a separate center or institute focused on physical medicine and rehabilitation research within the NIH. This would provide greater visibility and funding for the rehabilitation research enterprise. Each NIH institute has its own budget line and can better set its research priorities and agenda. This would facilitate budget advocacy and accountability. A new institute would have its own National Advisory Council for the second-line (not R01) peer review. Also, a new institute would establish its own priorities through “request for applications” and “program announcements,” which would probably be reviewed by its own study section. This would result in an increase of reviewers from the field of medical rehabilitation. The establishment of a National Institute for Medical Rehabilitation Research would provide an opportunity to build a new intramural research activity. This should also include a medical student and resident research fellowship component. The director of this new institute would be appointed by and report to the director of the NIH.

This concept needs to be embraced by the field. It would take a major concerted effort over many years to make this a reality. Thus far, it has been endorsed by the Association of Academic Physiatrists, the American Congress of Rehabilitation Medicine, and the American Academy of Physical Medicine and Rehabilitation. It would require a long-term, consistent political advocacy coalition with significant financial resources to establish this new institute, as it requires congressional authorization.

The advocacy effort can be quite expensive and time consuming, but it has been hampered at times by a lack of a unified approach. Establishing a coordinating inter-association committee for research funding between the Association of Academic Physiatrists, American Academy of Physical Medicine and Rehabilitation, and American Congress of Rehabilitation Medicine, with a linkage to consumer-based groups such as Paralyzed Veterans of America, Brain Injury Association of America, United Spinal Association (formerly Eastern Paralyzed Veterans Association), and the National Multiple Sclerosis Society, could provide more clout and greater effect than the current, somewhat fragmented efforts of these organizations.

Political Process

The NCMRR statute creates an Advisory Board on Medical Rehabilitation Research in the NIH, which is housed in National Institute of Child Health and Human Development. This statute also requires the creation of a research plan by the NCMRR and an advisory board for medical rehabilitation research that would oversee funding via the various federal entities (e.g., the NIH, NIDRR, Department of Veterans Affairs, and the CDC) through the Interagency Committee on Disability Research. NCMRR’s plan was created in 1993 but has not been revised.

Mechanisms for Funding

The field of medical rehabilitation research has been built within the past 40 years by the estab-

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**TABLE 3** Significant problems in medical rehabilitation research and potential solutions

<table>
<thead>
<tr>
<th>Problems</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Decrease in funding level for NIH grants</td>
<td>Establishment of separate Rehabilitation Institute at NIH</td>
</tr>
<tr>
<td>2. Increased competition for NIDRR FIR grants</td>
<td>Allocation of more resources into this program</td>
</tr>
<tr>
<td>3. Lack of well-trained doctoral-level rehabilitation researchers</td>
<td>Increase funding for more training grants</td>
</tr>
<tr>
<td>4. Lack of emphasis of academic PM&amp;R departments on research</td>
<td>Supporting enhanced research infrastructure in academic PM&amp;R departments</td>
</tr>
<tr>
<td>5. Lack of clinical trials demonstrating effectiveness of rehabilitation interventions</td>
<td>Shift emphasis of research towards RCTs and industry-sponsored clinical trials</td>
</tr>
<tr>
<td>6. Lack of coordinated, unified, sustained advocacy for research funding on behalf of organized rehabilitation and consumers with disabilities</td>
<td>Establish inter-association advocacy committee for increased funding</td>
</tr>
</tbody>
</table>

NIH, National Institutes of Health; NIDRR FIR, National Institute on Disability Rehabilitation and Research Field-Initiated Research; PM&R, physical medicine and rehabilitation; RCTs, randomized, controlled trials.
lishment of center-type grants. Specifically, funding from NIDRR established a network of Medical Rehabilitation Research and Training Centers in the 1960s and 1970s that provided an impetus for medical rehabilitation research at many of the foremost centers in rehabilitation medicine. Although Medical Rehabilitation Research and Training Centers still are part of the NIDRR portfolio, there has been a shift of emphasis, with relatively fewer dedicated resources to medical rehabilitation research. Similarly, model system grants have enabled many clinically oriented centers to establish research programs that have led to the capability to conduct clinical trials or to contribute to the science of physical medicine and rehabilitation. Expansion of existing model system-type programs in spinal cord injury, traumatic brain injury, and burns and consideration of additional programs in stroke, multiple sclerosis, and others can be an enormous impetus for the field. Additional resources are needed to build the infrastructure of medical rehabilitation research.

CONCLUSION

Increased federal funding is critical for medical rehabilitation research to either maintain or increase its research capacity. However, increases in specific federal agency budgets (e.g., NIH) should not be at the expense of reducing existing budget levels in other rehabilitation research funding programs (e.g., NIDRR). At present, however, the outlook for additional funding levels for the NIH, NIDRR, AHRQ, and Veterans Affairs do not seem optimistic. The NIH Roadmap is not expected to yield direct benefit to medical rehabilitation research. The federal budget deficit is expected to reach $477 billion in fiscal year 2004.26 Also, the Bush Administration’s plan to halve the deficit in 5 years while implementing $1.1 trillion in tax cuts through 2013 would leave no short-term federal surplus.27 This is further complicated by the report that the Bush Administration will be requesting an additional $70 billion for Iraq. This will make the challenge of increasing the research capacity of rehabilitation medicine a very difficult goal to achieve. Greater visibility within government is needed for the rehabilitation research program so that adequate research leadership and advocacy can be provided. This includes greater involvement in these granting agencies by consumers and professionals in budget formation, planning, and priority selection.9

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Building Research Capacity
The Role of Partnerships

ABSTRACT

What “connections”—a broader term than “partnerships”—need to be made to build research capacity? Connections build capacity to the degree that they augment the skills, knowledge and resources of the focal investigator or investigating entity. We suggest that the goal of capacity building through partnerships/connections is to maximize research utility, i.e., its potential to effect desired changes in targeted systems. Specifically, an investigator or research organization must create connections that will enable: the selection and framing of research questions to address matters of importance to relevant stakeholders, especially and necessarily responding to the needs of people with disabilities; the development of a research design adhering to the highest standards of science; and the translation of new knowledge into messages about the results useful to those who are potential beneficiaries, tailoring the message so that it will be clearly “heard” by each respective target audience (including clinicians, other researchers, administrators and/or people with disabilities and their family members). Utility of research traditionally has not comprised the standard for judging research. However, the current focus in Federal funding appears to be shifting, with a demand to assess outcomes (i.e., utility) of research, thus, bolstering the argument to strengthen research utility through creating appropriate partnerships.

Key Words: Research Summit, Research Capacity, Partnerships

Before beginning this article, the authors want to point out their “biases” in discussing partnerships. We are both social scientists working within a medical rehabilitation setting. Although the lead author has had extensive experience across a full range of topics that are the focus of rehabilitation research, much of this article draws on our experiences in doing research on posttraumatic brain injury psychosocial interventions and community integration. We hope that the examples we use will be sufficiently broad to apply to a wide range of questions that are the targets of medical rehabilitation research, and also that they will be seen as examples only and that other researchers will contribute their ideas to the discussion. Our “bias” also refers to the fact this discussion focuses primarily on building capacity of individuals, with capacity building specific to organizations not separately discussed. Also, we do not discuss
partnerships with funding sources, because this topic has been covered in another paper.

We begin this discussion of capacity-building with respect to “partnerships” with a question: What “connections”—a broader term than “partnerships”—need to be made to build the capacity of any one person’s/organization’s research activity? Connections build capacity to the degree that they augment the skills, knowledge, and resources of the focal investigator or investigating entity. Augmentative connections are of two types: actual partners (human or organizational) and linkages to resources. For example, an individual or team may partner with members of specific disciplines to broaden their experiential base, an organization may partner with another rehabilitation setting to gain access to a larger potential pool of research subjects, or a research group may partner with a consumer-based group to effect better dissemination of research findings. In terms of connecting with resources, for example, one can establish a linkage to a specific knowledge base such as the data of a needs assessment study.

Why should we be concerned with augmenting what any person or organization brings to the research table? The answer depends on the standards adopted for judging research. If one extrapolates from Trostle’s definition of capacity-building in research, we suggest that the goal of capacity-building through partnerships or connections is to maximize research utility, because “utility” is the standard we have adopted in judging our research. In defining “utility” of research, we adhere to a view similar to that promulgated by the National Institute of Disability and Rehabilitation Research (NIDRR), i.e., research is useful to the degree that it effects desired changes in targeted systems. For example, if a new treatment is being evaluated through research, the utility of that effort should be judged in terms of its impact on potential beneficiaries of the innovation. If the treatment is shown to be successful, in the short term, do potential users of the innovation actually adopt it into practice? In the long term, does the new method improve outcomes of service recipients? If an old treatment is evaluated and shown to be unsuccessful, do those results affect current practice? As another example, in a study with a goal of adding to the field’s knowledge of some aspect of disablement, the study is useful in the short term to the degree that others view the results as an actual addition to the knowledge base and, in the long term, to the degree that the addition contributes substantively to the research of others.

We would explicitly add to this definition of research utility in the field of rehabilitation the necessity for a study’s addressing defined needs of people with disabilities. In other words, the changes that our research activities are to effect should specifically be targeted to address—in the long or short term—needs of the target population. The obverse, we suggest, is as true as it is obvious: rehabilitation research that does not address real needs of people with disabilities has little utility.

Utility of research traditionally has not comprised the standard for judging research. Too much rehabilitation research has been done simply because one could—not with the idea of research needing to be done. One result is a paucity of intervention research. Instead, studies are done because of their being feasible, and, even if useful in the end, their ultimate utility does not comprise the rationale for doing the research. Also, traditionally, the rules of science have almost solely been used as standards for judging research quality. However, the current focus in federal funding seems to be shifting, with a demand to assess outcomes (i.e., utility) of research. Within the funding agency that we know best—NIDRR—through its adoption of performance management, the potential utility of research has become (to all appearances at this point) a sine qua non for funding. (Before we declare, however, a new paradigm within NIDRR, we need to see evidence of the degree to which performance management standards become fully integrated into peer review.)

Our article focuses on how partnerships—or, more broadly, connections—add to the usefulness of rehabilitation research. Specifically, to engage in maximally useful research, an investigator or research organization has to create connections that will enable:

- The selection and framing of research questions to address matters of importance to relevant stakeholders, especially and necessarily responding to the needs of people with disabilities;
- The development of a research design adhering to the highest standards of science so that it maximizes the possibility of success, as well as the selection of appropriate statistical methods, to maximize the integrity of results; and
- The translation of new knowledge into messages about the results useful to those who are potential beneficiaries, tailoring the message so that it will be clearly “heard” by each respective target audience (including clinicians, other researchers, administrators, and/or people with disabilities and their family members).

These are the elements, we believe, that optimize potential utility of research in the sense of research output effecting changes in targeted systems based on needs of people with disabilities.
Many researchers are used to addressing only one of these three elements: we survive by repeatedly demonstrating our ability to tweak research design to the limit. (Also, clearly, research that fully addresses the demands of science has greater potential for being useful, because it adheres to rules meant to ensure that emerging information is relevant and valid.) However, utility as a bottom-line forces researchers to take on tasks that in large part we are not trained to do or that demand something other than our professional expertise. We are not used to framing our research to address population needs, and we are not used to thinking about expanding our vision of research to include its targeted dissemination and a concern for its ultimate utilization. In other words, we historically thought our job was to create new knowledge, not to also get it heard and then used. Thus, augmentative connections become particularly necessary to the degree that we are, indeed, working within a new—utility-focused—research paradigm.

Although the specific kinds of connections that are relevant for capacity-building depend on the purpose the research is addressing—whether evaluating interventions, developing measurement tools, assessing needs, or some other purpose—some common elements need to be considered to ensure utility:

In selecting/framing research questions:

- Partner with the ultimate beneficiaries of research (i.e., people with disabilities, their family members)—what are their needs? What is of importance to them?
- Partner with short-term beneficiaries of research (e.g., clinicians, other researchers)—What are their questions? How are these questions shaped based on their prior experience?
- Rely on an evidence base (i.e., expand what we already know) extending into the past and across fields.
- Tap into theory (i.e., what does theory, particularly in related fields, suggest?).

In shaping research design and in selecting statistical methods:

- Partner with practitioners (i.e., those who will carry out implications of research).
- Partner with “veterans,” those who have a history with a related research question or with engaging in a similar intervention.
- Partner with the ultimate beneficiaries: How does the design seem to them? Do they think its intended output will address their needs?
- Partner with methodologists.
- Partner with peers as reviewers.

In translating new knowledge to convey results:

- Partner with all potential audiences for research results, including the ultimate beneficiaries and multiple professional groups.
- Partner with experts in dissemination.
- Partner with evaluators.

We discuss these potential partnerships and connections in turn.

FRAMING RESEARCH QUESTIONS

The first goal of partnerships/connections is to help in selecting and framing research questions to address needs of relevant stakeholders and beneficiaries. In our perspective, the ultimate stakeholder is the person with a disability. Short-term beneficiaries are those with a stake in helping the person with a disability in addressing his or her needs, including funding agencies, clinicians, and family members.

The first question, then, is how do we ensure that our research ultimately addresses real needs of people with disabilities? Also, how do we frame questions to address those needs? What are the connections/partnerships that will aid in this first aspect of ensuring research utility?

The typical approach is to turn to the literature, which is clearly an important connection to be made in defining the issues that research activities should be addressing. For example, in our area of focus—posttraumatic brain injury (TBI) functioning—the research literature points to several foci for research that are clear problems for people with TBI. For example, we know from a myriad of studies that post-TBI depression is a major challenge, as is the high level of unemployment among those who have experienced brain injuries. Because of the repetition of findings and the large number of studies, we do not need a special “in” with stakeholders, beyond what is found in the literature, to know that these challenges are experienced by too many in the population and that we have incomplete answers in addressing the problems that underlie depression and unemployment.

We would make four additional points with respect to “connecting” with the literature. First, the literature, as it exists today in our area of TBI, tells us about problems but not specifically about needs. The literature repeatedly has defined the major mountain peaks in the topography of challenges faced by people after a brain injury. Additionally, some research has asked people about their service needs, documenting for small and large samples rankings of listed services in terms of their perceived utility. We also have a few examples of small focus groups or community groups reflect-
ing on their needs and challenges. However, what is unavailable to researchers in our area of post-TBI functioning are data documenting perceived needs within our target population. We define such a needs assessment as a critically valuable connection to expand our capacity to focus rehabilitation research on problems, gaps, and challenges that people with disabilities themselves define as important. What is missing from the available literature is the sense of what is important to potential beneficiaries in putting their lives back together; this is not the same as a list of “problems” defined by disability outsiders.

Second, as noted, the literature is important in pointing toward the major problems that we may seek to address in research. Also, this topography—this descriptive database—is incomplete. We need to have a better sense of the full panoply of issues that have yet to be addressed in terms of rehabilitation research. However, conducting studies—in the tradition of “because we could”—that simply repeat what we know, describing at best some minor outcropping of known high peaks can be clearly characterized as not useful.

Third, all too often in turning to the literature, we fail to make connections because we are very narrow in our focus across time and across areas of study. As scientists who have been working in the area of rehabilitation and disability studies since the mid-1960s, we are shocked when we see reviews of the literature that imply that anything before “last year” is not worth citing. In fact, a recent review in a widely read psychology journal failed to look beyond the reviewer’s years of participation in rehabilitation, in another nonuseful tradition of “before me—nothing.” The other approach to narrowness is embodied in assumptions that only rehabilitation research—typically only that of “our” discipline—is worth reviewing. As two rehabilitation psychologists, we find that the literature of a wide gamut of academicians and clinicians is relevant to our work, including clinical psychology, occupational therapy, physiatry, disability studies, animal studies, sociology, anthropology, and others. We all need to connect with a much broader range of prior work.

Fourth, all too often rehabilitation research is adamantly atheoretical. However, making connections to the literature of other fields often leads to treasure troves of theory developed with respect to phenomena other than disability, which may be highly useful in framing research questions applicable to our research arena. For example, we are currently exploring a theory developed in clinical psychology as a potential basis for creating new interventions to address post-TBI depression.

When we were invited to do this article, we assumed that it was because we have been associated for more than 12 years with participatory action research (PAR). Over that time, our ways of doing PAR—specifically, the kinds of connections we make—have changed and shifted. When our research focus was on community integration of people with TBI, we defined PAR as professional researchers partnering with people with TBI and their friend/family network in all phases of research—from agenda setting, to formulation of specific research questions, to developing research designs, gathering data, analyzing results, and disseminating findings. In our current research, in which the focus has shifted to interventions and treatments for people with TBI, we have shifted our PAR focus to include not just people with TBI and family members, but also those who potentially will adopt new treatments that are the focus of research—primarily physiatrists and psychologists in the field. Thus, the nature of PAR varies with the type of research and the situation or context of research.

When it comes to “framing research questions” to address real needs in the population, partnering with people with brain injuries has been keenly important to us in a variety of studies. For example, in 1993, we invited a group of women with TBI to discuss the issues and challenges they face as survivors of brain injury. In the course of the intense and broad-ranging discussion that followed, the women repeatedly mentioned a variety of health issues that they felt had been triggered by brain injury but were for the most part being dismissed by their physicians. This led to our augmenting an interview we were developing to systematically document challenges to quality of life after TBI; we added an extensive series of questions about health complaints, which were asked of both male and female interviewees. Clearly, the women with TBI who we connected with were speaking of what was important to their lives, and this helped frame our research questions to address real needs. The results were disseminated in several ways, to try to address these needs: through presentations to professionals and consumers (i.e., people with TBI and family members), through publication and in a lay-oriented newsletter—TBI Consumer Report—shared with state brain injury associations and available by downloading on our web site.

