Version 10-16-2023

[Category: Systematic Review]

Research Metrics and Development of the PACER Tool for Productivity and Capacity Evaluation in Research: A Scoping Review

Stephen K. Stacey, DO

Melanie Steiner-Sherwood, PhD

Paul Crawford, MD

Joseph W. LeMaster, MD, MPH

Catherine McCarty, PhD, MPH, HEC-C

Tanvir Turin Chowdhury, MBBS, PhD

Amanda Weidner, MPH

Peter H. Seidenberg, MD, MA, FAAFP, FACSM, RMSK

Author Affiliations: Department of Family Medicine (Stacey), Mayo Clinic Health System – Southwest Wisconsin region, La Crosse, Wisconsin, USA; Department of Family and Preventive Medicine (Steiner-Sherwood), Spencer Fox Eccles School of Medicine, University of Utah, Salt Lake City, Utah, USA; Military Primary Care Research Network (Crawford), Uniformed Services University, Bethesda, Maryland, USA; Department of Family Medicine and Community Health (LeMaster), University of Kansas School of Medicine, Kansas City, Kansas, USA; Department of Family Medicine and Biobehavioral Health (McCarty), University of Minnesota Medical School, Duluth, Minnesota, USA; Department of Family Medicine (Turin Chowdhury), Cumming School of Medicine, University of Calgary, Calgary, Alberta, Canada; Department of Family Medicine (Weidner), University of Washington, Seattle, Washington, USA; and Department of Family Medicine (Seidenberg), LSU Health School of Medicine, Shreveport, Louisiana, USA.

Corresponding Author: Stephen K. Stacey, DO, Department of Family Medicine, Mayo Clinic Health System – Southwest Wisconsin region, 700 West Avenue South, La Crosse, WI 54601 (stacey.stephen@mayo.edu, phone 608-392-9103).

Text word count: 2,063

Abstract word count: 277

No. of tables: 2

No. of references: 37

No. of figures: 1

No. of supplemental materials: 1

Short title: Productivity and Capacity in Research

Publisher: To expedite proof approval, send proof via email to scipubs@mayo.edu.

Key Points

Question: Can we identify relevant, standardized metrics for evaluating research productivity and research capacity in academic research departments?

Findings: Through data-charting research productivity and capacity metrics from a scoping review of 20 articles, we considered 42 relevant metrics to be included in the Productivity And Capacity Evaluation in Research (PACER) Tool, which were reviewed by a Delphi panel.

Meaning: The PACER Tool includes 31 standardized metrics to evaluate research productivity and capacity, to be used for benchmarking and tracking over time.

Abstract

Evaluating research activity in research departments and education programs is conventionally accomplished through measurement of research funding or bibliometrics. This limited perspective of research activity restricts a more comprehensive evaluation of a program's actual research capacity, ultimately hindering efforts to enhance and expand it. The objective of this study was to conduct a scoping review of the existing literature pertaining to the measurement of research productivity in research institutions. Using these findings, the study aimed to create a standardized research measurement tool, the Productivity And Capacity Evaluation in Research (PACER) Tool. The evidence review identified 726 relevant articles in a literature search of PubMed, Web of Science, Embase, ERIC, CINAHL, and Google Scholar with the keywords "research capacity" and "research productivity." Thirty-nine English-language studies applicable to research measurement were assessed in full and 20 were included in the data extraction. Capacity/productivity metrics were identified, and the relevance of each metric was data-charted according to 3 criteria: the metric was objective, organizational in scale, and applicable to varied research domains. This produced 42 research capacity/productivity metrics that fell into 7 relevant categories: bibliometrics, impact, ongoing research, collaboration activities, funding, personnel, and education/academics. With the expertise of a Delphi panel of researchers, research leaders, and organizational leadership, 31 of these 42 metrics were included in the final PACER Tool. This multifaceted tool enables research departments to benchmark research capacity and research productivity against other programs, monitor capacity development over time, and provide valuable strategic insights for decisions such as resource allocation.

