



## Short Communication

# Global rehabilitation research equality index across health conditions during 1990–2019: an alignment analysis between bibliographic and epidemiological data

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Rehabilitation is described as interventions that aim to optimize functioning and reduce disability in individuals with health conditions, considering their environment [1]. Global estimates of rehabilitation needs revealed that about one-third of the world's population could potentially benefit from rehabilitation in 2019, making a substantial 69% increase in years lived with disability (YLDs) since 1990 [2]. With the expanding global population, aging demographics, and shifts in health trends, the health burden of functional recovery is experiencing a significant escalation [3]. Large-scale global unmet needs for rehabilitation require more attention, as “Rehabilitation 2030: a Call for Action” was launched by the World Health Organization (WHO).

While medical advances have improved health outcomes, inequalities in health research persist, exemplified by the “10/90 gap,” warning that a mere 10% of global spending on health research is devoted to diseases or conditions that afflict more than 90% of the world's population [4]. Without prioritization, market forces often guide research and development (R&D) toward profitability rather than health needs [5]. The Global Observatory on Health Research and Development aims to address these disparities by monitoring health R&D prioritizing new investments, and addressing capacity strengthening needs [6]. Furthermore, linking research efforts to disease burden is critical for shaping health policies. Previous studies have revealed diverse correlations between the allocation of funding for health-related research and disease

burdens [7,8]. Additionally, growing studies are investigating the relationship between health research outputs and disease burden [9–11].

Globally systematic and dynamic assessment for health R&D equality across various research activities encounters challenges in monitoring research efforts, resolving data integration concerns, and establishing universally accepted disease classifications [12]. This study provides a quantitative assessment of rehabilitation research equality by measuring the disparities between health needs and research efforts. Inspired by the Health Research Opportunity Index [13], we propose the Research Equality Index (REI) to evaluate imbalances (formulae 1–6 in the [Supplementary materials](#)). The REI integrates bibliographic data (e.g., grants, publications, clinical trials, and patents) from PubMed and Dimensions and epidemiological data on rehabilitation needs from the WHO Rehabilitation Need Estimator. This study was exempt from ethical approval by the Ethical Committee of Peking University, as the WHO Rehabilitation Need Estimator data is available freely for non-commercial use. To ensure consistency, we standardized health condition classifications and country/region names across data sources. Additional details, including methods, descriptive analyses, and mappings, are available in the [Supplementary materials](#) (Figs. S1–S5 and Tables S1–S5 online).

We compared the proportions of rehabilitation needs and research presented by YLDs, grants, publications, clinical trials, and patents at the global level, showing significant disparities (Fig. S6 online). The REI is based on the ratio of research efforts to disease burden for each health condition. The health

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condition-specific REI (sREI) comprehensively evaluated research equality relative to health needs across 25 health conditions and seven broader categories for various research activities during 1990–2019 (Table 1). A positive value of sREI indicates relatively adequate research efforts, while a negative value suggests inadequate research efforts. Health conditions like musculoskeletal disorders (low back pain, neck pain, fractures, osteoarthritis, and amputation), mental disorders (developmental intellectual disability, schizophrenia, and autism spectrum disorders), and chronic respiratory diseases which exhibited research deficiencies contributed up to 75% of the rehabilitation needs (Fig. S7 online). Generally, the sREI followed similar trends across various research activities. For overall equality assessment, the REI is acquired by weighting the absolute magnitude of sREI for each health condition by the proportion of disease burden. The absolute value of sREI represents the degree of imbalance, where larger values indicate greater research inequality. The closer REI is to 0, the smaller the disparity in research activities among all health conditions. Research publications demonstrate a relatively balanced distribution across various activities, while patents exhibit the most pronounced unevenness.