Our current research focuses on development and evaluation of rehabilitation interventions. A major issue is ensuring that the general approach to treatment embodied in the intervention will, if shown through the proposed research to be effective, also be acceptable to both those who potentially will adopt the intervention and those who are potential service recipients. Obviously, there is little point in conducting research on an approach that will be rejected either by rehabilitation
Clinicians or by potential recipients of treatment. So, a clear need is to connect with partners representing both of these groups to help shape the approach and questions addressed before engaging in an expensive study of something that, without appropriate input, will simply sit on the shelf, rejected as a clinical treatment.

Finally, we would like to briefly describe how one creates partnerships or makes connections with people with disabilities. We focus at this point on connecting for the purpose of helping frame one’s research agenda and/or helping frame a specific research activity. The guiding principle here is simply to reach out. Our advice is to first approach groups that you know. For example, in brain injury, in practically every state, there is a brain injury association. For us, this was a starting place for one of our projects, in which we created and evaluated a peer-mentoring program. The next piece of advice is to be clear that you are not asking people with disabilities to rubberstamp your research agenda. If you want their input as to their needs, challenges, values, and issues of importance, then be prepared for what you are asking. In 1992 and 1993, when we were first engaging in PAR, we, as professionals, had a great research agenda that we wanted to address through creating a research and training center. After our first meeting with a group of politically active consumers, our agenda was in tatters, but a better one had emerged. We got what we needed, but not what we had asked for. We have been better researchers ever since.

SHAPING RESEARCH DESIGN AND STATISTICAL METHODS

Clearly, the potential utility of research expands to the degree that the research is done well. What connections are needed to enhance the research capacity of a researcher or organization in creating “good science”? Because this is an area in which most investigators are well versed in creating partnerships, we focus on how we make connections in ways that may differ from others. Our approach can be characterized as inclusive–collegial. That is, we try to expand the definition of colleague to include diverse others. In this way, we ensure connections with a variety of people, serving in a variety of roles, in the design and in the implementation of the study. This adds to our capacity to detect poor approaches and methods and to brainstorm solutions. Based on our experience, a very simple suggestion is to avoid the titular director of a project being the only person giving the project direction. For us, group review at least once a week of every research project has been a successful means of capacity-building in our research endeavors. Every research assistant— including people with TBI—and every professional sitting around our Wednesday morning research forum equally “owns” each project discussed—at least at that moment. This group includes the project director, the program evaluator, training and dissemination directors, the research coordinator, principal investigators, fellows and interns, as well as research assistants. All members of our research group learn weekly the benefits of opening their thinking to the input of diverse others.

What specific kinds of partnerships and connections have we found useful? First, we draw into our staffing people with many different educational and experiential backgrounds. As necessary, this diverse expertise is augmented for special tasks. For example, one of our colleagues at Mount Sinai is expert in most matters statistical, but we also have on board a statistical consultant. From their conversations emerge better statistical plans than would otherwise occur. When we were planning a particular randomized control trial recently, we invited a third statistical expert to join in the planning, to bring his particular expertise on randomized control trials into the mix. Furthermore, in developing the same project, we asked colleagues in other institutions to review the proposal—getting a “peer review” before submission.

Our partnerships through PAR are also relevant in ensuring the soundness of research methods, strategies, and implementation. For example, we have hired people with TBI to be research assistants, to help in shaping interviews and approaches to potential study participants, based on their experience with brain injury. They have helped in interpreting data, in writing the results for publication, and in presenting results to consumer and professional audiences. For these roles, we seek individuals with TBI who may have diverse impairments, but who, more importantly, bring strong capabilities demanded in the job description. For example, one research assistant with TBI is quite skilled at interviewing study participants but experiences typical post-TBI fatigue and so works part-time. We find these recruits through those who seek us out—they know of our work and want to contribute, or through colleagues and local organizations that know of people with TBI who are seeking meaningful employment and have capabilities that will add to our research capacity.

KNOWLEDGE TRANSLATION TO CONVEY RESEARCH RESULTS

Publishing in professional journals and presenting at conferences have constituted the traditional approach to communicating results of research. However, within a utility paradigm, this will rarely suffice, because we know from experience research results so treated often lead to absolutely nothing. Clearly presented results do not
necessarily get read, appreciated, and their implications adopted into the field.

To “effect changes in targeted systems” requires new thinking and actions, which can be aided through partnering with at least three types of experts. First, we believe that PAR should play a key role in dissemination. Connect with potential short-term (e.g., clinicians, researchers) and long-term beneficiaries (e.g., people with disabilities, family members): What do they need to adopt your innovative treatment? How can they best be reached to “hear” your results in a way that is clearly comprehended and appreciated? This should be done before the project’s implementation so that implications can be built into the project, if necessary. For example, we are currently conducting a randomized control trial evaluating two approaches to cognitive rehabilitation. We asked people in the field what they would need to adopt either or both approaches if the study demonstrates efficacy. A clear answer pointed toward the need to create detailed manuals that would allow replication of the program. The manuals—first drafts, at least—are being developed before the start of the trial as a means of quality control for the two programs being compared. These manuals will be revised, as needed, and disseminated at the end of the program. They will be made available on our web site for free downloading.

Second, experts in dissemination can advise researchers, particularly in reaching and in appropriately communicating with audiences other than members of our own professional discipline. In the public sector, we have used the National Center for Dissemination of Disability Research to assist in our thinking. Also, private sector consultants specialize in marketing, communications, and public relations. Other “experts” in dissemination include those who have conducted research that has successfully achieved changes in the systems targeted in one’s own research. Connect to learn from those who pioneered successfully.

Finally, evaluators provide another useful connection. They can assess progress in achieving the types of changes that define utility for any specific project. Their feedback and advice—again, based on their experience with others who have been successful—can aid in reshaping dissemination activities to better achieve utility-oriented goals.

**SUMMARY**

Rehabilitation researchers may be working within a new paradigm in which utility has become a primary standard by which research is judged. Given the newness of the utility paradigm and that it requires capabilities and resources beyond those any single researcher or organization brings to the research table (e.g., information on population needs, dissemination skills), the demand to create linkages and partnerships has grown stronger. Capacity-building within rehabilitation research requires our reaching out to individuals with disabilities and to diverse professionals, bringing augmentative expertise into our activities. A diversity of voices at the research table is a primary tool in building capacity.

**REFERENCES**

Response to “Building Research Capacity: The Role of Partnerships”
Communication Holds the Key to Productive Collaboration

ABSTRACT

One cannot disagree with a central assertion of Gordon and Brown1: partnerships between persons with disabilities and research teams (themselves frequently interdisciplinary and collaborative) are often crucial to conducting studies that really matter— that improve health outcomes valued by persons with disabilities. In reality, however, such partnerships are more fruitful in some research contexts than others. Basic science at the laboratory bench generally offers fewer opportunities for productive collaboration between persons with disabilities and researchers than might translational studies, clinical trials, and health services research.

Nonetheless, Gordon and Brown1 are also right on another score: collaborations between persons with widely divergent life and professional backgrounds are challenging, and partners must open themselves to altering strongly held views. In my commentary, I argue that communication, when credible to all stakeholders, holds the key to successful partnerships between persons with disabilities and researchers. Some points specifically address physical medicine and rehabilitation (PM&R); others relate to research generally. Because it offers potential lessons for communication in research partnerships, I start by drawing an analogy to patient-centered care.

PHYSICIANS COLLABORATING WITH PATIENTS

In Crossing the Quality Chasm, its 2001 landmark report describing serious quality shortfalls endemic to the American healthcare system, the Institute of Medicine argues that patient-centered care should guide fundamental reforms.2,3 Care that respects patients’ preferences, needs, and values holds special resonance for persons with disabilities, many of whom find others defining and circumscribing their lives and options. However, especially when persons have lived with impairments for years or decades, they can become “experts” in the physical, and even physiologic, functioning of their bodies. “Patients with rare and chronic illnesses have always collected information about their conditions that rivaled or exceeded that of many physicians. . . .”4 Thus, some persons with
disabilities develop important technical expertise that informs their daily self-management and choices of care.

Sometimes, persons with disabilities think that their clinicians “just don’t get it”—fail to make basic connections between patients’ impairments and daily needs. For instance, Steffie, in her late 40s, uses a manual wheelchair: “I love my physician dearly. She lets me manage my own care, and she knows I know what I’m talking about. But she doesn’t know a lot about spinal cord injury. One time my shoulders were really hurting. So she told me, ‘Don’t use your arms so much.’ I’m a paraplegic, and all I have is my arms! I do everything with them, even talk with them. I told her she was absurd to say something like that to me.”

Marcia, in her mid-30s, also uses a manual wheelchair: “I think that, more than the able-bodied community, we have to be very resourceful. We have to be problem-solvers because doctors don’t solve problems for us very often. I’ve been nursing a rotator cuff injury, and I’ve decided not to seek any help for it. I’m thinking that I can reason it out—figure out what’s aggravating it in my daily routine and see if I can do something differently.”

For persons like Steffie and Marcia, “traditional” models of patient-clinician interactions—which “regard physicians and other health professionals as experts, with patients bringing little to the table besides their illness”—do not work. For many persons, solutions involve shifting to a self-management and collaborative care approach (Table 1). Increasing evidence suggests substantial benefits from this paradigm shift. Not only do patients feel more satisfied and in control of their care, but also clinical outcomes can improve. A collaborative care approach would instead assert that the physician’s goal is working together with persons with disabilities, each contributing their unique expertise, so that persons can achieve outcomes they most value.

This discussion offers important lessons for research partnerships, beginning with the notion that persons with disabilities can bring forward important expertise and valuable new information. Strategies for changing roles and communication patterns outlined in Table 1 translate directly to the research context. For researchers with traditional professional training, adopting this collaborative approach can require fundamental changes in attitudes and perspectives.

### RESEARCHERS COLLABORATING WITH PERSONS WITH DISABILITIES

Collaborations often founder because of communication barriers. As in collaborative clinical care, the life and career experiences of persons with disabilities and researchers can differ so fundamentally that language, expectations, and viewpoints diverge widely. In research, challenging and debating ideas among collaborators drives creativity and insight. However, engaging in productive intellectual interactions requires that participants sense they are on a level playing field and share definitions of basic terms. Participants must feel free to make controversial assertions or say something.

<table>
<thead>
<tr>
<th>Question</th>
<th>Traditional Care</th>
<th>Collaborative Care</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relationships</td>
<td>Clinicians are experts; patients are passive</td>
<td>Clinicians and patients share expertise. Clinicians are experts about disease; patients are experts about their lives.</td>
</tr>
<tr>
<td>Principal caregiver</td>
<td>Clinicians</td>
<td>Clinicians and patients share responsibility for caregiving and solving problems.</td>
</tr>
<tr>
<td>Goals</td>
<td>Adherence to instructions</td>
<td>Patient sets goals; clinicians help patient achieve goals. If goals are not achieved, change strategies.</td>
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<tr>
<td>Change behavior</td>
<td>External motivation</td>
<td>Internal motivation, as patients learn and develop confidence to change behaviors.</td>
</tr>
<tr>
<td>Identify problems</td>
<td>By clinicians</td>
<td>By patients and clinicians</td>
</tr>
<tr>
<td>Solve problems</td>
<td>By clinicians</td>
<td>Clinicians teach patients to solve problems and assist in problem solving.</td>
</tr>
</tbody>
</table>

Adapted from Bodenheimer et al.6
they fear that others might denigrate as “stupid.” Developing sufficient trust and respect among collaborators to permit constructive dialogue can take time and resources that financially constrained research projects do not have.

For PM&R specialists collaborating with professionals trained in medicine or other scientific disciplines, a first communication step involves introducing themselves. Even within my large teaching hospital, physiatrists are rare, if present at all. Other professionals may not know what PM&R specialists do. The onus therefore falls onto PM&R physicians to seek out professional collaborators and to offer engaging research ideas. It takes education and time for potential research colleagues to appreciate the special skills and insights of physiatrists and how they might interface with, for instance, geriatricians, rheumatologists, neurologists, orthopedists, and primary care physicians.

For PM&R specialists collaborating with persons with disabilities serving as representatives of a targeted population (note that collaborators with disabilities can sometimes be scientist colleagues), challenges might arise on several levels. First is the issue of language and perceptions of respect. For instance, a seemingly trivial but critical question is whether all collaborators address each other by first names or use more formal appellations. Obviously, consistency across collaborators in the choice of address is optimal. Avoiding technical terms and overly simplistic language, which could seem patronizing, is essential. The second challenge is developing a sense of comfort among collaborators. PM&R specialists used to viewing persons with disabilities as “patients” may face difficulties making the shift to treating them as colleagues; for example, not making assumptions about their abilities and preferences. Many persons with disabilities develop sensitive antennae for detecting insincerity. As Joe, in his mid-40s and a manual wheelchair user, observed: “You can tell the people that are real and the people that over-compensate, trying to be friendly to you because you’re in a chair.... [The genuine people] talk to you normally. A lot of people say they don’t even see the chair when they’re talking to me, and I can tell. Other people try to pretend like the chair doesn’t bother them, but it really does, and they’re overfriendly. And there’s some people that can’t deal with it at all.... The fake ones are the worst. They’re overzealous, buddy-buddy, and hanging onto you.”

These issues of language, comfort, and respect can raise a third challenge for researchers: crafting productive ways to contest or correct unrealistic or unscientific positions advanced by collaborators with disabilities. When “lay” persons—regardless of disability—collaborate in research activities, they may offer ideas that are simply inappropriate for research. In this situation, the scientists are the experts on technical topics and are responsible for successfully completing the project. Nonetheless, scientists without disabilities may hesitate to disagree with their partners with disabilities, afraid of offending or appearing churlish. These situations are easier to handle once collaborators know each other better and have developed the productive relationships described above.

A fourth communication challenge is setting realistic expectations and goals for the research that garner, if not complete consensus, at least support among all collaborators. As suggested by Steffie and Marcia, this presents challenges in clinical relationships, as well. In research, technical, scientific, and resource limitations may pose barriers to achieving certain ends, and scientists must explain them to their partners without appearing overly discouraging or directive and without damping creativity and enthusiasm for the project. However, as in clinical care, scientists must not automatically assume that persons with disabilities will have wildly unrealistic expectations about clinical outcomes. Many have lived with the realities of their impairments and are well grounded in what is possible. They do not expect—or even necessarily dream about—“cures.”

Finally, collaborators must reach a common understanding of what constitutes “success” of a project or “evidence” that new interventions work. Different stakeholders can hold divergent views of what constitutes credible evidence. Research must test outcomes of interventions that matter to persons with disabilities, but sometimes scientists focus on different effects. For example, scientists might track radiographic or biochemical markers of disease, whereas persons with the condition want to know functional or quality-of-life outcomes. Especially when studying rare conditions, having large enough sample sizes to provide good statistical power can prove daunting. In some contexts, randomized controlled trials are logistically or ethically infeasible, requiring reliance on observational or quasi-experimental designs that may produce different impressions of treatment effects. Some collaborators may tolerate less statistically and scientifically rigorous definitions of evidence, especially when testing new ideas in populations that have historically frequently been excluded from clinical studies.

**CONCLUSIONS**

Collaborating productively with persons with disabilities requires special attention to communication, possibly adapting perspectives used in patient-centered communication for collaborative clinical care. Developing enjoyable and fruitful col-
Collaborative relationships take time and demands a shared sense of trust, respect, purpose, and goals. In their clinical populations and local communities, PM&R researchers therefore might begin identifying individuals and groups who could become potential collaborators—introducing them to the research process and listening to their ideas about critical areas for study. That history of sharing ideas and educating each other will form a critical foundation for future research projects involving partnerships between persons with disabilities and PM&R investigators.

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Metrics of Rehabilitation Research Capacity

ABSTRACT


This article describes approaches to assessing rehabilitation research capacity and measuring capacity growth within the context of basic science, clinical research, health services research, and engineering and technology development. Related metrics are also described, including the selectiveness of research training programs, ways of measuring research productivity, the impact on education, clinical practice and policy, increasing and tracking retention, and measurement requirements.

Key Words: Research Summit, Metrics, Research Capacity

For the purposes of this article, the Swedish Department for Research Cooperation’s definition of research capacity was adopted: the ability to independently identify and define researchable problem areas; plan and implement research tasks; participate in and utilize international research; evaluate, select and adapt research findings; publish, disseminate and apply research findings; offer attractive research environments; [and] the capacity to reproduce its own capacity.

ASSESSING CURRENT CAPACITY AND MEASURING CAPACITY GROWTH

Advancing and promoting research in medical rehabilitation requires appropriate means of measuring research capacity. The Merriam-Webster dictionary defines metrics as a “standard of measurement.” Other sources specify it as a measurement that is “taken over a period of time that communicates vital information about a process or activity. A metric should drive appropriate leadership or management action.” In our context, such measures should consider not only the number of individuals and organizations engaging in rehabilitation research, but the quality and consequences of their efforts and, most importantly, the trainees preparing for careers in rehabilitation research.