Keywords: academics; bibliometrics; collaboration; education; funding; leadership; personnel

Abbreviations

BRC, Building Research Capacity

PACER, Productivity And Capacity Evaluation in Research

Introduction

Effective research can have a profound impact, leading to significant advancements in new technologies, medicines, and evidence-based policies. In recent years, the use of research metrics has gained significant attention as a way to assess the quality and impact of research.[1, 2] Measuring the impact and quality of scientific research, however, remains a challenge for researchers, institutions, and funding agencies.[3-6]

As a solution to this problem, the Building Research Capacity (BRC) Steering Committee commissioned a study to form a panel of research metrics. BRC comprises members from the North American Primary Care Research Group and the Association of Departments of Family Medicine. Since 2016, BRC has been engaged in offering resources to departments of family medicine to enhance and expand research, including consultations and leadership training through a research leadership fellowship.[7] The development and monitoring of research capacity is a topic of significant practical interest to the committee, which has compiled a list of research metrics that have proved useful in providing consultations to clinical research departments and teaching fellows. Starting with this list as a template, the BRC Steering Committee commissioned a scoping review to investigate other metrics in the scientific literature that have been shown to be relevant and to collect a list of research assessment resources. The objective of this review was to generate a structured collection of metrics, termed the *Productivity And Capacity Evaluation in Research (PACER) Tool*.

Methods

We performed a scoping review using the method outlined by Arksey and O'Malley that was further developed by Levac et al.[8, 9] We aimed to identify previously reported metrics or tools that have been used as indicators to track, report, or develop research capacity and productivity in medicine. Arksey and O'Malley[8] identified a process consisting of 6 steps: 1) identifying the research question, 2) identifying relevant studies, 3) selecting studies, 4) charting the data, 5) collating, summarizing, and reporting results, and 6) consulting (optional). The scoping review checklist described by Cooper et al[10] was used to guide the process.

A medical librarian performed a literature search of relevant databases to identify other citations in PubMed, Web of Science, Embase, ERIC, CINAHL, and Google Scholar by using the keywords "research capacity" and "research productivity"; further search details are given in the Supplemental Material. Further forward and backward citation searching was performed to identify any additional articles. Deduplicator in the Systematic Review Accelerator package was used to remove duplicates from the results of the above database searches, producing a final list of citations, which were then uploaded to Rayyan, a web and mobile app for systematic reviews.[11] This article follows the PRISMA-ScR checklist.[12]

Results

For the study selection for the scoping review, 2 authors (S.K.S. and P.C.) screened the titles and abstracts of 726 articles to determine their relevance to research capacity and/or productivity (Figure). Articles were selected if they met 3 metrics: 1) they developed or assessed a research tool or metric; 2) the tool or metric was objective in nature; and 3) the assessment was organizational in scope. If the primary screeners disagreed, a third screener (C.M.) adjudicated. Before article screening, the authors completed training to ensure consistency.

After the screening round, 39 articles were selected to assess for eligibility (Figure). These articles were retrieved in full and underwent independent analysis by 2 authors (S.K.S. plus M.S.-S., P.C., J.W.L., C.M., T.T.C., or P.H.S.) to determine study inclusion. Conflicts between the reviewers in the independent analysis were resolved by discussion between researchers. Ultimately, 20 articles were selected for data extraction.

For the 20 included studies, the following information was recorded on a data-charting form: article title, authors, publication year, study objective, study type, target population, sample, data collection method, study duration, location of study, and study limitations. For studies that evaluated a tool or instrument for research capacity evaluation, the following additional data were recorded: name of tool/instrument, whether the tool/instrument was original or adapted, description of the tool, how it was developed, if and how it was validated, number of metrics captured, description of metrics, and how the tool performed. Key takeaways from the data extraction are summarized in Table 1. These data were used to generate an initial list of metrics that were objective, organizational in scale, and relevant to varied research domains. This formed the first draft of the PACER Tool.

Using the Delphi Method, we submitted the initial tool to a panel of 31 research leaders (eg, deans, administrators, department chairs) to provide feedback, content expertise, and additional perspectives on the preliminary draft.[31] The panel represented various expertise areas, including medicine (n=21, from family medicine, internal medicine, psychiatry, pain and addiction medicine, and sports medicine), business administration (n=2), finance (n=1), research operations (n=3), and population health (n=4). The feedback from the Delphi panel was used to formulate a second draft of the PACER Tool. This was then sent to the panel for further comment. The process was repeated a third time. After consensus was achieved by incorporating panelists' feedback, the final PACER Tool was created.