We explored the annual trends in rehabilitation research equality at the global level from 1990 to 2019 (Fig. 1 and Fig. S8 online). Regarding the overall research trends across the 25 health conditions, the growth in sREIs for neurological disorders was primarily driven by increasing sREIs for stroke and multiple sclerosis, with Alzheimer's disease (AD) and Parkinson's disease (PD) showing a

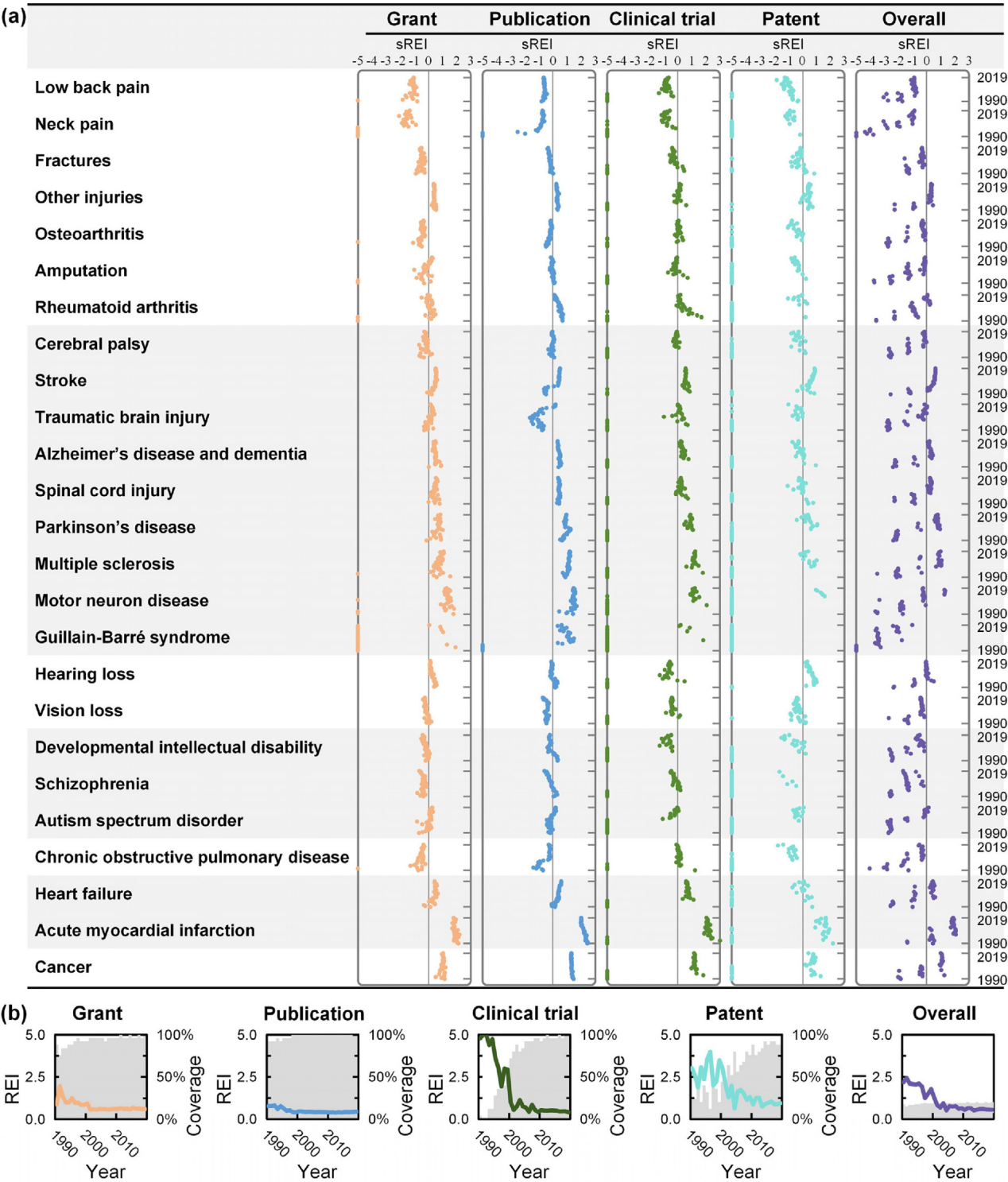
notable decline. For most other health conditions, the sREIs decreased or remained stable, except for autism spectrum disorders, which exhibited a clear upward trend. It is noteworthy that in chronic obstructive pulmonary disease (COPD) and heart failure, opposite trends—increasing sREIs for grants and publications, but decreasing sREIs for clinical trials and patents—were observed, indicating potential fragmentation in the innovation chain. Globally, the REI exhibited a declining trajectory, suggesting improved research equality over the past three decades. A synchronous analysis of research coverage trends across 25 health conditions revealed that the higher REI values in earlier years primarily resulted from missing research on many health conditions. For grants, the research area coverage began to exceed 95% in 2001, coinciding with a notable decline in grant REI prior, subsequently stabilizing around 0.6. The publication REI remained relatively constant, with coverage ratios consistently exceeding 90%. Clinical trials and patents experienced a more severe missing research area, with research area coverage ratios reaching 80% until 2010, after which the clinical trial and the patent REI stabilized at 0.4 and 0.9, respectively. These findings suggest that the improved rehabilitation research equality during 1990–2000 is predominantly attributable to a reduction in missing research areas.