There is no single source that documents the current rehabilitation research capacity of our nation in the areas of basic sciences, clinical research, health services research, or engineering and technology development. A simple approach might be to survey medical school departments of physical medicine and rehabilitation; allied health programs in rehabilitation sciences, including...
occupational and physical therapy and speech language pathology; psychology; social work; vocational rehabilitation; therapeutic recreation; and engineering schools and programs. Information from a survey would help document the number of faculty and staff members conducting rehabilitation research, the research funds awarded to them, and the products and benefits of their research activities. Frequent, repeated surveys with similar methodology over a period of time would help document trends in research capacity. Alternately, a proposal to charge the Department of Education’s National Center for Education Statistics with the responsibility of tracking students’ progress individually would allow educational attainment to be monitored and aggregated. In the absence of such surveys, it is, arguably, more valuable to focus on research training programs, their costs and “outputs,” as these programs prepare the next generation of rehabilitation researchers. The following sections of this article review the major Federal agencies that fund rehabilitation research capacity building and the means they use to evaluate grantee efforts.

Rehabilitation Research Training Funding Mechanisms

Several federal agencies are responsible for the majority of rehabilitation research training, including the National Institutes of Health (NIH), specifically the National Center for Medical Rehabilitation Research within the National Institute of Child Health and Human Development, the Agency for Healthcare Research and Quality, the National Institute on Disability and Rehabilitation Research (NIDRR) within the United States Department of Education, and the Department of Veterans Affairs (VA) Health Services Research and Development and Rehabilitation Research and Development programs. Several other federal (e.g., Centers for Disease Control and Prevention) and private organizations (e.g., Robert Wood Johnson Foundation and the Whitaker Foundation) provide research training but are not reviewed given the focus of the Research Summit on rehabilitation research. Reviewed below are the major training mechanisms used by these selected agencies and the criteria they use to evaluate program performance.

NIH

By way of background, the United States Congress enacted the National Research Service Act (NRSA) Program in 1974 to ensure that a diverse pool of scientists is available to carry out biomedical and behavioral research. In 2002, the NRSA Program was renamed the Ruth L. Kirschstein National Research Service Award Program as a tribute to Dr. Kirschstein’s years of extraordinary service to the nation. Dr. Kirschstein is a member of the Institute of Medicine and a fellow of the American Academy of Arts and Sciences, and she serves as the deputy director at the NIH.

NIH Research Training Grants take several forms, including Institutional Research Training Grants (T32), Minority Access to Research Careers (MARc), Undergraduate Student Training in Academic Research (U*STAR Program; T34), National Institute of Mental Health Career Opportunities in Research Education and Training, Honors Undergraduate Research Training Grant (T34), and Kirschstein–NRSA Short-Term Institutional Research Training Grants (T35). NIH also awards fellowships to individuals using Individual Predoctoral Kirschstein–NRSA Fellowships for MD/PhDs (F30), including specific funding mechanisms for minority students and students with disabilities (F31), Individual Postdoctoral Fellowships (F32), and Senior Fellowships (F33). Figure 1 illustrates the career timing appropriate for NRSA fellowships and training grants for individuals with a research doctorate; Figure 2 illustrates the same information for individuals with a health-professional doctorate. Given the large number of training mechanisms and the similarity of their review criteria, this article focuses on institutional and individual NRSA fellowships and their associated review criteria.

The NIH awards NRSA Institutional Training Grants (T32) to institutions to develop or enhance research training opportunities for individuals training for careers in biomedical, behavioral, and clinical research. The NRSA program is the primary means of supporting graduate and postdoctoral research training. Institutional research training grants provide support to training programs at institutions of higher education and are designed to allow the director of the program to select trainees and develop a curriculum of study and research experiences that ensure high-quality research training. Training grants cover stipends and tuition support for trainees and can be awarded to predoctoral trainees who are pursuing a PhD or a comparable research doctoral degree or to postdoctoral trainees who have received a doctoral degree.

Agency for Healthcare Research and Quality

Similar to NIH institutes, the Agency for Healthcare Research and Quality supports a variety of intramural and extramural predoctoral and postdoctoral educational and career development grants. Consonant with its mission, the Agency for Healthcare Research and Quality awards are focused on health services research. Institutional training awards include National Research Service Award (NRSA) grants to institutions (T32) for pre-
doctrinal and postdoctoral training. Institutional Training Innovation Incentive Awards (R25) provide support for the design and implementation of new models of health services research training. Institutional-level grants also include Research Infrastructure Development Initiatives, grants designed to support the planning and development of health services research in traditionally minority-serving institutions (M-RISP-R24) and institutions in states that do not receive significant health services research funding (BRIC-R24). Individual-level predoctoral awards include Health Services Research Dissertation Awards (R36) and Fellowship Awards for Minority Students (F31); postdoctoral training is provided through Individual Postdoctoral Fellowship Awards (F32) to individuals who have completed clinical or research doctoral degrees. Independent Scientist Awards (K02) provide career development support for new investigators, and Career Development Mentored Clinical Scientist Development Awards (K08) provide support for clinicians.

NIDRR

The NIDRR funds research training through Advanced Rehabilitation Research Training Awards, Rehabilitation Research and Training Centers (RRTCs), Rehabilitation Engineering Research Centers, and individual Switzer Fellowships, among several other mechanisms (e.g., New Schol-
NIDRR supports research capacity development that is relevant to the concerns of individuals with disabilities, service providers, consumers, and scientists. The agency supports training that emphasizes the contextual paradigm of disability, cross-disciplinary efforts, and participatory research that reflects disability culture.

NIDRR's primary statutory mandate for training is to support advanced instruction for researchers and service providers.7 NIDRR also has an implied mandate, emphasized in the 1992 Rehabilitation Act Amendments, to train consumers in the application of research knowledge and in the uses of assistive technology. NIDRR's scope of capacity building activities includes:

1. Advanced training in disability-related research for scientists, including individuals with disabilities and from minority backgrounds.
2. Application of research knowledge and new techniques for rehabilitation practitioners.
3. Developing the capacity of researchers to conduct research that describes disability as a contextual phenomenon and in nonclinical settings such as homes, work places, schools, recreational facilities, and community-based organizations.
4. Training consumers, family members, and advocates in the use of research findings.

NIDRR's Long Range Plan8 guides its research, training, dissemination, and utilization activities. This plan emphasizes a “new paradigm of disability” as a function of the interaction between impairments and other personal characteristics and the larger physical, social, and policy environments. NIDRR's relational paradigm views as insufficient unidimensional and static measures of function, improvement, outcomes, and other aspects of disability and the rehabilitation process. Instead, researchers are encouraged to develop measures that capture the contributions of the social and physical environments to disability.

NIDRR's focus on disability in various contexts and adaptive processes has implications for research training. First, training should emphasize interdisciplinary research and use of methods that can test complex hypotheses, attract researchers from disciplines not usually involved with disability and rehabilitation research, incorporate an understanding of disability policy and disability studies among researchers in varied disciplines, apply the principles of universal design in broad research areas, include consumers in research, and focus on adaptive processes. Adaptive processes comprise not only changes in individual performance in response to a physical limitation, but changes in the environment to better accommodate individual needs.

NIDRR's Long Range Plan emphasizes the cultural context of disability. Acknowledging the contributions of disability studies, persons with disabilities are viewed as individuals who are adapting to challenges. Thus, the use of personal assistance services and assistive technology, problems accessing services and public accommodations, and civil rights are legitimate subjects of research, as are society's response to them, such as issues of stigma, policy innovations, economic issues, transportation, and housing. This perspective requires skills in the methods and knowledge about this body of knowledge to conduct research effectively. NIDRR's Long Range Plan emphasizes that individuals from subject groups must have the opportunity to participate in the development of research plans, dissemination of results, and promulgation of curricula.

An important consequence of implementing this new paradigm of rehabilitation research is that research questions and the types of training needed for rehabilitation professionals must mirror NIDRR's priorities. Whereas much rehabilitation research has been conducted in hospitals and other clinical settings, NIDRR expects that future studies will be conducted in homes, workplaces, schools, recreational facilities, and community-based support programs. This change involves adapting to reduced access to subject and control groups, working with paraprofessionals and peers with disabilities in the data collection effort, and working with shared or existing databases. Consequently, training models, research training curricula, and issues studied also must change.

Advanced Rehabilitation Research Training awards are the primary mechanism NIDRR uses to expand research capacity. These awards are designed to develop the capability to conduct high-quality research, including the skills required to design scientific studies, select appropriate research methods, analyze data, and interpret findings. This training focus reflects NIDRR's commitment to participatory research methods that enhance the relevance of research findings. Like the NIH, NIDRR emphasizes research training opportunities for minorities and persons with disabilities.

Advanced Rehabilitation Research Training grants provide advanced research training to individuals with doctorates or similar advanced degrees who have clinical or other relevant experience that integrates disciplines, teaches research methodology in the environmental, or new paradigm, context, and trains researchers in disability studies and rehabilitation science. These training programs are expected to be based in interdisciplinary environ-
ments and provide rigorous training. Advanced Rehabilitation Research Training Awards projects carry out the following activities: (1) recruit and select candidates for advanced research training; (2) provide a training program that includes didactic and classroom instruction, is multidisciplinary, emphasizes scientific methodology, and may involve collaboration among institutions; (3) offer research and laboratory experience, or its equivalent, in a community-based setting, and a practicum that involves clinical research and activities with organizations representing individuals with disabilities; (4) plan for academic mentorship and opportunities for scientific collaboration with researchers; and (5) provide opportunities for participation in the development of professional presentations and publications and for attendance at professional meetings. Advanced Rehabilitation Research Training Awards applicants describe their program goals, objectives, and expected outcomes for the proposed capacity building activities and for the expected public benefits, especially benefits for individuals with disabilities. Applicants are encouraged to include information describing how they will measure outcomes, including the indicators that will represent the end result.

Applicants are given considerable latitude in developing a management and evaluation plan, but they are expected to provide specific details about their expected outcomes. To comply with Government Performance and Results Act of 1993 requirements, NIDRR has adopted logic models as an approach to program evaluation. These models describe the relationships among inputs and resources, project activities, outputs and services, and utilities. Figure 3 illustrates a generic logic model. In the context of capacity development, inputs and resources would include the faculty and trainees; activities would include the training program requirements; outputs would include publications, presentations, and trainees who have completed a program; and utilities would include benefits to society from increased knowledge and services derived from rehabilitation training. This application of logic models is discussed below in “Measuring Effect on Education, Clinical Practice, and Policy.”

RRTCs further the statutory requirement to train service providers in the application of research findings to real-world needs of persons with disabilities. Training can occur at many levels, including preservice, graduate, and in-service. The unifying theme of training across RRTCs is to transfer research findings into practical use. Thus, training must be sensitive to changes in service delivery settings, including a reduced reliance on inpatient care and greater use of postacute and community settings. The target audience, curriculum, duration, and nature of the training are left to the discretion of RRTC project directors, though detailed evaluation plans are required.

Although the NIDRR has a long history of funding RRTCs at universities, medical rehabilitation facilities, and vocational and social service agencies, training has been given increased importance in the mission of the Rehabilitation Engineering Research Centers. Enhancing the capacity to conduct disability and rehabilitation research requires planning and coordination of three key components of research training: mentors and trainers, relevant topics, and appropriate sites. Rehabilitation Engineering Research Centers are designed to have a critical mass of expertise and knowledge to provide: (1) advanced, experiential training for researchers; (2) classroom training for researchers and clinicians, at undergraduate and graduate levels; (3) short-term training for scientists learning about new methodologies; (4) in-
service training for rehabilitation practitioners; (5) training for consumers and families in implications and applications of research-derived knowledge; (6) community-based training in disability studies and related areas; (7) education and training in disability professions and in disability research for individuals with disabilities and for minority individuals; and (8) training of rehabilitation educators and educators in a range of related disciplines. As with RRTCs, project directors have considerable discretion as to the target audience, curriculum, duration, and nature of research training.

Mary Switzer Fellowships augment scholarly knowledge in the field and function in an integrative capacity to define new frontiers of disability and rehabilitation research. Fellows may conduct original research in any area authorized by section 204 of the Rehabilitation Act of 1973, as amended. Fellows must address problems encountered by individuals in their daily lives that are due to the presence of a disabling condition, problems associated with the provision of rehabilitation services to individuals with disabilities, and problems connected with the conduct of disability research. The program provides two categories of full-time fellowships: merit fellowships and distinguished fellowships. Distinguished fellowships are awarded to individuals who have ≥7 yrs of research experience and a doctoral degree, other terminal degree, or comparable academic qualifications. Merit fellowships are awarded to individuals who have either advanced professional training or independent study experience in an area that is directly pertinent to disability and rehabilitation.

Department of Veterans Affairs

Two Department of Veterans Affairs (VA) programs offer rehabilitation-related, research career development training: the Rehabilitation Research and Development Service and Health Services Research and Development Service. Research development opportunities for clinicians are provided through several funding mechanisms. Research Career Development awards are designed for early career clinicians who seek mentoring and research support for up to 3 yrs of concentrated research activity. Advanced Research Career Development awards are designed for clinician-investigators with ≥3 yrs of postdoctoral research experience who need additional mentoring to become fully independent. Advanced Research Career Development awards provide an additional 3 yrs of research support for a focused research activity. Applicants are expected to have a major role in a merit-reviewed research project funded by the VA or another national agency.

Career Development Enhancement awards support established clinician scientists by providing a full-time research sabbatical of up to 1 yr to learn new research skills. Eligible individuals must have been an independent investigator within the VA for ≥6 yrs. Early-Career Scientists Merit Review Entry Program awards provide entry-level doctoral nonclinicians with an opportunity for a period of concentrated mentoring and research activities. The awards provide 3 yrs of support to prepare awardees to enter the VA’s Health Services Research and Development Service Merit Review Program.

Research Career Scientist awards are designed for established nonclinician investigators with a minimum of 6 yrs of independent research support from the VA or other sources who have current VA project support. Research Career Scientist recipients may apply for a Senior Research Career Scientist award. These senior-level awards recognize VA researchers who are international leaders in their fields. Awards are for 7 yrs and are renewable indefinitely.

SELECTION CRITERIA FOR RESEARCH TRAINING PROGRAMS

NIH and Agency for Healthcare Research and Quality

The review criteria for NIH and Agency for Healthcare Research and Quality individual postdoctoral fellowships focus on four main components: (1) the candidate, including previous academic and research performance and the potential to become an important contributor to biomedical, behavioral, or clinical science; (2) the sponsor and training environment; (3) a research proposal, including the scientific merit of the proposal and its relationship to the candidate’s career plans; and (4) the training potential, considering the candidate’s needs in preparation for a career as an independent researcher.

Despite the specificity of considerations, the criteria allow considerable interpretation, and reviewers draw on their own experiences as trainees or educators in weighing and evaluating these criteria. For example, in assessing candidates’ potential to become an important contributor to biomedical or behavioral science, reviewers are asked to consider the extent and level of previous education, including any undergraduate or graduate degree(s), the field, the date received or expected, academic performance, the mentor, and the institution; dissertation topics; previous postdoctoral research or clinical experience, including the mentor, institution, topic, and dates; evidence of commitment to a career in research; awards and honors, other relevant research experience, professional training, and publications; and reference letters, considering both the numerical rankings and the text of the
productive scientific career can include a record of
ments, and similar accomplishments. Evidence of a
lowships, career awards, further training appoint-
of further career development includes receipt of fel-
lishing productive scientific careers. Evidence of
seeking further career development and in estab-
panels, including the success of former trainees in
minority recruitment and retention plans.
search training or other research activities; and (7)
search training program in retaining health-pro-
the success of former trainees in
searchers; (4) quality of the institutional training
program; (3) caliber of preceptors as re-
the program and the designated preceptors; (2)
objectives, design, and direction of the research
training program; (3) caliber of preceptors as re-
searchers; (4) quality of the institutional training
environment; (5) quality of the applicant pool and
the selection of individuals; (6) record of the re-
training program; (7) quality and level of formal education, pre-
ment.
Criteria of sponsor qualifications are to con-
sider research expertise and experience as a men-
tor, the degree to which the level of funding for the
proposed project, the environment of the host lab-
oratory, the proposed training program, and the
extent to which the institution will be conducive to
successful postdoctoral training. Within two to
three short paragraphs, reviewers’ critiques of can-
didates’ research proposals are to evaluate the
merit of the research proposal and the general
design, considering the candidate’s research back-
ground and the respective contributions of the
candidate and the sponsor in the development of
the research proposal. The proposal must have
scientific merit, but unlike a research grant pro-
posal, it is evaluated in the light of the candidate’s
previous training and career development. While
avoiding a detailed critique of technical aspects of
the research, reviewers are to check for flaws so
severe that they cast doubt on the candidate’s or
the sponsor’s scientific judgment and qualifica-
tions.
Consideration of candidates’ training potential
is to note their qualifications and previous research
experience and to evaluate the proposed training
experience as it relates to preparation for an inde-
pendent research career. Candidates may choose to
remain in a scientific area related to their previous
work or shift to an entirely new area of research,
but the proposed experience should augment the
candidate’s conceptual and experimental skills. The
overall training potential is to be evaluated in light
of the requested period of fellowship support. Re-
viewers’ experience and care with proposal review
and their discussions among review panel mem-
ers influence candidate appraisals.
Institutional NRSA applications are evaluated
in terms of (1) the past research training record of
the program and the designated preceptors; (2)
objectives, design, and direction of the research
training program; (3) caliber of preceptors as re-
searchers; (4) quality of the institutional training
environment; (5) quality of the applicant pool and
the selection of individuals; (6) record of the re-
search training program in retaining health-pro-
fessional postdoctoral trainees for ≥2 yrs in re-
search training or other research activities; and (7)
minority recruitment and retention plans.
A variety of criteria are considered by review
panels, including the success of former trainees in
seeking further career development and in estab-
lishing productive scientific careers. Evidence of
further career development includes receipt of fel-
lowships, career awards, further training appoint-
ments, and similar accomplishments. Evidence of a
productive scientific career can include a record of
successful competition for research grants, receipt
of special honors or awards, a record of publica-
tions, receipt of patents, promotion to scientific
positions, and any other measure of success con-
sistent with the nature and duration of the training
received. Quality of the institutional training envi-
ronment requires consideration of the level of insti-
tutional commitment, quality of the facilities,
availability of appropriate courses, and the avail-
ability of research and research training support.
Reviewer experience is critical in evaluating the
quality of the training environment.
Assessment of the quality of the applicant pool
and the selection of individuals for appointment to
the training program includes a consideration of
the racial and ethnic diversity of the trainee pool
and takes into account the described recruitment
and retention efforts and the availability of individ-
uals from underrepresented groups within the rel-
vant pool of applicants. Competing continuation
and noncompeting applications are to include a
detailed account of experiences in recruiting indi-
viduals from underrepresented groups during the
previous funding period. Information must be on
the extent of success in implementing recruitment
strategies. The report is to provide information on
the racial/ethnic distribution of (1) students or
postdoctorates who applied for admission or posi-
tions, (2) students or postdoctorates who were of-
fered admission to or a position, (3) students actu-
ally enrolled in the academic program, and (4)
students or postdoctorates who were appointed to
the research training grant. For trainees who were
enrolled in the academic program, the report is to
include information about the duration of research
training and whether those trainees finished their
training in good standing.