Our review process resulted in a list of 42 separate metrics that were considered for inclusion in the PACER Tool. Each of these 42 metrics fit within 1 of 7 domains of research capacity that were identified during the review. These categories are:

1. Bibliometrics
2. Impact
3. Ongoing research
4. Collaboration activities
5. Funding
6. Personnel
7. Education/academics

An eighth category, recognition, was identified but ultimately not included after the Delphi panel determined that each of the identified metrics in that category was either infeasible or irrelevant.

The Delphi panel reported that the initial tool was too complex and requested simplification. This resulted in the removal of several metrics, including internal publications and speaking invitations. There was also strong feedback from panel members that we needed to include more data surrounding the impact of research. As a result of that feedback, we added "number of citations" and "median h-index" to the PACER Tool.

The final PACER Tool consists of 31 numeric metrics that, when taken as a whole, shed light on domains of research capacity and productivity that are amenable to such analysis (Table 2).

Discussion

Research metrics are important for academic institutions because they allow institutions to evaluate the productivity and impact of departments, teams, and individual researchers.[2, 22] By following relevant metrics, institutions are able to identify strengths and weaknesses and allocate resources more effectively. Bibliometric indicators, including citation counts, h-index, and impact factor, have become widely accepted measures of scientific productivity.[32, 33] However, they do not reflect the quality or validity of the research, and they can be influenced by factors such as the popularity of the research topic, the size of the research community, and the publishing practices of the field.[29, 34, 35]

Quantifying research capacity through measurements like bibliometrics or external funding often requires contextualization, which demands the collection of additional data.[36] To assess whether any such data would be useful, we must be able to evaluate their effectiveness in measuring excellence of scientific output.[25] Such an evaluation can seem circular, however, because it requires a prior definition of what constitutes excellence. Given the numerous possible metrics and the complex parameter landscape, it is worthwhile to define a priori what, at a minimum, may render a metric practical. In response to this, Kreiman and Maunsell[29] posited that useful research metrics should possess the following characteristics:

1. Quantitative

2. Based on robust data
3. Based on data that are rapidly updated and retrospective
4. Presented with distributions and CIs
5. Normalized by number of contributors
6. Normalized by discipline
7. Normalized for career stage
8. Impractical to manipulate
9. Focused on quality over quantity

These requirements necessitate that multiple metrics be obtained simultaneously. For example, to normalize quantitative bibliometric data by number of contributors or career stage, one would need to compare the data with additional data regarding the quantity and demographics of researchers. What is called for, then, is not a single metric but a panel of metrics that, when taken together, create a reasonably comprehensive picture of an organization's research productivity and capacity. To normalize research data by discipline, a panel of metrics would need to be widely used. Such data would also need to be available to researchers so research productivity could be compared within and across organizations to discover and track trends.

As the scientific landscape continues to evolve, research metrics will continue to have an increasingly important role in shaping the future of scientific research.[1, 2] A robust research data set could serve multiple purposes, including 1) equipping department chairs and deans with a set of practical measures to monitor research development; 2) allowing third-party organizations to compare research productivity at the organization or network level; and 3) providing researchers with a data set to evaluate the research economy (ie, how scarce resources of funding, personnel, and publications are allocated).[2, 37] Currently, no widely adopted set of research indicators exists that could serve these purposes.

The PACER Tool was developed to meet the need identified by our team and supported by our scoping review for robust and comprehensive research capacity measurement systems. It provides a system of metrics that can be used to benchmark, monitor, and compare research productivity and capacity in various research settings. In particular, the PACER Tool provides a way for research programs, funders, and researchers themselves to benchmark research capacity and productivity in a way that is standardized, allowing for comparison across programs and within programs over time.

Use of the PACER Tool will enable leaders to form a detailed evaluation of the capacity and productivity of their research enterprise and make evidence-based resourcing decisions for their own organizations. Additionally, once such data become widely available, they could be used for benchmarking research enterprises across organizations. Consistent, widespread use of PACER data would allow researchers to find answers to important questions in research capacity development. For example, PACER data could be used to discover the average number of new publications an organization could expect if they were to focus resources on adding more junior researchers or having fewer senior researchers.

Although the PACER Tool provides an array of metrics, it may be infeasible for an organization to obtain all data contained within the tool. Many members of the Delphi panel agreed, with one commenting that “some [measures] might be zero or not adopted, such as patents and [institutional review board] applications.” Another mentioned that using “a select subset of metrics would be best.” In response to this, the individual metrics in the PACER Tool are grouped by category. This allows users to focus on obtaining data in the domains that are most important and/or practical to them and their organizations.