Among different income groups (Figs. S9–S18 online), the sREI distribution patterns are generally similar between high- and upper-middle-income groups, where health conditions related to musculoskeletal disorders (e.g., low back pain and neck pain), mental disorders (e.g., schizophrenia), and COPD exhibit varying

**Table 1**  
Global rehabilitation research equality index for health conditions during 1990–2019.

| Health condition                      | Grant | Publication | Clinical trial | Patent | Overall |
|---------------------------------------|-------|-------------|----------------|--------|---------|
| Musculoskeletal disorders             | −0.42 | −0.30       | −0.36          | −0.39  | −0.37   |
| Low back pain                         | −1.12 | −0.66       | −0.81          | −1.15  | −0.94   |
| Neck pain                             | −1.48 | −0.79       | −0.78          | −0.87  | −0.98   |
| Fractures                             | −0.49 | −0.26       | −0.35          | −0.17  | −0.32   |
| Other injuries                        | 0.31  | 0.20        | 0.02           | 0.34   | 0.22    |
| Osteoarthritis                        | −0.33 | −0.12       | 0.13           | −0.52  | −0.21   |
| Amputation                            | −0.05 | −0.13       | −0.21          | −0.68  | −0.27   |
| Rheumatoid arthritis                  | 0.16  | 0.46        | 0.25           | −0.12  | 0.19    |
| Neurological disorders                | 0.47  | 0.37        | 0.45           | 0.50   | 0.45    |
| Cerebral palsy                        | −0.07 | 0.07        | 0.07           | −0.24  | −0.04   |
| Stroke                                | 0.55  | 0.39        | 0.60           | 0.86   | 0.60    |
| Traumatic brain injury                | 0.25  | −0.39       | 0.12           | −0.45  | −0.12   |
| Alzheimer's disease and dementia      | 0.59  | 0.51        | 0.43           | −0.13  | 0.35    |
| Spinal cord injury                    | 0.50  | 0.40        | 0.20           | −0.13  | 0.24    |
| Parkinson's disease                   | 0.88  | 1.05        | 1.05           | 0.52   | 0.88    |
| Multiple sclerosis                    | 0.90  | 1.13        | 1.22           | 0.32   | 0.89    |
| Motor neuron disease                  | 1.36  | 1.45        | 1.15           | 0.69   | 1.16    |
| Guillain-Barré syndrome               | 0.39  | 0.91        | 0.24           | −5.00  | −0.86   |
| Sensory impairments                   | 0.06  | −0.18       | −0.49          | 0.24   | −0.09   |
| Hearing loss                          | 0.20  | −0.04       | −0.58          | 0.46   | 0.01    |
| Vision loss                           | −0.19 | −0.44       | −0.40          | −0.35  | −0.34   |
| Mental disorders                      | −0.24 | −0.14       | −0.40          | −0.79  | −0.39   |
| Developmental intellectual disability | −0.30 | −0.15       | −0.74          | −0.69  | −0.47   |
| Schizophrenia                         | −0.38 | −0.16       | −0.30          | −1.79  | −0.66   |
| Autism spectrum disorders             | 0.08  | −0.07       | −0.22          | −0.31  | −0.13   |
| Chronic respiratory diseases          | −0.37 | −0.28       | 0.08           | −0.85  | −0.36   |
| Chronic obstructive pulmonary disease | −0.37 | −0.28       | 0.08           | −0.85  | −0.36   |
| Cardiovascular diseases               | 0.77  | 0.87        | 0.99           | 0.35   | 0.74    |
| Heart failure                         | 0.54  | 0.49        | 0.74           | 0.05   | 0.45    |
| Acute myocardial infarction           | 1.90  | 2.15        | 2.13           | 1.55   | 1.93    |
| Neoplasms                             | 1.13  | 1.40        | 1.31           | 0.80   | 1.16    |
| Cancer                                | 1.13  | 1.40        | 1.31           | 0.80   | 1.16    |
| REI                                   | 0.61  | 0.39        | 0.49           | 0.72   | 0.51    |