NIDRR

The NIDRR assesses the quality of its funded
projects through a review of grantee performance.
The list of explicit review criteria is shorter for the
NIDRR than for NIH training grants. The NIDRR
examines its Advanced Rehabilitation Research
Training Awards grantees’ applications to deter-
mine the percentage of NIDRR fellows and post-
doctoral trainees who authored or coauthored pub-
lications in refereed journals based on informa-
tion and data that were derived from NIDRR funding.
NIDRR uses information submitted by grantees as
part of their Annual Performance Reports. NIDRR
also determines, using information submitted as
part of the Annual Performance Report, the num-
ber of publications in refereed journals that are
based on NIDRR-funded research and development
activities.
Switzer Fellowship selection criteria empha-
size (1) quality and level of formal education, pre-
vious work experience, and recommendations of present or former supervisors or colleagues that include an indication of the applicant’s ability to work creatively in scientific research and (2) the quality of the research proposal. Research proposal criteria include the importance of the problem to be investigated considering the purpose of the Rehabilitation Act and the mission of NIDRR, scientific methodology, and availability of necessary data resources, equipment, or institutional support.

Department of Veterans Affairs

Research Career Development and Advanced Research Career Development applications are evaluated on eight criteria: (1) quality and appropriateness of the plan to advance the applicant’s success as an independent investigator; (2) applicant’s training and accomplishments, including the quality of completed research; (3) qualifications and commitment of the proposed mentors; (4) compatibility of the applicant’s background with research and career plans; (5) appropriateness of the sponsoring medical center for the applicant’s proposed research and development; (6) anticipated effect of the potential award on the applicant’s VA research career; (7) quality of the proposed research, including appropriateness of the conceptual framework; and (8) relevance of the applicant’s research interests to the needs of VA. For Advanced Research Career Development applicants, the applicant’s record of local and national service to the VA is also considered.

EVALUATING RESEARCH CAPACITY BUILDING ACTIVITIES

Information on the career outcomes of predoctoral NRSA recipients was described in a report titled “The Early Career Progress of NRSA Predoctoral Trainees and Fellows.”12 To assess the extent to which the program achieved its capacity building goals, the NIH’s Office of Research Training, in conjunction with the Committee on Research Training Assessment, compiled and analyzed information on trainees who received ≥9 mos of NRSA predoctoral support and who completed their doctorate between 1981 and 1992. Characteristics of these individuals’ training were examined and measures of their accomplishments in several areas were summarized. These included: (1) educational attainment, (2) postdoctoral training, (3) research-related employment, (4) success in applying for NIH and National Science Foundation research support, and (5) research productivity as defined by publication and citation rates.

The benefits of NRSA predoctoral training are impressive. NRSA predoctoral trainees and fellows completed their doctoral training in slightly less time, were more likely to pursue postdoctoral training, more likely to hold a tenure-line faculty appointment 7–8 yrs after their degree, more likely to be employed at institutions ranked in the top quartile of those with doctoral programs in the biomedical sciences, and were more likely to be in research career positions as compared with peers from the same departments and from departments without NRSA training grant awards. Trainees were also more likely to have applied for and received one or more research grants from the NIH or the National Science Foundation. Both the numbers of publications and citations to those publications were higher for NRSA predoctoral training recipients. The criteria used in this report are clear and provide relevant process and outcome indicators of research training.

NIDRR defines performance measures that are used to evaluate the overall success of its research program, and it relies on information submitted by grantees for Annual Performance Reviews. Two measures are listed: (1) the percentage of NIDRR fellows and postdoctoral trainees who authored or coauthored publications in refereed journals based on information and data from NIDRR funding and (2) the number of publications in refereed journals. No report summarizes the overall success of NIDRR’s research capacity building activities, although the information should be available from grantees who are derived from their Annual Performance Reports.

One of the most accessible sources of information about research productivity is PubMed Central, the United States National Library of Medicine’s digital archive of the life sciences literature.13 Author searches can quickly identify the number and type of publications contained in the life sciences literature. Information about citations of journal articles, books, and other documents can be accessed through the ISI Web of Science for three citation indexes: Science Citation Index, Social Sciences Citation Index and Arts and Humanities Citation Index. Web of Science indexes journals in science, medicine, technology, engineering, social sciences, management, law, humanities, and arts. It is especially useful for interdisciplinary research because of its comprehensive coverage of the scholarly literature—more than 10,000 journals from around the world are indexed. Abstracts are provided for current articles, and the database is updated weekly.

The most popular kind of searching in Web of Science is by cited reference. This kind of search examines the footnotes of articles to find those that have cited a known book, article, or patent. One can also search for related records—articles that share one or more citations, and are therefore
presumed to be related in their subject matter. The presumed impact of an article or chapter can be estimated by knowing the frequency with which it is cited. University administrators and faculty use citation counts to inform hiring, promotion, and tenure decisions. Citation information can also be used to evaluate success in capacity building efforts.

In summary, several measures seem to be likely candidates to demonstrate changes in research capacity. They include likelihood of students or fellows completing a degree or training, time to complete training, likelihood of pursuing postdoctoral training, likelihood of holding a tenure-line faculty appointment; employment at top-ranked institutions; holding a research career position; and application for and receiving research grants from a federal agency such as the NIH, NIDRR, Centers for Disease Control and Prevention, or the National Science Foundation. Information about the number of publications of trainees and citations of those publications and trainees’ subsequent research grant support provides important information about the success of capacity building efforts.

**MEASURING EFFECT ON EDUCATION, CLINICAL PRACTICE, AND POLICY**

The Department of Education, including NIDRR, has implemented a new mechanism to guide evaluation of project activities. Logic models are promoted as a planning tool and a mechanism to help NIDRR meet its performance accountability requirements. Logic models link outcomes with project activities, resources, and target systems, thus producing an integrated picture of how project activities are organized to achieve specific results. Outcomes are described in terms of short-term, mid-term, and long-term intervals. They help NIDRR and grantees manage a project to achieve specific results. Their primary focus is on planning the outputs and outcomes that will be achieved as a result of capacity building activities rather than on the number of activities completed. This approach requires that one express goals and objectives as outputs and anticipated outcomes and implement management and data systems to track performance.

Inputs and infrastructure refer to the human and financial resources and systems needed to conduct a high-quality program. Examples include agency priorities and requirements, host institutional support, staff expertise, management practices and evaluation plans, collaborations, and previous accomplishments. Program activities are the actions, tasks, procedures, and services performed in conjunction with implementing a planned program of capacity building. Outputs are the direct results of program activities and can consist of publications and grant applications. They can be expressed in quantitative or qualitative terms, such as the number of manuscripts published or students trained. They are directly observable and serve as indicators of productivity. Utility has been added to the NIDRR logic model because it is central to its mission and because demonstrating the usefulness of outputs constitutes a critical link between outputs and short-term outcomes. Outcomes are the anticipated or actual effects of capacity building activities and outputs. They constitute changes or improvements in the target system.

Specifying the components of a logic model for a capacity building project can help clarify the anticipated effects of training and help clarify the ways in which resources should be allocated. The extent to which outputs and outcomes can be discerned from publicly available sources was determined by searching for the term “rehabilitation” in NIH’s Computer Retrieval of Information on Scientific Projects (CRISP) system. CRISP allows one to locate all past and present grant awards and to identify T32, F, and K series training grants. A review of the 45 active T32 awards identified in November 2004 permits one to review abstracts and the varying levels of detail about the purpose, activities, and anticipated effects that were listed by applicants. Although the subject area was always identifiable, the number of trainees and the anticipated benefits of training were described inconsistently. Similarly, the National Rehabilitation Information Center maintains a list of Advanced Rehabilitation Research Training projects. The 15 records found in the same month provide varied details about training objectives, activities, and outputs and provide few outcome details.

Asking grantees to report components of a logic model in a consistent manner would help summarize the nature and foci of capacity building programs and the number of applicants, offers made and accepted, and trainees who completed the program. Information about trainees’ productivity—time to completion, presentations, publications, grant applications and awards, citations and recognition—would help evaluate these programs. Subsequent employment information regarding job titles and employers would help determine the longer-term outcomes of these programs.

**MEASURING RETENTION**

Information about training program retention is valuable because it reflects the success of programs in organizing and delivering high-quality research training. Program selectiveness is also reflected, as is the capacity of a program to match trainees with mentors. It reflects the quality of the
leadership, mentors, course work, and management. Success in retaining students from minority backgrounds and students with disabilities reflects the cultural sensitivity of the program and its host institution and demonstrates the capacity to provide architectural and programmatic accommodations.

Information about research career retention is valuable because it reflects the extent to which trainees achieve a transition from a student role to faculty or other professional status. Although career evolution or redirection is inevitable and perhaps desirable over the course of a lifetime, a rehabilitation research training program that loses many of its graduates to clinical or other career paths reflects poorly on the quality of training. A number of external factors can affect career retention, including illness and disability, marriage and child birth, and availability of research funds. Follow-up with former trainees would be needed to distinguish the reasons for career changes.

MEASUREMENT REQUIREMENTS

Measuring capacity development in rehabilitation research would be enhanced by the development and maintenance of a publicly accessible database that contains the kind of information tracked by Pion in her study of NRSA trainees. Despite the privacy concerns resulting from the development of a database by the Department of Education’s National Center for Education Statistics, such an information source is necessary to track trainee’s progress across institutions. Such a database would contain information about training program inputs and infrastructure, program activities, outputs, short-term outcomes, and intermediate-term outcomes. Protection for student privacy must be ensured in any such database.

Periodic aggregation of longer-term outcomes such as was prepared by Pion in her 2001 report on NIH’s predoctoral NRSA program would also be valuable. The criteria used by the NIH included completion of training, completion of subsequent postdoctoral training, eventual research-related employment, success in applying for research support, and research productivity as defined by publications and citation rates. Mentoring of the next generation of research trainees might well be added to this list. Table 1 summarizes the general elements, components, and potential metrics of rehabilitation research capacity.

CONCLUSIONS AND RECOMMENDATIONS

This brief review by necessity overlooks the research training support provided by the Centers for Disease Control and Prevention, the Rehabilitation Services Administration, the National Science Foundation, other federal agencies, and various private organizations such as the Robert Wood Johnson Foundation and Whitaker Foundation. It also focuses on training aspects of rehabilitation research capacity and does not explore the evolving kinds of faculty promotion and tenure criteria that are used by medical schools, public health programs, schools of engineering, and schools with rehabilitation science programs, among others. Promising approaches include consideration of the criteria used by the NIH in reviewing its NRSA program and adopting logic models for program evaluation as described by NIDRR. Congressional requirements that promote greater agency accountability have spawned new methods of program evaluation, including logic models. These models encourage funders and grantees to specify the expected outputs and outcomes of their train-

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ing initiatives and help develop consistent ways of measuring research capacity building. A database of trainee information, aggregated by program and with sufficient safeguards to ensure individuals’ privacy, would help document the need for and preparation of the next generation of rehabilitation researchers.

REFERENCES
Response to “Metrics of Rehabilitation Research Capacity”
Within and Beyond Our Borders

ABSTRACT


This commentary responds to Dr. Allen Heinemann’s paper on “Metrics of Rehabilitation Research Capacity.” We follow his outline. Because Dr. Heinemann focuses primarily on training capacity, we take a panoramic view addressing the balance between training new researchers and the support of established investigators. We explore challenges, barriers, and solutions to enhancing research capacity in rehabilitation within contexts of the larger scientific enterprise. Our main premise is that the best way to build a strong and sustainable research capacity in the United States is to study and adopt component strategies developed by other medical disciplines and other nations. We propose a model referred to as the “dynamic cycle of research capacity-building” by adapting a framework for studying the eradication of infectious diseases in developing countries to concepts of disability recovery. The concept of career mapping is proposed as a means to measure research productivity among faculty according to “standardized” academic tracks with different balance among research, educational, and clinical activities. The first and most important step in building rehabilitation capacity is developing an understanding of and belief in the mission and the need for research to support it.

Key Words: Research Summit, Metrics, Capacity

We are pleased to note the broad definition of research capacity endorsed by Dr. Heinemann. Elements include: 1) definition of a researchable problem, 2) performance of research tasks, 3) participation in international research, 4) adaptation of findings, and 5) the training of tomorrow’s scientists.1 Consistent with this definition, we visualize research capacity as a multifactor, multilevel, content-driven phenomenon. People, networks, tangible technologies, and policies represent factors within the infrastructure that generate research capacity.

THE PROPOSED DYNAMIC CYCLE OF RESEARCH CAPACITY-BUILDING

Numerous models of research capacity-building exist within and beyond the rehabilitation disciplines emphasizing different aspects of research capacity. Dr.
Heinemann presents the “basic logic model” as a means to measure the inputs and outcomes of research. Participants at a workshop on assessing organizational capacity for research in Alberta, Canada, developed several models that emphasize associations among tangible resources, training, and culture. The Special Programme for Research in Tropical Diseases (TDR) (www.who.int/tdr/index.html) conceptualizes capacity-building as a “strategic emphasis matrix,” including the components of new basic knowledge, new and improved tools of measurement, new and improved interventions, and new and improved strategies and policies. Drawing on concepts from these models, the proposed “dynamic cycle of research capacity-building” (Fig. 1) views research processes as emergent, translational, and ever-fluctuating continuous systems of input and output. In this model, rehabilitation research is seen as part of and contributing to the larger scientific enterprise. The entire scientific enterprise (of which rehabilitation is a part) is drawn on to address big questions of huge importance.

The dynamic cycle maps the four components of the TDR “Strategic Emphasis Matrix” into a continuously moving cycle. The cycle begins with new basic science knowledge that often comes from outside the rehabilitation field. “New basic knowledge” generates “improved tools of measurement.” Improved tools of measurement facilitate the development of “improved technologies and interventions.” Improved technologies and interventions demand “new improved strategies and policies.” We add “technologies” to the TDR concept of “interventions,” emphasizing the importance of assistive technologies and environmental facilitators to the care of people with disabilities. The dynamic cycle is driven by stakeholders representing the science makers (at the center of the diagram) and the science users and other influencers (surrounding the cycle).

Stakeholders at each level will evaluate the significance of research outputs and outcomes differently (section 7). The cycle provides a framework for capacity-building and metric development. The assessment of capacity will optimally occur at each level of the cycle within the context of the infrastructure and cultural demands (section 1). Trainees must be groomed to answer the most significant questions as determined through advocacy and policy initiatives (section 2). Mechanisms must be established so that the most salient improvements in technologies and interventions are disseminated through education, clinical practice, and policy initiatives (section 5). The culture within each of the rehabilitation professions must shift such that the immediacy and importance of research is recognized by all practices (section 7).

SECTION 1: ASSESSING CURRENT CAPACITY AND MEASURING CAPACITY GROWTH

Dr. Heinemann notes that there is no single source documenting rehabilitation research capacity in basic science, clinical research, health services research, or engineering and technology development. He suggests that a simple approach might be to survey medical school departments of physical medicine and rehabilitation as well as allied health programs. He notes that a federal agency such as the Department of Education’s National Center for Education Statistics might take on the responsibility of monitoring educational attainment and tracking research productivity. He further notes that there is no single source documenting rehabilitation research capacity that can be applied in developing topical research priorities at the national level across programs and disciplines.

Comments

We agree that such surveys are essential to further development of the rehabilitation sciences. Applying frequent surveys with similar methodology over time could help document trends and growth in research capacity. The need for developing capacity in specific areas would be addressed by analyzing survey data for the match or mismatch between current capacity and the demands for future knowledge. This could guide trainees and faculty in appropriate directions of investigation.