One limitation of this study is that it may not be applicable to commercial entities or countries with emerging research. All authors and Delphi panel members were from academic departments in the US and Canada. However, we tried to include perspectives from a wide array of experts in different, including nonmedical, disciplines. Additionally, the review identified no non-English studies, which suggests a need for further research to extend these results to departments in non-English speaking countries.

The PACER Tool represents a robust, multidimensional set of metrics, but it is important to acknowledge that research assessment is a complex and evolving field. The tool should be viewed as a starting point and may require further refinement and adaptation to specific research contexts. Continued feedback and evaluation from colleagues in multiple disciplines and organizations, as well as ongoing validation and improvement of the metrics, will help ensure the ongoing relevance and usefulness of the PACER Tool.

Conclusion

The PACER Tool offers an adaptable, multifaceted approach for monitoring research performance. By incorporating a diverse set of metrics across multiple domains, it addresses many of the limitations of existing research metrics that focus only on bibliometrics and funding. This will enable organizations to evaluate the productivity and impact of research departments, teams, and individual researchers more effectively.

Acknowledgments

Authors' contributions

All authors participated in study design, study execution, and manuscript creation. Each author has read and approved the final manuscript.

Conflicts of interest and financial disclosure

The authors report no financial conflicts of interest.

Sources of funding and support/role of the sponsor

No funding was received for this study. Database searching assistance was provided by a reference librarian affiliated with Louisiana State University Health Sciences Library.

The Scientific Publications staff at Mayo Clinic provided editorial consultation, proofreading, and administrative and clerical support.

References

1. Kilmarx PH, Maitin T, Adam T, et al. Increasing Effectiveness and Equity in Strengthening Health Research Capacity Using Data and Metrics: Recent Advances of the ESSENCE Mechanism. *Ann Glob Health*. 2023;89(1):38. doi:10.5334/aogh.3948
2. Myers BA, Kahn KL. Practical publication metrics for academics. *Clin Transl Sci*. Sep 2021;14(5):1705-1712. doi:10.1111/cts.13067
3. Cooke J, Nancarrow S, Dyas J, Williams M. An evaluation of the 'Designated Research Team' approach to building research capacity in primary care. *BMC Fam Pract*. Jun 27 2008;9:37. doi:10.1186/1471-2296-9-37
4. Ekeroma AJ, Shulruf B, McCowan L, Hill AG, Kenealy T. Development and use of a research productivity assessment tool for clinicians in low-resource settings in the Pacific Islands: a Delphi study. *Health Res Policy Syst*. Jan 29 2016;14:9. doi:10.1186/s12961-016-0077-4
5. Frontera WR, Fuhrer MJ, Jette AM, et al. Rehabilitation Medicine Summit: building research capacity. *J Spinal Cord Med*. 2006;29(1):70-81. doi:10.1080/10790268.2006.11753859
6. Wootton R. A simple, generalizable method for measuring individual research productivity and its use in the long-term analysis of departmental performance, including between-country comparisons. *Health Res Policy Syst*. Jan 14 2013;11:2. doi:10.1186/1478-4505-11-2

7. Ewigman B, Davis A, Vansaghi T, et al. Building Research & Scholarship Capacity in Departments of Family Medicine: A New Joint Adfm-Napcrg Initiative. *Ann Fam Med*. Jan-Feb 2016;14(1):82-3. doi:10.1370/afm.1901

8. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *Int J Soc Res Methodol*. 2005/02/01 2005;8(1):19-32. doi:10.1080/1364557032000119616

9. Levac D, Colquhoun H, O'Brien KK. Scoping studies: advancing the methodology. *Implement Sci*. Sep 20 2010;5:69. doi:10.1186/1748-5908-5-69

10. Cooper S, Cant R, Kelly M, et al. An Evidence-Based Checklist for Improving Scoping Review Quality. *Clin Nurs Res*. Mar 2021;30(3):230-240. doi:10.1177/1054773819846024

11. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan-a web and mobile app for systematic reviews. *Syst Rev*. Dec 5 2016;5(1):210. doi:10.1186/s13643-016-0384-4

12. Tricco AC, Lillie E, Zarin W, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Ann Intern Med*. Oct 2 2018;169(7):467-473. doi:10.7326/M18-0850