\*REIs are rounded to two decimal digits. REI: research equality index.



**Fig. 1.** Dynamic trends of global rehabilitation research equality index during 1990–2019. (a) sREI; (b) REI. REI: research equality index; sREI: health condition-specific REI.

research gaps across all research activities. In the high-income group, research activities for rheumatoid arthritis, cerebral palsy, AD and dementia, and cancer are generally adequate, but an unexpected research gap appears in patents. In the upper-middle-income group, gaps in patents are evident in spinal cord injury, multiple sclerosis, and heart failure, suggesting a disconnect between basic research and technological translation. We unexpectedly discovered that research activities in the lower-middle-

income group focus on conditions such as stroke, PD, and multiple sclerosis, with a higher burden in the high- or upper-middle-income groups. Generally, the trends of rehabilitation REI in high-income countries align with global patterns, driven by the dominant role of the high-income group in various rehabilitation research activities. Compared with the high-income group, time lags occur in the decrease of the REIs of upper-middle- and lower-middle-income groups. In the upper-middle-income group,

REIs for grants and publications reached a low point after 2005, while REIs for clinical trials reached a low point after 2010. Surprisingly, in 2019, the REIs for publications and clinical trials in the lower-middle-income group were even lower than those in the high- and upper-middle-income groups. Without considering the impact of blank research areas, REI in the high-income group was not better than that in upper-middle- or lower-middle-income groups.

Our findings represent the first quantitative assessment of the extent of rehabilitation research equality across health conditions, revealing significant inequalities. Health conditions with insufficient research constitute up to 75% of the total rehabilitation needs. Research on low back pain and neck pain continues to be lacking across various research activities. Furthermore, research gaps for musculoskeletal disorders are still widening despite their significant and growing burden and health spending [8]. Sensory organ injuries affecting both the elderly and children, demonstrate an increasing research gap, especially in vision loss, where the proportions of research activities consistently fall short of half of the disease burden. In relation to mental disorders, a serious deficiency and an increasing gap are observed in research on developmental intellectual disability and schizophrenia, both of which are prevalent in children and young adults. Moreover, we identified “neglected diseases” in the field of rehabilitation research, which are even more prevalent in high-income countries. For instance, a positive association was observed between the age-standardized YLD rate of low back pain and sociodemographic index over the past thirty years [14].

Rehabilitation significance extends beyond the traditional focus on persons with disabilities, now involving a broader spectrum of health conditions affecting individuals across the lifespan, from children with cerebral palsy and developmental intellectual disability, to adults with musculoskeletal conditions, to older people experiencing stroke, COPD, or difficulties associated with aging. As populations are expected to age and the epidemiological shift from communicable to noncommunicable diseases, the huge need for rehabilitation is going to increase. However, rehabilitation seems widespread under prioritized. In response to the substantial and escalating unmet need for functional recovery, WHO has launched the Rehabilitation 2030 initiative and released a series of frameworks and packages to strengthen the rehabilitation in health system. In 2023, the World Health Assembly’s landmark resolution on “Strengthening Rehabilitation in Health Systems” further emphasized to support for implementing research and innovation for efficient delivery and equitable access. Health resource allocation—including workforce development, infrastructure, financing, and access to assistive technologies—is pivotal to achieving these goals. These resources not only address rehabilitation needs but also directly impact research efforts by fostering evidence generation and innovation. Rehabilitation research and evidence play an important role in rehabilitation strengthening efforts [15]. Simultaneously, the equality of rehabilitation research is vital to better serve the global public interest.