Dr. Martin Grabois and colleagues established and published a survey on research capacity among physiatrists in the 1980s. Of the 550 survey re-
turns, 58% of physiatrists reported devoting no time to research and only 2% spent more than 25% time on it.5 These figures could serve as baseline for addressing current and future capacity. The survey being fielded currently by the American Academy of Physical Medicine and Rehabilitation (AAPM&R) has certain questions that are similar enough in structure to the Grabois questions to enable longitudinal comparisons. We advocate for expansion of these approaches across all of the professions with a stake in rehabilitation research capacity. We also believe that surveys designed to measure research capacity need to go beyond science makers to include the science users.

Before fielding the next set of surveys on research capacity, we suggest the need: 1) to identify the strategic questions about capacity that need to be answered; 2) to seek operational definitions of the components of research capacity relevant to the strategic questions; 3) to design metrics to answer the strategic questions; and 4) to establish a clear definition of the academic rehabilitation clinician. Perhaps one of the major research funding entities could issue a call for proposals to define variables and develop a research capacity-monitoring system that is interagency and interdisciplinary in scope. A similar call for proposals was issued in Wales in efforts to build strategic research capacity in areas of importance to the economy, culture, and society in the United Kingdom.6

The development and implementation of broad strategic questions and surveys should occur through a coalition of professional societies with input from multiple types of rehabilitation professionals and consumer stakeholders.

SECTION 2: REHABILITATION RESEARCH TRAINING FUNDING MECHANISMS

Dr. Heinemann next describes the National Center for Medical Rehabilitation Research (NCMRR) within the National Institute of Health (NIH), the National Institute on Disability and Rehabilitation Research (NIDRR) within the U.S. Department of Education, the Department of Veteran Affairs, and the Agency for Health Care and Quality. He details NIDRR’s long-range plan. We supplement this information by discussing additional funding sources. We contrast the NCMRR and NIDRR strategic plans. We end with some observations.

The Centers for Disease Control and Prevention (CDC) includes a disability and health team with a budget for intramural and extramural research.7 The disability and health team focuses on disability across the lifespan by: assessing health status and secondary conditions; developing and testing health interventions; and developing training programs for health professionals in disability and public health (see http://www.cdc.gov/ncbddd/dh/contact.htm).

The Veterans Health Administration Rehabilitation Research and Development (Rehab R&D) program8 supports topical centers of excellence. Example centers include the Center for Aging Veterans with Vision Loss, Center for Medical Consequences of Spinal Cord Injury, and the Center for Functional Electrical Stimulation among others. In addition to the centers, which attract broad interdisciplinary groups of scientists at all career stages, the VA also includes career development awards similar in structure to the NIH (see http://www1.va.gov/resdev/programs/rrd.cfm).

Private foundation funding is underused by rehabilitation scientists. For example, the Robert Wood Johnson Foundation funds various scholars’ programs and interdisciplinary clinical research fellowships. Because it tends not to include high overhead rates, foundation support can be seen as less attractive to university administrators who depend on larger federal overheads to support operations.

Dr. Heinemann notes that NIDRR’s long-range plan emphasizes a new paradigm in which disability is seen as an interaction between the person and the physical, social, and political environments consistent with the International Classification of Functioning Health and Disability (ICF).9 The movement of disability research beyond the hospital into real-life communities is an essential step if rehabilitation is to meaningfully impact on people’s lives. Research methods such as participatory action research, narrative qualitative methods, and experience sampling methods10–12 that image the idiosyncratic traits of individual experience will be essential in understanding the nature of disability. These methodologies have the potential to answer questions of a high value to individuals. Yet, these methods are not always accepted in biomedical circles. Payment for services is increasingly limited to evidence-based practices supported by clinical trials of sufficient methodological rigor to link interventions to outcomes causally.

Although there is some overlap, when compared with NIDRR, the NIH tradition promulgates basic science and biomedical approaches focusing on clearly measurable constructs and analytic methodologies designed to test explicit hypotheses. Although such methodologies have their merits when answering clearly defined questions with known levels of precision, they do not ensure that the questions being addressed have intrinsic value. An important aspect of NIH peer review is the evaluation of whether the question posed is important to answer (i.e., its “significance”). “Intrinsic value” is another matter. The evaluation of intrin-
Criteria, and priorities of the two organizations NIDRR and NIH funding. The philosophies, review
process might seem to have little to do with
the measurement of research capacity, the types of
fellowships awarded today determine the work
force that will be available for tomorrow's research.
Thus, it will be essential to develop a means to
ensure that selection criteria and the structure of
fellowship opportunities will attract the most ca-
pable young scientists into rehabilitation research.
Only a handful of investigators have realized both
NIH and NIDRR funding. The philosophies, review
criteria, and priorities of the two organizations
differ. A project successfully targeted to one agency
will not necessarily prove successful in application
for funding to the other. Differences in applicant
and mentor selection criteria highlight the impor-
tance of selecting funding mechanisms carefully
relative to applicant qualifications and career ob-
jectives. The types of funding received early in
one's career will shape future endeavors, because
most agencies look for a track of previous funding.
Therefore, it is important to select mentors who
have received awards through the particular agen-
cies of interests.
As research funding becomes more difficult to
obtain, clinician scientists will need to become
proficient in writing proposals for various types of
organizations. Private foundations and industry
will need to become part of the successful support
portfolio and thus research-training curricula.
Topics such as how to word research contracts to
ensure academic freedom and ways to reduce bias
when working with industry will become essential
as research becomes increasingly reliant on private
sector funding.
The mentoring of junior faculty clearly helps
increase research productivity among rehabilita-
tion professionals and in academic medicine in
general.13–15 Yet, there are relatively few indepen-
dent investigators who have sufficient track
records to serve as mentors for young rehabilita-
tion researchers with career development awards.
Clinical researcher trainees may need to select re-
search mentors from rehabilitation fields related to
but outside their own discipline to serve as primary
research mentors and senior clinicians from their
own disciplines to serve as secondary mentors.
With these issues in mind, metrics might be devel-
oped to track the number, type, and scientific in-
terests of rehabilitation clinicians completing re-
search fellowship training and with sufficient
qualifications to serve as formal mentors for the
various types of awards. In addition, it might be
important to track the type of funding support
listed in research articles in key journals such as
the Archive of Physical Medicine and Rehabslita-
tion. Categories might include NIH, NIDRR, pri-
ivate foundation, and industry.
SECTION 3: SELECTION CRITERIA FOR RESEARCH TRAINING PROGRAMS
Dr. Heinemann discusses selection and review
criteria for individual NIH and NIDRR postdoctoral
fellowships. Although on the surface, such selec-
tion criteria might seem to have little to do with
Pathophysiology at the most fundamental level is
defined as “interference with normal physiologic
and developmental structures.” “Societal limita-
tion,” at the most complex level, is defined as
“restrictions attributable to social policy or barriers
(structural or attitudinal) which limit fulfillment of
roles or deny access to services and opportunities
associated with full participation in society.” “Dis-
ability,” an intermediate domain, is defined as “lim-
itation in performing tasks, activities and roles at
levels expected within physical and social con-
texts.” The breadth of this model could bridge the
social and medical models of disability, both of
which are necessary to fully enhance the qual-
ity-of-life experience (see http://www.nichd.nih.
gov and http://moon.ouhsc.edu/dthompson/ICIDH/
ncmrr.htm).
Challenges and Opportunities
Abrupt change in annual increases to the NIH
budget with continuing increases in the number of
applicants has resulted in declining funding pay
lines. In efforts to maintain capacity, the NCMRR
Advisory Board suggested that the Institute main-
tain support for the training of new investigators,
particularly when pay lines are reducing. Other
topics of importance noted by the Board included
maintaining balance between funding initiatives
and investigator-initiated proposals.
SECTION 4: EVALUATING RESEARCH CAPACITY-BUILDING ACTIVITIES
When evaluating research capacity-building
activities, we advocate simultaneously addressing
initiatives at the research trainee, the individual
researcher, institutional, funding agency, national
and international levels. If capacity is insufficient
at any one of these levels, the entire enterprise will
be compromised. At the individual level, research
trainees, fellows, and junior faculty are challenged
by the need to build a personal research infrastruc-

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Response to Metrics of Rehabilitation Research Capacity

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ture of skills, knowledge, interdisciplinary collaborators, resources for scholarly writing, grantsmanship, statistical analysis, and research design that will be compatible with and complementary to the broader departmental infrastructure in which they are working or hope to work in the future. The process of mapping past and projected productivity can help in career planning at any career stage. Career maps provide a way to measure research capacity at the individual faculty level. Issues with regard to personal vision, departmental vision, and the individual's personal track can be considered tailoring the measurement process to personal circumstance. Applying the map in self-assessment or in mentoring asks: Is there a logical stepwise progression in skill acquisition, in research output, and in the scientific questions being asked over time? Over time, how do achievements and the benchmarks shown match up?

Figure 2 shows an example of a (hypothetical) career plan for an aspiring postdoctoral fellow attempting to manage time and efforts in learning, publication, and grant writing. Similar to a grant activities timeline, this Gantt chart (http://www.ganttchart.com/History.html) career map begins with the 3-yr postdoctoral fellowship and projects into the first faculty year. Future objectives are projected while the grayed-in areas document past accomplishments. Using this chart, the trainee and mentor can evaluate balance in the proposed career trajectory. In this example, training is heavy early, building toward data collection, analysis, and a series of interrelated publications. The fellow’s ultimate objective is to win a career development award in preparation for securing a faculty position with sufficient protected time and intellectual freedom to emerge as an independent investigator.

Recognizing that many of the best clinical research questions grow out of practice experience, some of the most fruitful research capacity-building activities occur within clinical departments. Clinical departments can take either a “bottom-up”

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Key: C=completed; A=awarded; T=triage; P=published; S=submitted; ED= in editorial/development stage. Shaded area indicates past accomplishments. Un-shaded areas are future plans.

**FIGURE 2** Career map for individuals preparing to enter an academic research track.
or “top-down” approach. With the bottom-up approach, a committed group of clinicians works together with more senior researchers, brought in from outside their group, in building projects. In the “top-down” approach, senior researchers are recruited by department chairs to direct research in an area of interest. Bringing their own funded projects, these senior individuals serve as a nidus. If successful, they will stimulate the growth of a research program around them.

There are lessons on capacity-building from other specialties and from around the world. We describe examples of capacity-building activities through a professional society, a foreign national cooperative initiative, and through two international initiatives, one for health care in general and one for rehabilitation services. At the 1998 and 1999 national committee meetings of the American Academy of Family Physicians, practice-based research was identified as a high priority for their specialty.16 That organization established a committee of leaders who participated in an “affinity diagram process” generating themes about the meaning of research capacity-building. Themes were to:

1. Form linkages between novice and expert family medicine researchers, among those interested in researching a common topic, and with those from other medical and nonmedical disciplines;
2. Build an infrastructure with a critical mass of experienced investigators willing to support each other and mentor others, support for grant administration, grant management, and non-clinical faculty essential to research, and experienced, funded senior researchers who can serve as role models;
3. Develop training programs with clear paths for students wanting to enter research careers and multidisciplinary research fellowships for physicians with 50–80% protected time for a period after recruitment;
4. Enhance reputation of the specialty through grant funding, service on key national or state advisory committees, or study sections and presentation of research results nationally;
5. Enhance support for the enterprise through publication;
6. Stimulate change in the culture of family practitioners such that research is valued, expected, respected, and appreciated;
7. Identify the most clinically compelling questions to change practice and the delivery of health care; and
8. Achieve greater funding through the production of more proposals.

The New South Wales Research Capacity Building Program in Australia provides an example of a national cooperative initiative intended to stimulate research capacity in primary care.17 This program combines a bottom-up approach in developing research skills among primary care practitioners with a top-down approach drawing expertise from universities and the commonwealth. The project aim is to increase research skills, establish systems to manage and facilitate research, and create networks to enhance the exchange of information between researchers and practitioners. The program is intended to increase research by building on the enthusiasm and interests of the small minority of primary care physicians in academia with a strong drive to do research. It provides these individuals with intensive support through the development of sustainable skills and an adequate organizational structure, including resources. Developers of this program acknowledge that the commitment of resources must be sustained; otherwise, the program will be lost (see http://www.racgp.org.au/printdocument.asp?id=5635).

The INCLEN program is an example of an international initiative. The INCLEN program created by the Rockefeller Foundation in 1980 was designed to enhance the practice of medicine in developing countries by combining public health, epidemiology, and health economics. Through this program, the best midlevel faculty in medical schools from the developing world are brought together and trained at clinical epidemiology units. After receiving a master’s degree, they return to the academic institutions within their own countries. More than 500 faculty members have been trained and numerous clinical epidemiology units established in developing nations.18,19

The last example is an international initiative involving rehabilitation services in developing countries. Presumably, the United States builds the best rehabilitation institutions in the world. Yet, the aim of rehabilitation is to prepare people with disabilities to live outside of institutions.17,20 Viewing disability programs within larger societies, the Disability and Rehabilitation (DAR) strategic plan of the World Health Organization aims to enhance the quality of life and equity of opportunities for all persons with disabilities by focusing on policy development and the strengthening of rehabilitation services in the health sectors of member states.21 Through promotion of United Nations Standard Rules on the Equalization of Opportunities for Persons with Disabilities22 and its collaborations with other agencies and organizations, the DAR team implements programs and tests new approaches for strengthening rehabilitation services. Working within contexts of the international classifi-
cation of functioning, disability, and health (ICF) framework. DAR further establishes international exchanges of information for disseminating new ideas, successful country models, and useful strategies (see http://www.who.int/ncd/disability/program.htm).

The South Wales Project establishing infrastructure linkages between researchers and practitioners, the INCLEN program training and seeding the best and brightest clinician scientists throughout the world, and the World Health Organization emphasizing the civil rights of people with disabilities within the contexts of rehabilitation provide important lessons to the development of rehabilitation research capacity. Capacity-building activities ultimately must follow the policy initiatives of nations, which drive the priorities of funding agencies.

The INCLEN program uses a number of indicators to define resources created by its program and to suggest ways it can be most productively sustained and enhanced in the future. This approach distinguishes among several of the stakeholder levels we proposed. These measures include the number of faculty trained, the countries in which they ultimately worked, the expertise present in the research units established by the program, and the development of regional and training programs for research. Individual scientists completing the program are evaluated based on number of research publications and their weightiness as established by the number of times the author’s papers were cited. Our multilevel stakeholder model is also supported by the TDR program measurement approach.

The TDR program uses a strengths, weaknesses, opportunities, and threats (SWOT) analysis to address the impact of its capacity-building activities on the prevention, diagnosis, treatment, and control of public health problems related to infectious disease in low-income countries. “Critical success indicators” are addressed at the individual, institutional, and TDR support priority levels. Examples of specific indicators are the development of research groups around research leaders, the ability of research groups to generate resources, the production of research results of national and international significance, the development of lead centers in particular lines of research, the adherence to ethical principles, and specific research results that are directly attributable to the capacity-strengthening efforts.

Returning to the concepts of the survey development (section 1) when building research capacity in the rehabilitation sciences in the United States, it will be essential to establish indicators to track the types of fellowships and training opportunities available across the various federal and nonfederal agencies, and access to those fellowships across the rehabilitation disciplines. Such indicators might include the number of training programs available to physiatrists, occupational therapists, physical therapists, and other rehabilitation professionals with terminal degrees according to the number of graduates from such programs each year, the proportion of slots filled, the research productivity of former fellows, and the scientific topics of fellowships. It will also be important to distribute funds appropriately across programs designed to support the development of new investigators with those intended to maintain the most essential ongoing work of more seasoned researchers. Linking key indicators to national health policy initiatives, demographic shifts in population, and emerging interventions are necessary to stimulate research-capacity development in those areas of greatest societal significance. Finally, evidence of how clinical research has impacted on practice will justify ongoing capacity-building efforts. With this process in mind, rehabilitation research needs champions who can demonstrate the importance and value of our vision to the United States public.

**SECTION 5: MEASURING IMPACT ON EDUCATION, CLINICAL PRACTICE, AND POLICY**

The NIDRR basic logic model described by Dr. Heinemann provides a planning tool for funding agencies to address their performance accounting requirements by linking long- and short-term outcomes with project activities, resources, and target systems. We offer the dynamic cycle of research capacity-building in complement as a means to conceptualize the processes of research capacity-building across broader scientific problems. Our hope is that this cycle will stimulate rehabilitation educators, clinicians, and researchers to look beyond our field to view their work within the contexts of mainstream science.

**Comments**

The dynamic cycle of research capacity-building (Fig. 1) is intended to be explanatory. It views rehabilitation science as one of many disciplines contributing to global banks of knowledge. We suggest that scientific knowledge building is nonlinear. As discussed in the introduction of this article, continuous movement through the cycle is driven by the science-maker and science-user stakeholder groups. Here, for illustration purposes (see Table 1, we apply the cycles as a means to conceptualize the building of research capacity to address the emerging technologies of functional magnetic resonance imaging (MRI) and constraint-induced upper extremity training postcerebrovas-
circular accident (CVA). The content areas for each of the four main components of the cycle relative to this broad scientific initiative are outlined in Table 1. The series of sequentially coordinated capacity-building steps believed necessary to build knowledge about each content area is linked to each initiative in a similar fashion to the TDR strategic emphasis matrix.