13. Sandstrom U, Sandstrom E. A metric for academic performance applied to Australian universities 2001-2004. Accessed Oct 2, 2023. http://eprints.rclis.org/10577/1/2metrics.pdf

14. Humphries D, Ma M, Collins N, et al. Assessing Research Activity and Capacity of Community-Based Organizations: Refinement of the CREAT Instrument Using

the Delphi Method. *J Urban Health*. Dec 2019;96(6):912-922. doi:10.1007/s11524-019-00374-0

15. Gill SD, Gwini SM, Otmar R, Lane SE, Quirk F, Fuscaldo G. Assessing research capacity in Victoria's south-west health service providers. *Aust J Rural Health*. Dec 2019;27(6):505-513. doi:10.1111/ajr.12558
16. Holden L, Pager S, Golenko X, Ware RS. Validation of the research capacity and culture (RCC) tool: measuring RCC at individual, team and organisation levels. *Aust J Prim Health*. 2012;18(1):62-7. doi:10.1071/PY10081
17. Lee SA, Byth K, Gifford JA, et al. Assessment of Health Research Capacity in Western Sydney Local Health District (WSLHD): A Study on Medical, Nursing and Allied Health Professionals. *J Multidiscip Healthc*. 2020;13:153-163. doi:10.2147/JMDH.S222987
18. Rahman M, Fukui T. Biomedical research productivity: factors across the countries. *Int J Technol Assess Health Care*. Winter 2003;19(1):249-52. doi:10.1017/s0266462303000229
19. Huang JS. Building Research Collaboration Networks - An Interpersonal Perspective for Research Capacity Building. *J Res Adm*. 2014;45:89-112.
20. Rubio DM. Common metrics to assess the efficiency of clinical research. *Eval Health Prof*. Dec 2013;36(4):432-46. doi:10.1177/0163278713499586
21. Sarre G, Cooke J. Developing indicators for measuring Research Capacity Development in primary care organizations: a consensus approach using a nominal group technique. *Health Soc Care Community*. May 2009;17(3):244-53. doi:10.1111/j.1365-2524.2008.00821.x

22. Cooke J. A framework to evaluate research capacity building in health care. *BMC Fam Pract*. Oct 27 2005;6:44. doi:10.1186/1471-2296-6-44

23. Bates I, Akoto AY, Ansong D, et al. Evaluating health research capacity building: an evidence-based tool. *PLoS Med*. Aug 2006;3(8):e299. doi:10.1371/journal.pmed.0030299

24. Matus J, Wenke R, Hughes I, Mickan S. Evaluation of the research capacity and culture of allied health professionals in a large regional public health service. *J Multidiscip Healthc*. 2019;12:83-96. doi:10.2147/JMDH.S178696

25. Patel VM, Ashrafian H, Ahmed K, et al. How has healthcare research performance been assessed?: a systematic review. *J R Soc Med*. Jun 2011;104(6):251-61. doi:10.1258/jrsm.2011.110005

26. Cole DC, Boyd A, Aslanyan G, Bates I. Indicators for tracking programmes to strengthen health research capacity in lower- and middle-income countries: a qualitative synthesis. *Health Res Policy Syst*. Apr 12 2014;12:17. doi:10.1186/1478-4505-12-17

27. Bilardi D, Rapa E, Bernays S, Lang T. Measuring research capacity development in healthcare workers: a systematic review. *BMJ Open*. Jul 7 2021;11(7):e046796. doi:10.1136/bmjopen-2020-046796

28. Kotsemir M, Shashnov S. Measuring, analysis and visualization of research capacity of university at the level of departments and staff members. *Scientometrics*. 2017/09/01 2017;112(3):1659-1689. doi:10.1007/s11192-017-2450-7

29. Kreiman G, Maunsell JH. Nine criteria for a measure of scientific output. *Front Comput Neurosci*. 2011;5:48. doi:10.3389/fncom.2011.00048

30. Matus J, Walker A, Mickan S. Research capacity building frameworks for allied health professionals - a systematic review. *BMC Health Serv Res*. Sep 15 2018;18(1):716. doi:10.1186/s12913-018-3518-7

31. Boulkedid R, Abdoul H, Loustau M, Sibony O, Alberti C. Using and reporting the Delphi method for selecting healthcare quality indicators: a systematic review. *PLoS One*. 2011;6(6):e20476. doi:10.1371/journal.pone.0020476