Previous studies on assessing research equality often involve correlation analyses and calculating the disparity between actual and predicted research activities. However, this methodology is sensitive to the overall scale, limiting it to specific research activity, country, or time period. Despite the attention paid to research equality for over 30 years, systematic quantitative measurements and methodologies remain scarce. In this study, the proposed REI allows for the integration of various research activities, enabling measurement of research balance at global and income group levels, and facilitates monitoring of dynamic trends. The analysis of the correlations between the burden of health conditions and

various research activities shows the strongest correlation in the patents (Fig. S19 online). However, a significant 75% of the patents are focused on stroke, other injuries, hearing loss, and fractures, resulting in more unbalanced REI for patents. It implies that a high correlation does not always imply a more rational allocation of research resources. Varied levels of correlation or non-correlation, and weak correlations provided limited practical guidance, without continuous and comparable monitoring. The REI provides a more objective and consistent measure of research balance, serving as a crucial tool for integrating research efforts and generating evidence. Allocating proportional and rational resources across rehabilitation-related health conditions is a complex decision-making task. Notably, “needs-driven” R&D may not follow a linear relationship between disease burden and funding [5]. However, based on the presumption that R&D is responsive to health needs, our study provides the policy community with a systematic and quantitative approach to prioritizing health R&D beyond the rehabilitation field.

Our study has several limitations. First, although we aimed to measure research activity comprehensively, the grants, publications, clinical trials, and patents do not fully accurately reflect all research efforts, excluding outputs like clinical guidelines or datasets and alternative measures such as funding amounts. Second, imperfect classifications of rehabilitation-related health conditions and retrieval methods and constraints regarding data availability hinder the comprehensive coverage of rehabilitation research. As our understanding of rehabilitation disease classification increases and monitoring becomes more comprehensive, our research will continue to improve. Third, it was not possible to encompass all rehabilitation research. This limitation arises from constraints in terms of both data availability and the MeSH terms-based methods of retrieval and standardized classification of health conditions. Only 43% of grants, 37% of publications, 58% of clinical trials, and 22% of patents are classified into specific disease areas. It may be due to many rehabilitation studies focusing on functional improvement or belonging to general supportive research that cannot be attributed to a specific disease. Finally, the estimates by REI are reasonable but not necessarily highly precise. The accuracy of REI interpretations depends on data quality. Considering the impact of missing data becomes crucial, when interpreting REI.

We call for strengthening rehabilitation research and innovation as well as research equality. Despite the increased rehabilitation research activities from 1990 to 2019 filling many blank research areas, the fundamental issue of imbalanced research has not seen substantial improvement. Addressing the inequality in rehabilitation research remains a major challenge for global and national health science and technology policy management. We hope that the issue of rehabilitation research inequalities receives attention and advocates for a global monitor in rehabilitation R&D that takes into account the health needs of the population.

## Conflict of interest

The authors declare that they have no conflict of interest.

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## Author contributions

Xin Guo and Jian Du conceptualized the study and performed the methodology. Xin Guo and Jiakang Huo processed the data, produced the original figures, and drafted the manuscript. Wanwei Dai, Tong Wang, Han Xiao, Wenjing Zhao, and Xuanyu Shi contributed to the acquisition, analysis, or interpretation of data for the work. Xueheng Wang, Yang Gao, Zhi Li, Rui Zhan, and Wenli Xu revised this work critically for important intellectual content. Erdan Dong and Jian Du provided administrative, technical, material support, supervision, and final approval of the version to be published. All authors approved the final manuscript before submission.

## Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.scib.2025.02.013>.

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