Neuroplasticity of the brain has been the underlying assumption of much post-CVA rehabilitation. Basic scientists and engineers have provided new technologies with the functional MRI (fMRI) and optical topography capable of documenting reorganization of the brain in response to treatment. Multidisciplinary clinical interventionists draw on fMRI evidence as well as clinical observations of changes in the quality of movement among patients having sustained a stroke who were

| TABLE 1 Application of the dynamic cycle of research capacity-building to cerebral reorganization |
|----------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Emerging Scientific Content      | Improved Tools                  | Improved Technologies and Interventions | Improved Policies               |
| Discovery of normal reorganization with new areas of brain showing activation with the taking over our function of impaired areas | Functional magnetic resonance imaging | Constraint-induced training\(^{24}\) | New models of care allowing people to come in and out of rehabilitation services to take advantage of this new intervention methods |

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treated with constraint-induced therapy. Such evidence must go beyond the level of pilot studies to make changes in standards of care.

Consumers, governmental, and scientific stakeholders shape policy initiatives and funding priorities, which in turn determine the directions of new scientific endeavors. The larger culture would need to supply both direction (research priority setting) and financial support (grants) to the study of neuroplasticity. Private citizens interested in stroke recovery, combined with industries interested in related product development, might convince government officials to support this research endeavor. The actual downstream application of scientific findings at the bedside typically requires more than strong research evidence. Even definitive trials, supporting the effectiveness of constraint-induced therapy, would not necessarily be sufficient to shift the standard of care. Education, dissemination, and social advocacy typically must precede policy change. The cycle can help conceptualize metrics for addressing the specific impact of a body of research on education, clinical practice, and policy. Example measures are listed for each level in Table 1.

Data collection efforts intended to draw connections among research, education, clinical practice, and policy must be governed by specific researchable questions to provide interpretable information. This should periodically include a gap analysis between research capacity globally and cultural priorities. Priorities are set based on meaningfulness as seen through the collective lens of our culture.

The following are examples of crosscutting strategic questions intended to guide capacity development through national policy. This process typically occurs through expert panels convened by governments, advisory panels to funding agencies, or national professional societies attempting to steer future directions of the entire field. Such questions are answered conceptually after review of various sources of data such as the National Health Interview Surveys:

1. Is current research-capacity matched to the prevalence and incidence of those diseases leading primarily to disability rather than death?
2. Given projections in demographic trends, what areas of research capacity must be grown?
3. What kinds of researchers are needed to address current and emerging rehabilitation problems?
4. How have any new programs to expand research capacity changed clinical practice?

SECTION 6: MEASURING RETENTION

"Retention" occurs when institutions do the infrastructure development necessary to keep the science makers making science. What qualities make a fellow or junior faculty member productive? A study of 238 person years in family medicine faculty defined productivity as publications, presentations, and funded grants. Faculty with PhDs and those with masters in addition to MDs were more productive than faculty with MDs only. National service to journals or to grant review panels as well as fellowship training were also associated with greater productivity.

Recognizing that career evolution or redirection is inevitable and perhaps desirable over the course of a lifetime, Dr. Heinemann notes that it reflects poorly when a research training program loses many of its graduates to clinical or other career paths. The factors that attract clinician scientists to research are not the same as those that attract clinicians to patient care. If research capacity-building is to be successful, facilitators and barriers to research will need to be addressed systematically. Facilitators and barriers can theoretically be measured and are relevant to our discussions. These barriers might be quantified and applied as metrics in attempts to increase research capacity. Indeed, the AAPM&R survey is measuring some of these barriers.

An Ad Hoc MD Research Task Force of the American Congress of Rehabilitation Medicine is currently addressing barriers and facilitators to physician participation in interdisciplinary research. We recognize that the factors that stimulate capacity development, faculty promotion, and tenure in medical school departments of physical medicine and rehabilitation, public health programs, schools of allied health, schools of engineering, and rehabilitation science programs may differ from those in medical schools. Consequently, we present the following comments, about barriers for physiatrists, as part of a larger discussion in which other types of rehabilitation professionals should join.

Early task force deliberations distinguished among barriers shared by physicians across all specialties and challenges unique to physiatrists. The barriers shared by physicians across all specialties include limited time resulting from ever-present demands to increase clinical volume, the growing complexity of research administration, economic disincentives related to the uncertainty of grants support compared with relative certainty of clinical revenue, few expectations for research within clinical departments, and less immediate altruistic gratification.

Barriers specific to the physiatric specialty include the nature of rehabilitation research and disability and are shared among all professions attempting to perform rehabilitation research. These include population heterogeneity, long out-
come timeframes, the logistic challenges of following people with disabilities, and lack of a critical mass of researchers. There are few standard patients in rehabilitation, and real people make the development of standard research protocols difficult. In contrast to specialties involving invasive procedures in which investigators often need only to wait seconds or days to see results, outcome timeframes in rehabilitation must be evaluated over weeks, months, or years. The long periods required for outcomes are confounded by the major logistic challenge of following people with severe disabilities who often face many physical barriers when attempting to return to follow up. Rehabilitation research, even combined across all professional disciplines, lacks a critical mass of investigators, making the development of interdisciplinary networks all the more essential.

The ACRM Task Force’s early brainstorming about potential solutions echoed those of the American Academy of Family Physicians’ committee on building research capacity presented in section 4. Fundamental is the need to change the cultural values of rehabilitation professionals: increasing the immediacy and importance of research in the eyes of the practitioner. This can occur through the development of economic incentives and academic models that reward research productivity. Clinical practice plans within departments of physical medicine and rehabilitation often include economic incentives to enhance patient volume. Those plans include few economic or other types of incentives to stimulate research or other academic pursuits. Overwhelming emphasis on clinical productivity will reduce incentives for research unless the culture is designed to reward it. Point systems involving relative value measures for academic productivity have been developed and implemented by other specialties in academic medicine. For example, in one family medicine department, being a principal investigator on a funded grant was rated as being the most valuable (relative value equal 3.23), whereas attending a faculty meeting was rated as least valuable (relative value equal 0.36). The department also used their system to address annual production in relative value units across the domains of administration, clinical activities, teaching, and scholarly activities.27

Scientists passionate about doing clinical research hope to discover ways to contribute something meaningful to people. Practicing clinicians are already in a position to receive altruistic fulfillment by touching lives. Moreover, unlike research, where gratification is typically delayed, in clinical practice, the rewards of improving the quality of tangible lives are often immediately visible. Although there can be lack of immediate altruistic gratification, as a researcher, one is in the position potentially to influence millions of lives downstream. The passion to do research is often kindled when the investigator recognizes that advances in science and practice, and, indeed, the rehabilitation fields’ very continuation, depend on strong scientific evidence of effectiveness. Although expecting all physiatrists to be researchers is clearly unrealistic, as part of maintaining clinical excellence, at some level, all physiatrists should commit to generating and applying new knowledge to enhance the functioning and quality of life of people with disabilities.

This change in the cultural values of physical medicine and rehabilitation might most effectively begin in residency programs with mandated training in research methods, critical analysis of the literature, and exposure to interdisciplinary research. This emphasis on academic productivity would be intended to ensure that, at a minimum, physiatrists emerging from residency training would be knowledgeable consumers of research capable of making the best evidence-based choices in evolving their approach to patient management over the life of their practices.

There are a number of different practice arrangements within medical schools, different academic tracks, and various freestanding research institutes. To formulate metrics, we suggest that a classification structure is needed to categorize the academic physiatrist by discrete levels of research involvement. An academic physiatrist might be defined as one who promotes the science and art of physiatry through education, research, and/or a practice based on evidence. Academic physiatrists, residents, and fellows would be expected to contribute to the research enterprise at one of three levels. The levels define alternative academic tracks with different incentives and promotion requirements balancing the amounts of clinical, research, and educational efforts according to objectives of the tract.

Implicit in these tracks would be the recognition that only a small minority of physicians will have the desire, enthusiasm, knowledge, and motivation to spend the majority of their professional time in research. The tracks might be labeled research, clinical research, and clinician. Physiatrists in the research track would seek to be principal investigators on externally funded projects. They would tend to be the primary mentors and stimulators of the research interests among other faculty, and would provide the methodological and overall scientific direction. Faculty in the “clinician research track” would collaborate on others’ grants providing some focused area of scientific expertise, inspiration through their clinical experiences and patient populations. The clinician research track forms the backbone of the patient-oriented re-
search infrastructure. Faculty in the “clinical track” would essentially be private practitioners working in or affiliated with an academic institution. These physiatrists would be knowledgeable research consumers. They would offer a supportive role allowing their patient populations access to enrollment in research studies. They may have portions of their salaries covered in grants as part of large research networks so that they can help in recruitment and possibly in implementing interventions. Resident training and fellowships would parallel these tracks. The career map provides an effective way to measure research capacity and productivity according to the track within the faculty member’s track. We offer a second example of a career map appropriate to an individual planning to enter a clinical research track (Fig. 3). Comparison of this map to the concentrated researcher map (Fig. 2), one appreciates two distinct career trajectories for young physiatrists at the same point of time in their careers. A similar approach to career mapping can be applied by the other rehabilitation disciplines.

Interdisciplinary scientists and clinicians, through fair rules of collaboration, need to build on each other’s work if they are to bring the bench to the bedside. Another key aspect of discussion is the recognition by physicians that they cannot build and maintain a research infrastructure alone. The most successful academic departments rely on doctoral-trained researchers as respective partners in the academic enterprise. To be successful, these individuals will need to be supported if they are to become highly productive members of the medical school faculty. In parallel to the physician tracks, PhD clinician researchers might either take on leadership faculty positions serving as principle investigators or seek senior staff positions on projects led by others. Often a transition period is necessary, in which the young scientist serves as a collaborator on his or her mentor’s projects until able to emerge as an independent investigator.

This model emphasizes the development of collaborative interdisciplinary national networks, reflecting those developed by other fields such as the National Comprehensive Cancer Network established by oncology.28 These networks consistent with the NIH roadmap29 would be designed to improve the exchange of information between researchers and practitioners, and to facilitate the development of multicenter trials. Depending on the types of questions being asked, networks may need to be formed among academic departments of physiatry, private practices (for patient recruitment), or academic departments in biotechnology or in the allied health professions.

Interestingly, many of the barriers and facilitators identified by the ACRM Task Force to en-

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Key: S=satisfactory/successful, N=needs work. 1, 2, 3 etc. indicates numbers of accepted abstracts, case studies, reviews/chapters or national presentations. Shaded area indicates past accomplishments. Un-shaded areas are future plans.

FIGURE 3 Career plan for individuals preparing to enter a clinical research track.
hancing physician involvement in interdisciplinary research were echoed by clinician researchers around the globe and therefore seem to be independent of divergent politics, economies, healthcare financing plans, and other policies. The solutions to these perceived barriers may indeed lie within us. This effort is in its infancy.

SECTION 7: MEASUREMENT REQUIREMENTS

Dr. Heinemann offers some useful elements, components, and potential metrics for research capacity. We build on these elements, offering a similar set (see Table 2) organized according to the dynamic cycle of research capacity-building model. As described previously, cultural demands through advocacy from science users, policy, and funding build the human and nonhuman infrastructure. The infrastructure drives the cycle facilitating the efforts of the science makers to make science happen.

Recognizing that the types of research inputs and outputs valued depend on the level of measurement (i.e., consumer, researcher, institution, funding agency, national or international), we propose some variables for measuring stakeholder outcomes appropriate to these levels (Table 2). An individual stakeholder can be classified at many levels (i.e., the researcher can become a consumer and vice versa, individual researchers make departments, scientific review panels are composed of faculty, and so forth).

SECTION 8: CONCLUSIONS AND RECOMMENDATIONS

There are four primary messages in our response. First, we offer the dynamic cycle of research capacity-building to stimulate a broader vision of rehabilitation research as being fed by and contributing to the larger scientific enterprise. Second, the strategic questions that we want research-capacity metrics to answer must be better specified, and the vantage points of science users and makers better appreciated before survey data

<table>
<thead>
<tr>
<th>Infrastructure Parameters: People, Networks, Tangibles, and Policies</th>
<th>Consumers</th>
<th>Individual Researchers</th>
<th>Institutions</th>
<th>Schools</th>
<th>Departments</th>
<th>Programs</th>
<th>Funding</th>
<th>Agencies,</th>
<th>Foundations,</th>
<th>and Industries</th>
<th>National*</th>
<th>International†</th>
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<tr>
<td>Number of peer-reviewed publications, books and reports; times cited</td>
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<td>X</td>
<td>X</td>
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<tr>
<td>Number and dollar value of research grants received</td>
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<td>X</td>
<td>X</td>
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<td>Number and costs of new products, patents, and treatments</td>
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<tr>
<td>Number and types of grants dispersed (research and training)</td>
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<td>Number of practicing researchers (FTE)</td>
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<td>X</td>
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<td>Specific content areas of research‡</td>
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<td>Network access to advanced technologies, statistical and technical support, clinical environments</td>
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<tr>
<td>Clinical access to new products and technologies</td>
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<tr>
<td>New policies, changes in national quality of life</td>
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</tbody>
</table>

* National encompasses all consumers of research from individuals to political constituencies.
† International refers to governmental and nongovernmental organizations.
‡ For example, stroke, independent living, and so on.
FTE, full-time equivalent.
collection will be useful beyond simple description. Third, barriers to research productivity in academia need to be acknowledged and specific strategies designed to overcome them at the individual researcher, institutional, funding agency, national and international levels. Finally, we are not an island. Globally, specific medical research-capacity requirements vary depending on local environments, cultures, economies, and policies. However, all research capacity-building efforts share certain parameters: people, bricks and mortar, networks, technology, mechanisms of support, and clinical base. The TDR and other interagency collaborations that measure and build research capacity offer us models and metrics for measuring and building research capacity in rehabilitation.

We advocate a call for proposals to develop strategic questions about rehabilitation research capacity that will guide capacity development and to model multidimensional measurement of research capacity in rehabilitation informed by global efforts to build research capacity in medicine generally. All stakeholders in rehabilitation research capacity must be served in the model. All stakeholders, including people with disabilities, private citizens, researchers, institutions, corporations, funding agencies, and policymakers, are equal constituencies. Furthermore, the multiple parameters of infrastructure that envelop research capacity must be represented with similar attention to detail to develop a balanced enterprise that is responsive locally, nationally, and internationally. Finally, we call for a major change in the cultural values of all rehabilitation professionals toward recognizing research as a vital and essential to the continuation of growth and maintenance of our practices.

ACKNOWLEDGMENTS

The authors acknowledge discussions from the following members of the Ad Hoc Physician’s in Research Task Force of the ACRM, including Diana Cardenas, Bruce Gans, Martin Grabois, Helen Hoe nig, Ric Morgan, Steve Page, Elliott Roth, John Whyte, Deb Wilkerson, and Shanti Ganesh.

REFERENCES


Appendices

Appendix A

Agency for Healthcare Research and Quality

EXTRAMURAL SUPPORT FOR REHABILITATION ACTIVITIES

Patricia Reynolds
Program Analyst, Center for Financing, Access and Cost Trends

The Healthcare Research and Quality Act of Dec. 6, 1999 (PL 106-129), reauthorized the Agency for Healthcare Research and Quality (AHRQ) and changed its name (from the Agency for Health Care Policy and Research).

AHRQ sponsored research provides the scientific foundation for the nation’s efforts to improve the quality, safety, effectiveness, and efficiency of health care. In addition to an intramural research program, AHRQ supports the work of health services research through extramural contracts and grants, including research training grants. AHRQ emphasizes partnerships and cofunding opportunities to maximize the effectiveness of its resources and works collaboratively with other government agencies and outside organizations to both share and gain expertise. AHRQ findings are being translated into improvements in clinical care and in the structure and delivery of healthcare services. As part of the AHRQ agenda there is a concerted effort to track “knowledge transfer,” or the impact of research on patient outcomes.

The reauthorization established the following areas and populations as priorities for AHRQ research, evaluation, and demonstration projects: the delivery of health care in inner-city and rural areas (including frontier areas); low-income groups; minority groups; women; children; the elderly; and individuals with special healthcare needs, including individuals with disabilities and individuals who need chronic care or end-of-life health care.

The AHRQ Website, www.ahrq.gov, has extensive detail on many of the activities described below and additional rehabilitation related information. The “Grants On-Line Database” (GOLD system) can be searched for recently funded “rehabilitation” grants. The site provides abstracts for all grants listed. The Web “Funding Opportunities” section provides information on contract solicitations, research and training grant announcements, and policy notices.

AHRQ has included and continues to include “medical rehabilitation research” directly and indirectly within its broad mission and program activities.

CONTRACTS

AHRQ has a long standing interest in medical rehabilitation. For example, work sponsored by AHRQ between 1992 and 1996 resulted in the Quick Reference Guide for Clinicians on “Cardiac Rehabilitation as Secondary Prevention” that highlights the major effects of multifactorial cardiac rehabilitation services. The guide can be accessed through the Web.

In 1997 AHRQ established 12 Evidence-based Practice Centers (EPCs). In 2002 the second award of 5-yr contracts went to 13 EPCs in the United States and Canada. EPCs review all relevant scientific literature on clinical, behavioral, organizational, and financing topics to produce evidence reports and technology assessments. With the EPC program, AHRQ became a “science partner” with private and public organizations in their efforts to improve health care by synthesizing the evidence and facilitating the translation of evidence-based research findings. Topics are nominated by nonfederal partners such as professional societies, health plans, insurers, employers, and patient groups. For topic nomination procedures, go to www.ahrq.gov/clinic/epc/epctopicn.htm.