32. Godin B. On the origins of bibliometrics. *Scientometrics*. 2006/07/01 2006;68(1):109-133. doi:10.1007/s11192-006-0086-0

33. Roldan-Valadez E, Salazar-Ruiz SY, Ibarra-Contreras R, Rios C. Current concepts on bibliometrics: a brief review about impact factor, Eigenfactor score, CiteScore, SCImago Journal Rank, Source-Normalised Impact per Paper, H-index, and alternative metrics. *Ir J Med Sci*. Aug 2019;188(3):939-951. doi:10.1007/s11845-018-1936-5

34. Blakeman K. Bibliometrics in a digital age: help or hindrance. *Sci Prog*. Sep 1 2018;101(3):293-310. doi:10.3184/003685018X15337564592469

35. Chandrashekhar Y, Narula J. Challenges for research publications: what is journal quality and how to measure it? *J Am Coll Cardiol*. Apr 28 2015;65(16):1702-1705. doi:10.1016/j.jacc.2015.03.039

36. Belter CW. Bibliometric indicators: opportunities and limits. *J Med Libr Assoc*. Oct 2015;103(4):219-21. doi:10.3163/1536-5050.103.4.014

37. Lodato JE, Aziz N, Bennett RE, Abernethy AP, Kutner JS. Achieving palliative care research efficiency through defining and benchmarking performance metrics. *Curr Opin Support Palliat Care*. Dec 2012;6(4):533-42. doi:10.1097/SPC.0b013e32835a7cb4

Table 1. Summary of Findings From Data Extraction

Title	**Author**	**Publication year**	**Location**	**Key takeaway**
A metric for academic performance applied to Australian universities 2001-2004	Sandstrom and Sandstrom[13]	2007	Australia	Use of a performance-related model that combines productivity with quality measures using a single database. Measured bibliometric data such as number of publications.
A simple, generalizable method for measuring individual research productivity and its use in the long-term analysis of departmental performance, including between-country comparisons	Wootton[6]	2013	Norway	Development of an indicator of individual research output based on grant income, publications, and numbers of PhD students supervised.
Assessing research activity and capacity of community-based organizations: refinement of	Humphries et al[14]	2019	US	Development of the Community REsearch Activity Assessment Tool (CREAT) instrument using a structured Delphi panel. Most metrics

the CREAT instrument using the Delphi method				are subjective. Objective, numeric measurements include staff and budget.
Assessing research capacity in Victoria's south-west health service providers	Gill et al[15]	2019	Australia	Implementation of the Research Capacity and Culture (RCC) tool which had previously been developed by Holden et al, 2012.[16]
Assessment of health research capacity in western Sydney local health district (WSLHD): A study on medical, nursing and allied health professionals	Lee et al[17]	2020	Australia	Implementation of the RCC tool, demonstrating differences between various professionals.[16]
Biomedical research productivity: factors across the countries	Rahman and Fukui[18]	2003	Japan	Analyzed country of origin for published articles to determine significant factors relating to research output defined as publications per million population per year. Significant factors included gross national product per capita, research and development expenditure,

				number of science and engineering students, and number of physicians.
Building research collaboration networks: an interpersonal perspective for research capacity building	Huang[19]	2014	Singapore	Highlights the value of research collaboration networks as evidence of research capacity.
Common metrics to assess the efficiency of clinical research	Rubio[20]	2013	US	Identification of metrics to assess the efficiency of clinical research processes and outcomes. They identified 15 metrics in 6 categories. Objective, numeric metrics include time for IRB submission to approval, time to publication, and number of technology transfer products. Categories included processes, careers, services, economic return, collaboration, and products.

Developing indicators for measuring Research Capacity Development in primary care organizations: a consensus approach using a nominal group technique	Sarre and Cooke[21]	2009	England	Development of a list of indicators to measure research capacity development at an organizational level using workshops and modified nominal group technique. Individual metrics include research personnel, funding, membership in research alliances, number of projects, and awards. They were grouped by category according to the model developed by Cooke.[22]
Development and use of a research productivity assessment tool for clinicians in low-resource settings in the Pacific Islands: a Delphi study	Ekeroma et al[4]	2016	Fiji, Samoa, Tonga, Vanuatu, Cook Islands, Solomon Islands	Focus group discussions to obtain viewpoints on meaningful research indicators. They developed a tool of 21 subjective and objective indicators. Example metrics include bibliometrics, funding, recognition, collaboration, and personnel.

Evaluating health research capacity building: an evidence-based tool	Bates et al[23]	2006	Ghana	Development of a tool to measure clinical research capacity–building programs. The framework was based on reported literature then adapted to the local context through an internal working group. Their resulting tool consisted of a mix of 12 objective and subjective measurements. Sample numeric metrics include bibliometrics, research funding, and researcher remuneration.
Evaluation of the research capacity and culture of allied health professionals in a large regional public health service	Matus et al[24]	2019	Australia	Evaluation of research among allied health professionals working in a large regional health service using the Research Capacity and Culture (RCC) tool.[16] Principal component analyses to determine key components that influence differences between various professional groups.

How has healthcare research performance been assessed?: a systematic review	Patel et al[25]	2011	Articles from several countries were included	Systematic review of indicators of health care research, along with evidence supporting their use. Indicators include publications, citations, impact factor, funding, authorship, population size, h-index, peer reviews, presentations, patents, doctoral students, and editorial responsibilities.
Indicators for tracking programmes to strengthen health research capacity in lower- and middle-income countries: a qualitative synthesis	Cole et al[26]	2014	Canada, UK, Switzerland	Qualitative evaluation of research evaluations to identify key indicators of research productivity. Quantitative indicators include awards, trainees with a mentor, workshop attendance, courses run by educational institutions, course attendance, collaboration activity attendance, joint projects, and bibliometrics.

Measuring research capacity development in healthcare workers: a systematic review	Bilardi et al[27]	2021	UK, Australia, Italy	Systematic review and narrative synthesis of articles containing tools to measure health care workers' individual research capacities. Many articles contained data on team and organizational level. Many domains of assessment were identified, including skills, motivations, bibliometrics, informatics, communication, collaboration activities, studies, ethics, quality, support, skills, infrastructure, leadership, efficiency, dissemination, culture, and sustainability.
Measuring, analysis and visualization of research capacity of university at the level of departments and staff members	Kotsemir and Shashnov[28]	2017	Russia	Literature review on methods of research capacity in the university. Their analysis focuses primarily on bibliometrics, including number of publications, h-index, impact factor of published studies, and articles with evidence of collaboration.

Nine criteria for a measure of scientific output	Kreiman and Maunsell[29]	2011	US	Identification of qualities that define an effective research metric. They advocate that metrics should be quantitative, based on robust data, rapidly updated and retrospective, presented with CIs, normalized by number of contributors, career stage and discipline, impractical to manipulate, and focused on quality over quantity.
Rehabilitation Medicine Summit: building research capacity	Frontera et al[5]	2006	US	Outcomes of a summit convened to advance and promote research in medical rehabilitation. They identified several important domains of research capacity, including research environment, infrastructure, and culture. Objective indicators they identified include bibliometrics and funding.

Research capacity building frameworks for allied health professionals - a systematic review	Matus et al[30]	2018	Australia	Systematic review of 5 databases to identify models and frameworks for research capacity building. They identified 3 main themes: supporting clinicians in research, working together, and valuing research for excellence.
Validation of the research capacity and culture (RCC) tool: measuring RCC at individual, team and organisation levels	Holden et al[16]	2012	Australia	Development of the Research Capacity and Culture (RCC) tool based on literature review and expert guidance. Validation performed for internal consistency and test-retest reliability. Indicators include funding, bibliometrics, age of researchers, evidence of partnerships and dissemination.

Abbreviation: IRB, institutional review board.

Table 2. Productivity and Capacity Evaluation in Research (PACER) Tool

Item	**Description**
Time frame	The time frame intended for monitoring is up to each department to determine. It is recommended that data be compiled at least quarterly.
Bibliometrics	Each publication, presentation, or patent is counted once regardless of the number of authors.
1. Peer-reviewed publications	Number of new original research articles published in the peer-reviewed literature.
2. Publications other than peer-reviewed	Number of new original research contributions published outside of the peer-reviewed literature (eg, book chapters).
3. Presentations (oral and poster)	Number of new oral and poster presentations given at regional, national, or international meetings or conferences. Presentations may be counted more than once if they are delivered more than once.
4. Number of published faculty	Total number of faculty who were listed authors on a publication in the peer-reviewed literature.
5. Number of presenting faculty	Total number of faculty who gave an oral or poster presentation at a regional, national, or international meeting or conference.
6. Patents filed	Number of new patents filed.
7. Patents issued	Number of new patents issued.