Reports cover clinical, healthcare services, and technical topics, and include the recently released “Spinal Cord Injury, Sexuality and Reproductive Health”; “Physical Activity, General Population and Cancer Patients and Survivors” (2004); “Multiple Sclerosis, Criteria to Determine Disability” (2004); “Failure to Thrive, Determining Disability in Infants and Children” and “Low Birth Weight, Determining Disability in Infants and Children” (both 2003); “Heart Failure and Left Ventricular Systolic Dysfunction, Pharmacologic Management” (2003); “Stroke Management Effectiveness” (2002); and “Chronic Renal Failure, Determinants of Disability” (2000), with an assessment of the best predictors of a dialysis patient’s functional status over 12 consecutive months.

AHRQ also gathers information from “outcomes research,” which seeks to understand the end results of particular healthcare practices and interventions. End results include effects that people experience and care about, such as change in the ability to function. In particular, for individuals with chronic conditions—where cure is not always possible—end results include quality of life as well as mortality.

The outcomes research literature review for clinicians, “Vision Rehabilitation: Care and Benefit Plan Models,” was prepared for AHRQ by The Lewin Group and explores factors related to the adoption of vision rehabilitation strategies in different service delivery and financing models. The scientific evidence on effectiveness of rehabilitation services for patients with vision impairments is examined in a broader context of rehabilitation for chronic impairment looking at evidence for effectiveness of rehabilitation in general and in specific situations (traumatic brain injury, stroke, and myocardial infarction).

The Integrated Delivery System Research Network (IDSRN): Field Partnerships to Conduct and Use Research is a model of field-based research that links the nation’s top researchers with some of the largest healthcare systems to conduct research on cutting-edge issues in health care on an accelerated timetable. As a group, the IDSRN provides health services to over 55 million Americans. The nine initial IDSRN awards were made in September 2000. A recompetition RFP for Accelerating Change and Transformation in Organizations and Networks (ACTION), successor program to the IDSRN, will be available in June 2005.

AHRQ actively seeks input on research topics. Organizations that would like to recommend topics for consideration are asked to describe the topic and its importance in a letter and send it to the designated AHRQ contact.

GRANTS

Research Grants

AHRQ uses two mechanisms to solicit grant applications, the Program Announcement (PA) and the Request for Application (RFA). The PA is a formal statement inviting applications (investigator initiated) on new or ongoing research activities, usually having standard annual application receipt dates, with no specific dollars or numbers of applications specified. In contrast, the RFA is a formal statement inviting applications (grants or cooperative agreements) on a well-defined area with specific objectives. There is usually one specific application receipt date, and dollars and numbers of applications to be funded are specified.

Funding mechanisms referenced include R01 (large research grants), R03 (small research grants), U18 (cooperative agreements), and about ten others. AHRQ uses the NIH system for application receipt and
referral, and all mechanisms are described in the NIH “Activity Code, Organization Codes, and Definitions Used in Extramural Programs” document found at http://Grants 2.nih.gov/grants/funding/ac/pdf/.

The Center for Education and Research on Therapeutics (CERTs) program is a national initiative to conduct research and provide education that advances the optimal use of therapeutics (i.e., drugs, medical devices, and biological products). The program consists of seven research centers (RCs) and a coordinating center and is administered as a cooperative agreement by AHRQ, in consultation with the United States Food and Drug Administration. The CERTs receive funds from both public and private sources, with AHRQ providing core financial support.

Researchers at the Duke University center examined trends in aspirin use, patient characteristics, and long-term outcomes for aspirin effectiveness in more than 25,000 patients with cardiovascular diseases, finding that the percentage of patients with heart disease who report taking aspirin regularly increased between 1995 and 1999. The United States Preventive Services Task Force recommends that clinicians discuss the benefits and risks of aspirin therapy with adults who are at risk for coronary heart disease.

Recent CERTs’ opportunities are indicated in the AHRQ RFA, RFA-HS-05-014, “The Centers for Education and Research on Therapeutics (CERTs),” released October 26, 2004. AHRQ’s intent is for new RCs to reflect one of the following themes: mental illness, the elderly, therapeutic devices, and consumers.

Other AHRQ grants targeted to rehabilitation issues include:

- Patterns of Rehabilitation Use Following Stroke (2001 – 2003)
- The Impact of Clinical Pathways for Rehabilitation Care (1999 – 2001)

AHRQ funded a July 2004 International Conference on Evidence-Based Occupational Therapy designed to marshal the efforts of the international community of occupational therapists to enhance dissemination of research information for evidence-based practice and to identify and address gaps in research.

AHRQ is one of the participating organizations in the PA, PAR-04-077, “Research Partnerships for Improving Functional Outcomes,” released March 18, 2004. It invites applications “to support . . . basic, applied, and translational multi-disciplinary research that addresses important biological, behavioral, medical, and/or psychosocial research problems related to rehabilitation or health maintenance of individuals with acute or chronic disease.”

**Research Training Grants**

AHRQ provides an array of predoctoral and postdoctoral educational and career development grants and opportunities in health services research including Institution Training Awards (T32 awards) and Individual-level Grants (selected R, F, and K awards). The AHRQ Website (under “Research Training”) lists the AHRQ training programs and support mechanisms, with a brief description of each, and provides lists of recently funded awards.

Key faculty on the Northwestern T32 award includes the Associate Director for Research of the Rehabilitation Institute Research Corporation (a research arm of the Rehabilitation Institute of Chicago) who mentors some fellows, and one of the foci of that training program is rehabilitation.

Three other T32 programs are located within departments of their respective universities that have disability as one of their foci: Case Western Reserve University, predoctoral program; the University of Washington; pre- and postdoctoral programs; and Wayne State University, postdoctoral program.

**Infrastructure Development Grants**

AHRQ has two institutional-level research training grant announcements specifically targeted to developing the health services research infrastructure. Grants are designed to support the planning and development of health services research in traditionally minority-serving institutions (see the PA “AHRQ Minority Research Infrastructure Support Program” (M-RISP-R24)) and in institutions in states which do not receive significant health services research funding (see the RFA “Building Research Infrastructure and Capacity (BRIC-R24) Program”).

Also, “CERTs RC funding [see RFA referenced earlier] provides infrastructure support (a research team with adequate facilities, institutional support, and access to appropriate expertise needed to perform research, education, dissemination, and translation of research into practice) such that an RC can fulfill the goals of the CERTs legislation and support the strategic needs of AHRQ, FDA, and other DHHS agencies with responsibilities for therapeutics.”

**Other Collaboration**

AHRQ collaborates with other government components and outside organizations to gain and share expertise. For example:

- It partners with the United States Department of Health and Human Services (HHS) Office on Disability through its New Freedom Initiative Workgroup to ensure that individuals with disabilities have the opportunity to learn and develop skills, engage in productive work, make choices about their daily lives, and participate in community life.

- AHRQ recognizes the need to become aware of and involved with Health Information Technology (HIT) efforts and agency leadership is working with the National HIT Coordinator. In October 2004, AHRQ awarded contracts and grants to promote the use of HIT through the development of networks for sharing clinical data. Included among the funded efforts related to rehabilitation services is the grant, Creating an Evidence Base for Vision Rehabilitation (referenced earlier under “Research Grants”).

**AHRQ Research and Funding Priorities**

Within the broad framework of its mission statement and strategic plan (available on the AHRQ Web), and finite resources, AHRQ must respond to current and emerging priorities such as bioterrorism and patient safety, and also to Congressional mandates. On Nov. 30, 2004, AHRQ issued a “Special Emphasis Notice: Research Priorities for the Agency for Healthcare Research and Quality,” providing information about the highest research priorities for unsolicited applications for fiscal year 2005. It will continue to provide regular updates of research priorities as research budget information becomes available.

The AHRQ fiscal year 2005 appropriation was $318,695 million, an increase of $15.0 million over the fiscal year 2004 appropriation of $303,695 million. Funding for the $15 million increase was authorized by Section 1013 of the Medicare Prescription Drug, Improvement, and Modernization Act of 2003, and was included in the Fiscal Year 2005 Consolidated Appropriations Act passed by Congress.

**Appendix B**

**Centers for Disease Control and Prevention**

John E. Crews, PhD  
Lead Scientist, Centers of Disease Control and Prevention

Most research supported by CDC focuses on prevention of disease, injury, or disability. CDC does, however, support a small program of research to address disability in the Disability and Health Team in the National Center on Birth Defects and Developmental Disabilities. The Disability and Health Team supports two broad areas of research. An intramural research group focuses upon health disparities among people with and without disabilities, and topical issues include aging and vision loss, aging with a disability, family caregiving, and women’s health. Research typically uses the International Classification of Functioning, Disability and Health as a conceptual framework for investigations.

In addition, Disability and Health supports a modest extramural research agenda. In the recent past, topics include assessment and measurement issues regarding the environment of people with disabilities, epidemiology of disabling conditions, health and employment, and health effects of caregiving. Current extramural research focuses upon the...
development of public health interventions to address health disparities between people with and without disabilities. In fiscal year 2005, ten research projects are supported, generally funded at about $300,000 annually for 3-yr funding cycles. New funding opportunities are expected to be announced in late 2005 or early 2006 for a new cycle of extramural research.

Moreover, others centers at CDC have begun to address disability concerns, and recent projects have been funded to investigate health and sensory impairment.

Appendix C

National Center for Medical Rehabilitation Research
National Institute of Health

Michael Weinrich, MD
Director

In 1990, Congress established the National Center for Medical Rehabilitation Research (NCMRR) at the National Institute of Child Health and Human Development, within the National Institutes of Health, to foster the development of the scientific knowledge needed to enhance the health, productivity, independence, and quality of life of persons with disabilities.

The NCMRR provides support for basic and clinical scientists to conduct research on impairments and functional changes associated with chronic physical conditions as well as rehabilitative strategies to reduce disability, improve health, and increase participation. Relevant conditions include stroke, brain or spinal cord injury, orthopedic injuries, developmental and degenerative disorders, and other chronic conditions. Investigations supported by NCMRR attempt to promote improvement at many levels: from reducing pathophysiology and physical impairment, to enhancing functional adaptation, to reducing disability and societal barriers. This requires an integration of biological, engineering, and sociobehavioral approaches to understand chronic conditions, secondary implications, and the interaction of the individual with his or her environment. Further information about NCMRR can be found at our Web-site: http://www.nichd.nih.gov/about/ncmrr/ncmrr.htm/.

Medical rehabilitation services are most effective when placed on a sound scientific footing. With increased effectiveness, more people with disabilities can return to work and to their homes, rather than remaining in long-term care facilities. The end result is both improved quality of life for service recipients, and long-term cost savings for society.

NCMRR Research Priorities and Projects

The Center’s resources and activities focus on seven research priorities. Items listed below include a description of the NCMRR priorities, as well as some of the current and past requests for applications (RFAs) and program announcements (PAs/PARs) related to each priority.

For a complete listing of current NCMRR-supported and recently funded research initiatives, please visit the NCMRR Website at http://www.nichd.nih.gov/about/ncmrr/funding.htm/.

Improving Functional Mobility

This area includes research, for example, on wheelchair use, coordination and control of arm movements, therapeutic footwear, surgical and drug interventions for spasticity, body strength, and exertion, constrained-use therapy, and improving respiratory control, to name a few. NCMRR-supported research in this area includes:

- Molecular and Cellular Basis of Contractures for Design of Therapeutic Interventions RFA (HD-02-022)
- Women’s Health in Sports and Exercise PA (HD-02-115)
- Training Materials on Surgical Amputations, Prosthetics and Orthotics (SBIR/STTR) (HD-03-019)

Promoting Behavioral Adaptation to Functional Loss

This area includes research on psychosocial adjustments, health promotion, wellness, exercise, impact on caregivers and family members, special issues for women with disabilities, and geriatric issues, among other topics. NCMRR-supported research in this area includes:

- Informal Caregiving Research for Chronic Conditions PA (HD-02-155)
- Cachexia: Research into Biobehavioral Management and Quality of Life PA (HD-01-109)

Assessing the Efficacy and Outcomes of Medical Rehabilitation Therapies and Practices

This area includes, but is not limited to, research on treatment for pain and depression, neuroimaging in stroke and traumatic brain injury, decision-making and access to care, and treatments to improve function after injury (e.g., respiratory function, motor control, and gait). NCMRR-supported research in this area includes:

- Pilot Clinical Trials in the Epidemiology, Prevention, and Treatment of Respiratory Failure in Children RFA (HD-02-027)
- Clinical Trial Planning Grants to Guide and Improve Timing, Intensity, Duration, and Outcomes of Pediatric Critical Care and Rehabilitation: Therapeutic Interventions in Childhood Cardiopulmonary Arrest RFA (HD-02-026)
- Clinical Trial Planning Grants to Guide Timing, Intensity, and Duration of Rehabilitation for Stroke and Hip Fracture RFA (HD-01-022)
- Cooperative Multicenter Traumatic Brain Injury Clinical Trials Network RFA (HD-01-007)

Developing Improved Assistive Technology

Small businesses (supported by the NCMRR, the NICHD, and the NIH as a whole) conduct a great deal of research in assistive technology, in addition to the research conducted by investigators at universities and medical centers. In general, this area includes research in wheelchair design, prosthetic hands, feet, and knees, improved fitting and monitoring of orthotics and prosthetics, design of specialized recreational equipment, and other topics. NCMRR-supported research in this area includes:

- Innovations in Powered Mobility Devices RFA (HD-03-023)
- Innovative Technologies for Pediatric Critical Care and Rehabilitation RFA (HD-03-014)
- Augmentative and Alternative Communication Strategies for Treatment of Acquired Cognitive and Linguistic Disorders RFA (HD-02-002)

Understanding Whole Body–System Responses to Physical Impairments and Functional Changes

This broad research area includes motor cortex changes associated with stroke and brain injury, spinal cord plasticity and regeneration, muscle atrophy and decreased bone density, cognitive and behavioral changes (e.g., attention, memory), and many other topics. NCMRR-supported research in this area includes:

- Biomechanical Modeling of Movement RFA (HD-03-011)
- Studies into the Causes and Mechanisms of Dystonia PA (HD-02-156)
- Genetic Basis of Recovery and Rehabilitation (HD-03-025)

Developing More Precise Methods to Measure Impairments, Disabilities, and Societal and Functional Limitations

This area includes research in brain imaging for diagnostics and prognosis, improved outcome measures of well-being, satisfaction, demo-
Training Research Scientists in the Field of Rehabilitation

This area includes support of individual fellowships for postdoctoral fellows, institutional training grants for graduate students and postdoctoral fellows, mentorship awards specifically targeted to those in rehabilitation fields, national development and training programs for physical medicine and rehabilitation departments, and other mechanisms. NCRR-supported research in this area includes:

- Medical Rehabilitation Scientist Development Program
- Pediatric Clinical Care Scientist Development Program RFA (HD-03-015)
- Jointly Sponsored NIH Predoctoral Training Program in the Neurosciences PAR (HD-02-017)

Some of the work of the NCRR falls outside of these priority categories, whereas other research conducted or supported by the NCRR cuts across multiple priority areas.

One additional major NCRR initiative is its nearly $4 million annual support of four rehabilitation research networks. These networks seek to facilitate ongoing projects and stimulate future research in medical rehabilitation, through multidisciplinary research cores, information transfer, and pilot projects. This initiative relies on major collaborations among three institutions and has the potential to connect network researchers with colleagues from other facilities within the region. Currently, the NCRR networks include facilities in the:

- West—RehabNet
- Midwest—The Midwestern Network
- South—Enhanced Rehabilitation Research in the South (ERRIS)
- Northeast—The Northeast Cognitive Rehabilitation Research Network

This network will be renewed with a new competition announced in Medical Rehabilitation Research Infrastructure (HD-04-005).

NIH Rehabilitation Coordinating Committee

NCRR is charged with coordinating rehabilitation research across the NIH through the NIH Rehabilitation Coordinating Committee. This committee held a trans-NIH and transagency meeting in July, 2003 on Physical Disabilities Across the Lifespan (summary slides of the breakout sessions are available at: http://www.nichd.nih.gov/about/ncmrr/disabilities/index.htm). In response to the recommendations of this conference the committee issues a new trans-NIH program announcement on Research Partnerships for Improving Functional Outcomes (http://grants.nih.gov/grants/guide/notice-files/PA-04-057.html). This announcement solicits innovative applications for basic, applied, and translational multidisciplinary research that addresses important biological, behavioral, medical, and/or psychosocial research problems related to rehabilitation or health maintenance of individuals with acute or chronic disease.

The NCRR also supports conferences and workshops related to its research priorities. For more information, visit http://www.nichd.nih.gov/about/ncmrr/workshops.htm/.

Funding Mechanisms

Approximately 80% of all research funded through NCRR is investigator initiated. Applications for new awards are accepted three times annually. All applications receive peer review, the vast majority through standing study sections. Indirect costs for grant awards are negotiated between institutions and the Office of Management and Budget. All applications requesting more than $500,000 in direct costs for any calendar year must receive approval from NICHD before submission.

NIH RESEARCH PROJECT GRANT PROGRAM (R01)

Introduction

The Research Project Grant (R01) is the original and historically oldest grant mechanism used by NIH. The R01 provides support for health-related research and development based on the mission of the NIH. R01s can be investigator initiated or can be in response to a program announcement or request for application. However, the R01 research plan proposed by the applicant must be related to the stated program interests of one or more of the NIH institutes and centers based on descriptions of their programs.