Impact	Researchers include doctoral level and other research faculty as defined under "Personnel."
8. New citations	Number of new citations in peer-reviewed literature of articles written by researchers in the department. This includes new citations for all articles of current researchers, regardless of when the article was published.
9. Median h-index	Median h-index for researchers in the department.
Ongoing research	Ongoing research includes projects approved or deemed exempt by an IRB.
10. New projects with IRB approval	Number of projects newly approved or deemed exempt within the past year.
11. Active projects with IRB approval	Number of projects actively under way. This includes new projects listed above.
Collaboration activities	Activities involving participation with organizations outside the department.
12. Joint activities with other research organizations	Number of activities as described under "Bibliometrics" or "Ongoing research" which involved direct participation from researchers outside the department (eg, other departments, other schools, or other organizations).
13. Peer-review panels for research funding proposals	Number of department faculty who have served on a peer-review panel at the national or international level for

	extramural/external research or research training funding proposals in the past year.
14. Personnel participating in national/international research leadership	Number of department faculty serving in leadership roles in national or international research-focused organizations. This can include committee service with regular meetings (at least twice yearly), committee chair, board of directors, or similar level of leadership.
Funding	Funding is defined as total direct dollar or in-kind support for activities intended to lead to external and peer/editorially reviewed presentations, publications, and dissemination. This includes start-up costs, bridge funding, core funding, pilot project funding, staff time, investigator support, consultation, and supplies.
15. Internal funding	Funding that the department or institution contributed to research activities.
16. External funding (including grants)	Funding-derived sources external to the department and external to the institution such as outside grants, industry funding, contracts, or philanthropy designated for research.
17. Other funding	Funding that does not fit in the above categories (eg, endowments, royalties).
18. Total funding	Sum of the 3 funding sources listed above.

Personnel	One research FTE includes 40 hours of work per week from personnel in the department whose time is intended to lead to external and peer/editorially reviewed presentations, publications, and dissemination.
19. Doctoral level research FTE	Total research FTE of doctoral-level faculty (not including trainees) with primary academic appointments in the department. This includes FTE (paid time designated or paid effort allocated) directed toward research, regardless of the funding source, for their salary compensation in the specified time frame.
20. Other research faculty FTE	Total research FTE of other research faculty with bachelor's or master's level degree (not including trainees) with primary academic appointments in the department. This includes FTE (paid time designated or paid effort allocated) directed toward research, regardless of the funding source, for their salary compensation in the specified time frame.
21. Nonresearch faculty FTE	Total nonresearch FTE of all department personnel at or above master's level education. This can include time spent for administration, teaching, patient care, or other activities.

22. Total research administration FTE	Total FTE for administrative time of all staff with research leadership roles.
23. Total faculty FTE	Total of the above 4 items
24. Total faculty	Total FTE for research activities of all faculty who perform or support research activities (even if not their whole job, not including trainees). This includes only faculty directly reporting within the department and does not include research faculty in other departments or organizations paid for with grant funds.
25. Total research support staff FTE	Total FTE for research activities of all staff who support research activities (even if not their whole job, not including trainees). This includes only staff directly reporting within the department and does not include research support staff in other departments or organizations paid for with grant funds. This may include statisticians, study coordinators, or research aides.
Education/academics	Trainee publications and presentations are included in this section, as well as in the “Bibliometrics” section. Each publication or presentation is counted once in this section regardless of the number of trainee authors.
26. Research trainees	Number of trainees who were actively involved in research during the past year, even if research is not the primary

	focus of their education. This includes trainees at all graduate levels who are actively contributing to ongoing research or publication activities and does not include trainees not participating in any such activities.
27. Trainee publications	Number of publications (peer-reviewed or other than peer-reviewed as defined above under Bibliometrics) with a trainee as a listed author.
28. Trainee presentations	Number of presentations (oral or poster) with a trainee as a listed author.
29. Faculty with rank of Assistant Professor	Number of research faculty with the academic rank of Assistant Professor or equivalent.
30. Faculty with rank of Associate Professor	Number of research faculty with the academic rank of Associate Professor or equivalent.
31. Faculty with rank of Professor	Number of research faculty with the academic rank of Professor or equivalent.

Abbreviations: FTE, full-time equivalent; IRB, institutional review board.

Legend

Figure. PRISMA Flow Diagram.