This link, http://grants.nih.gov/grants/award/research/avgr01fy6801.htm, provides information regarding the number of funded new and competing R01s, the dollars budgeted, and the average size of R01s for the years 1968–2001.

The NIH awards R01 grants to organizations of all types (universities, colleges, small businesses, for profit, foreign and domestic, faith-based etc.), and the R01 mechanism allows an investigator to define the scientific focus or objective of the research based on a particular area of interest and competence. Although the principal investigator writes the grant application and is responsible for conducting the research, the applicant is the research organization.

Definition of an R01

The Research Project (R01) grant is an award made to support a discrete, specified, circumscribed project to be performed by the named investigator(s) in an area representing the investigator’s specific interest and competencies, based on the mission of the NIH.

Scope

The NIH is comprised of institutes and centers that support specific areas of health-related research, and almost all institutes and centers at NIH fund R01 grants. Research grant applications are assigned to an institute or center based on receipt and referral guidelines, and many applications are assigned to multiple institutes and centers, as interdisciplinary and multidisciplinary research is encouraged. Each institute and center maintains a Website with funding opportunities and areas of interest. These should be reviewed carefully, and contact with an institute or center representative may help focus the research plan based on an understanding of the mission of the institute or center.

Allowable Costs

- Salary and fringe benefits for principal investigator, key personnel, and other essential personnel
- Equipment and supplies
- Consultant costs
- Alterations and renovations
- Publications and miscellaneous costs
- Contract services
- Consortium costs
- Facilities and administrative costs (indirect costs)
- Travel expenses

Application Characteristics

- Applicants for an R01 award are not limited in dollars but need to reflect the actual needs of the proposed project. Modular applications are most prevalent with modules of $25,000, up to the modular limit of $250,000. Applications that exceed this level must be submitted as nonmodular and provide detailed budget information.
Applications are generally awarded for one to five budget periods, each normally 12 mos in duration.

Applications can be renewed by competing for an additional project period.

Supplements and amendments are allowed.

Only two revisions of a previously reviewed R01 grant application may be submitted.

The Research Plan (Specific Aims, Background and Significance, Preliminary Studies, and Research Design and Methods) of an application for an R01 should adhere to the instructions provided in PHS 398 Grant Application kit, at http://grants.nih.gov/grants/forms.htm/.

Applicants may also find it helpful to seek advice from an experienced investigator and to contact the institute or center most likely to fund their application. NIAID provides an annotated R01 and attached summary statement on their Website http://www.niaid.nih.gov/nci/ grants/app/default.htm/.

Standard receipt dates for grant applications are February 1, June 1, and October 1. AIDS and AIDS-related grant application receipt dates are May 1, September 1, and January 2. For additional information on the receipt, review and award cycle schedules are posted on: http://grants.nih.gov/grants/funding/submissionschedule.htm/.

R01 Participating Institutes, Centers, and Offices

All institutes and most centers at NIH support the R01 grant mechanism. For specific information about the mission of each institute and center, this link, http://www.nih.gov/cdc/, provides access to individual home pages. In addition, there are NIH Offices of the Director that do not accept applications, but do provide funding for investigator-initiated R01 applications. They are the Office of Behavioral and Social Sciences Research (OBSSR), Office of Disease Prevention (ODP), Office of Rare Diseases (ORD), Office of Dietary Supplements (ODS), and Office of Research on Women’s Health (ORWH).

NIH EXPLORATORY/DEVELOPMENTAL RESEARCH GRANT AWARD (R21)

Introduction

The NIH has standardized the Exploratory/Developmental Grant (R21) application characteristics, requirements, preparation, and review procedures to accommodate investigator-initiated (unsolicited) applications. This Website describes the use of the investigator-initiated R21 and describes the NIH institutes and centers (ICs) that accept such applications.

The R21 is intended to encourage exploratory/developmental research projects by providing support for the early and conceptual stages of development. Investigators wishing to apply for an R21 grant should be aware that not all ICs accept investigator-initiated R21 applications. Investigators are strongly encouraged to consult the list of participating ICs shown below. Consultation with the NIH staff contacts is also encouraged. All investigator-initiated exploratory/developmental grant applications described in this announcement will be assigned to ICs according to standard NHLBI referral guidelines. The R21 application should include an appropriate PA number and title on line 2 of the PHS 398 application.

Applications for R21 awards should describe projects distinct from those supported through the traditional R01 mechanism. For example, long-term projects or projects designed to increase knowledge in a well-established area will not be considered for R21 awards. Applications submitted under this mechanism should be exploratory and novel. These studies should break new ground or extend previous discoveries toward new directions or applications. Projects of limited cost or scope that use widely accepted approaches and methods are better suited for the R03 small grant mechanism (see R03 announcement citation).

Please note that, according to the NIH Guide Notice, Reminder: Program Announcement Needed to Identify R03 and R21 Applications, investigators submitting R21 applications must include an appropriate PA number and title on line 2 of the PHS 398 application.

Application Characteristics

• You may request a project period of up to 2 yrs.
• The combined budget for direct costs for the 2-yr project period may not exceed $275,000. For example, you may request $100,000 in the first year and $175,000 in the second year to meet the needs of your project. Normally, no more than $200,000 may be requested in any single year.
• All budgets should be in modular format.
• Exploratory/developmental grant support is for new projects only; competing continuation applications will not be accepted.
• Two revisions of a previously reviewed exploratory/developmental grant application may be submitted as defined in NIH Policy at http://grants.nih.gov/grants/policy/amendedapps.htm/.
• Items a–d of the Research Plan (Specific Aims, Background and Significance, Preliminary Studies, and Research Design and Methods) may not exceed a total of 15 pages.
• No preliminary data are required, but may be included if available.
• A progress report is not needed; competing continuation applications for an exploratory/developmental grant will not be accepted.
• Use the instructions for the appendix detailed in the PHS 398, except that no more than five manuscripts previously accepted for publication may be included.

R21 Participating/Nonparticipating Institutes and Centers

• NIH institutes and centers that do accept investigator-initiated R21 applications include the following: NCCAM, NCRR, NEI, NIA, NIAAA, NIAID, NIAMS, NIBIB, NICHD, NIDA, NIDCD, NIDCR, NIEHS, NIMH, NINDS, and NLM.
• NIH institutes and centers that accept investigator-initiated R21 applications only in response to their initiatives specifying this mechanism include the following: FIC, NCI, NCMHD, NHGRI, NHLBI, NIDDK, NIGMS, and NINR.

NIH SMALL GRANT PROGRAM (R03)

Introduction

The NIH has standardized the Small Grant (R03) application characteristics, requirements, preparation, and review procedures to accommodate investigator-initiated (unsolicited) applications. This Website describes the use of the investigator-initiated R03 and describes the NIH institutes and centers (ICs) that accept such applications.
As in the past, the R03 award will support small research projects that can be carried out in a short period of time with limited resources. Investigators wishing to apply for an R03 grant should be aware that not all ICs accept investigator-initiated R03 applications and that the different ICs may have specific purposes for which they use this funding mechanism. Before preparing an application for an R03 grant, all investigators should consult the list of participating ICs (shown below) as well as the IC staff listed as contacts to determine whether an R03 application is appropriate. There is also a list of ICs that do not accept unsolicited R03 applications. All investigator-initiated small grant applications described in this announcement will be assigned to the ICs according to standard PHS referral guidelines and specific program interests. Applications that are assigned to an IC that does not participate in this program may be returned without review.

Some of the nonparticipating ICs may solicit R03 applications using requests for applications (RFAs) or special program announcements (PAs) to meet specific programmatic needs. In some cases those announcements may specify different application characteristics, review criteria, and receipt dates. All such announcements will be published in the NIH Guide for Grants and Contracts at http://grants.nih.gov/grants/guide/index.html. The PA for investigator-initiated R03 applications, which can be found at http://grants.nih.gov/grants/guide/pa-files/PA-03-108.html, articulates the policies and procedures that apply to this program.

Please note that, according to the NIH Guide Notice, Reminder: Program Announcement Needed to Identify R03 and R21 Applications, investigators submitting R03 applications must include an appropriate PA number and title on line 2 of the PHS 398 application.

The common characteristic of the small grant is the provision of limited funding for a short period of time. Examples of the types of projects that ICs support with the R03 include the following:

**Scope**

- Pilot or feasibility studies
- Secondary analysis of existing data
- Small, self-contained research projects
- Development of research methodology
- Development of new research technology

**Application Characteristics**

- Applicants for an R03 award may request a project period of up to 2 yrs and a budget for direct costs of up to two $25,000 modules or $50,000 per year (See Table 1).
- Small grant support is for new projects only; competing continuation applications will not be accepted.
- Small grant support may not be used for thesis or dissertation research.
- Only two revisions of a previously reviewed small grant application may be submitted.
- The Research Plan (Specific Aims, Background and Significance, Preliminary Studies, and Research Design and Methods) of an application for a small grant may not exceed a total of ten pages.
- A progress report is not needed; competing continuation applications for a small grant will be not accepted.
- The appendix may include only original, glossy photographs or color images of gels, micrographs, etc., provided that a photocopy (which may be reduced in size) is also included within the page limits of the research plan. No publications or other printed material, with the exception of preprinted questionnaires or surveys, may be included in the appendix.

**R03 Participating/Nonparticipating Institutes and Centers**

- NIH institutes and centers that do accept investigator-initiated R03 applications include the following: NEL, NIA, NIAAA, NIAID, NIBIB, NICH, NIDA, NIDCR, NIEHS, NIMH, NINDS, NINR, and NLM.
- Listing of NIH institutes and centers that do not accept investigator-initiated R03 applications includes the following: FIC, NCCAM, NCI, NCMD, NCRR, NHGRI, NIMHL, NIAMS, NIDCD, NIDDR, and NIGMS.

**K Awards:** A variety of awards are available—see: http://grants1.nih.gov/training/careerdevelopmentawards.htm.


**Appendix D**

**National Institute on Disability and Rehabilitation Research: Support of Capacity Building in Rehabilitation Research**

Ruth Brannon, MSPH, MA
Associate Director, Division of Research Sciences, National Institute on Disability and Rehabilitation Research

The National Institute of Disability and Rehabilitation Research (NIDRR) evolved from the National Institute of Handicapped Research (NIHR) established in 1978. NIHR moved from HEW to the Department of Education in 1980. In 1986, NIDRR was established in amendments to the Rehabilitation Act of 1973. Its mission is to generate, disseminate, and promote the use of knowledge that will improve the ability of disabled individuals to perform activities in the community and increase the capacity of society to provide full opportunities and support for participation. Capacity building is an integral part of NIDRR’s activities, as specified in its last published long-range plan and in its statutory authority, Title II of the Rehabilitation Act of 1973, as amended.

Information has been requested on NIDRR’s support of people,
things, funds, and partnerships. Each of these issues will be addressed in turn.

People, defined as support of researchers, research training, incentives for research, and retention of investigators. NIDRR’s support of research activities can be implied in its Title II funding (see Table 2). Major funding mechanisms during this time frame include:

- Advanced Rehabilitation Research Training (ARRT)
- Disability Rehabilitation Research Projects
- Fellowship Training
- Field Initiated Projects
- Knowledge, Dissemination, and Utilization Projects
- Model Systems Projects
- Rehabilitation Research Engineering Centers (RERCs)
- Rehabilitation Research and Training Centers (RRTCs)
- Section 21 Funding
- Small Business Innovation Grants (SBIR)

Each of these mechanisms has eligibility criteria, evaluation criteria, funding levels, and indirect rates that are specific to the mechanism. Only a few of these mechanisms are investigator initiated, e.g., the field initiated project, the SBIR projects, and the ARRT program. For all other areas, NIDRR creates priorities, based on input from a variety of sources, to which applicants must respond. Four NIDRR priorities are regulatory and published at approximately the same time each year: ARRT, Fellowships, Field Initiated, and SBIRs. All other priorities are published on an “as needed” basis, subject to availability of funding.

In addition to this funding, NIDRR is required in Section 21 of the Rehabilitation Act to set aside 1% of its Title II budget to support capacity building for traditionally underserved populations. In the past, these funds were frequently expended as supplements to funded entities engaged in such work. At present, these funds are predominantly awarded on a competitive basis.

Three funding mechanisms focus on research training: the ARRT program, the Fellowship program, and the Section 21 funds. Training is a required element in other funding programs, specifically the RERCs and the RRTCs. This training is multitaced and can focus on consumers, clinicians, researchers, and policymakers. A number of these centers fund doctoral or postdoctoral research. NIDRR does not have any current ability to track the amount of such training that occurs in these grants. Using the percentage that training contributes to the evaluation criteria, however, an estimate of training support is provided.

NIDRR does not undertake any specific activities aimed at incentivizing or retaining investigators, other than maintaining an open-door policy for discussions with investigators, appointment of investigators to standing panels for the Field Initiated Program, recruitment of young investigators to serve as peer reviewers, and preapplication meetings to explain requirements for NIDRR competitions.

Things, defined as NIDRR support for research infrastructure, e.g., institutional support (public, private), administrative support, collaboration, technology, equipment, travel, professional meetings, or other conferences.

NIDRR does not have any funding specifically targeted at research infrastructure. The program that comes closest to this is the ARRT program, the funds from which go to institutions of higher learning and can support faculty, equipment, travel, etc. A majority of funds in this program support fellow stipends.

All of our grants, however, support direct and indirect costs. Approved direct cost lines include collaboration, technology, equipment, and travel. Thus, NIDRR’s funding at all levels contributes to infrastructure development.

Funds. Please see the Tables for information on funding levels. These tables convey information on a) NIDRR’s funding levels for last 10 yrs, and b) investment in key R&D budgets during the period from 1997 to 2004.

Review mechanisms are as follows: Standing panels for field initiated program and SBIR competitions. Modified standing panel for ARRT program. For all other competitions, panels are formed as required. NIDRR requires a balance of research methodology, clinical or service delivery expertise, and consumer input, with a weighting toward research methodology. Evaluation criteria are regulated, meaning that the current criteria were presented for public comment in 1997, and NIDRR staff select criteria from this approved list as appropriate for a specific competition. Elements of these criteria are selected for each competition and reflect statutory requirements for program elements. New criteria can be published for comment if required. Each competition has an assigned competition manager and may have panel managers in addition. Each competition manager is required to prepare a technical review plan to include required elements of a competition as reflected in the Department of Education’s Discretionary Grant Handbook. This technical review plan is annotated to provide information specific to individual competitions.

Partnerships. Different funding mechanisms and requirements make it difficult to collaborate for funding rehabilitation research. Despite this, NIDRR makes efforts to foster such partnerships. The Rehabilitation Act names NIDRR as the coordinator of the Interagency Committee on Disability Research, under the directorship of the NIDRR director. This committee now has 29 member agencies and includes a subcommittee on medical rehabilitation. NIDRR has interagency agreements that facilitate joint funding with a number of agencies, including the Substance Abuse and Mental Health Services Administration, with which we cofund four major centers on psychiatric disability. We currently cofund with AHRQ the development of the disability component of the consumer assessment of health plans (CAHPS) project. We have memoranda of understanding (MOUs) with the National Institutes of Health (Clinical Services Branch) and the Department of Labor. These MOUs have established conditions and guidelines for cooperation on conferences and research initiatives.

### Appendix E

#### Department of Veterans Affairs: Support of Capacity Building in Rehabilitation Research

Mindy L. Aisen, MD  
Director, Rehabilitation Research and Development

The VA RR&D mission is to support research activities relevant to the needs of veterans with chronic impairments leading to disability. Ours
is an intramural program, so funds are available only to fund VA employees conducting research principally within VA Medical Centers, visible to and including veteran subjects. The range of scientific issues addressed spans the applied to the theoretical, and includes psychosocial to bench disciplines. The areas of focus include vocational, cognitive, visual, motor, sensory, amputation, cardiopulmonary, and general medical rehabilitation. In response to rising rehabilitation needs of veterans and to the increasing opportunity for meaningful interventions (stemming from new medical and technological developments), the number of Centers of Excellence and the overall budget for rehabilitation research has grown.

For example, the 2002 budget was 39.8 million dollars; in 2003, 45.4 million dollars; in 2004, 50.6 million dollars; and in 2005, 53.7 million dollars.

An increase in research activity requires that the number of trained junior faculty available to conduct future research must grow, and so the RR&D program has invested in “human capital,” by developing mentored career development programs. A summary of the number of career development awardees and resultant expenditures is given in the Table:

All programs funded by RR&D are done so only after undergoing formal merit review by panels of scientific and clinical experts.

Centers of Excellence are awarded for 5-yr periods and are renewed only after undergoing competitive review during their fourth year. Investigator-initiated project applications are reviewed twice each year; funding ranges from 150–250,000 dollars per year for 3 yrs.

Other mechanisms for funding include pilot projects and special initiatives.

Periodically state of the art conferences are conducted to assess the clinical and scientific questions that beg investigation in specific fields, if analysis shows that the overall research portfolio requires expansion in an area (based on prevalence of a condition within the Veteran population). VARR&D seeks to collaborate with other federal agencies funding rehabilitation research (NCMRR, NIBIB, NSF, NIDRR), frequently attending interagency meetings and occasionally developing collaborative solicitations.

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