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The Comprehensive Researcher Achievement Model (CRAM):

a framework for measuring researcher achievement, impact and influence derived from a systematic literature review of metrics and models

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1 The Comprehensive Researcher Achievement Model (CRAM):

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- 3 a systematic literature review of metrics and models
- 4

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35	ABSTRACT
36	Introduction
37	Effective researcher assessment is key to decisions about funding allocations, promotion
38	tenure. In the age of ubiquitous data availability, however, weighing the achievements,
39	impact and track record of researchers is a challenge. Despite increased interest in this i
40	there is a lack of clarity about what information to include and how.
41	Objective
42	We aimed to identify what is known about methods for assessing researcher achievement
43	drawing on this to propose a new composite assessment model.
44	Methods
45	A set of inclusion criteria was applied to information gathered through a systematic sear
46	Web of Science Core Collection, MEDLINE, and BIOSIS Citation Index review for lite
47	published between 2007 and 2017. The research followed the Preferred Reporting Items
48	Systematic Review and Meta-Analysis Protocols (PRISMA-P) framework.
49	Results
50	Four hundred and seventy-eight articles were included in the final review. Established
51	approaches, which had been developed prior to our inclusion period (e.g., citations and
52	outputs, h-index, journal impact factor), remained dominant in the literature and in prac
53	There was a profusion of new bibliometric methods and models in the last 10 years incl
54	measures based on PageRank algorithms or "altmetric" data, those purporting to improv
55	upon existing methods to apply peer judgement, and novel techniques to assign values t
56	publication quantity and quality. Each assessment method tended to prioritize certain as
57	of achievement-academic productivity, quality of research, impact or popularity-ove
58	others.
59	Conclusions
60	Judging researchers' achievement is complex. All metrics and models focus on an eleme
61	elements, at the expense of others. Because of these issues, a new composite design, the
62	Comprehensive Researcher Achievement Model (CRAM) is presented, which limits
63	disadvantages with any one metric and supersedes past anachronistic models. The CRA
64	contains a blend of measures and is modifiable to a range of applications.
65	
66	Keywords: Researcher assessment; Research metrics; h-index; Journal impact factor;
67	citations; outputs; Comprehensive Researcher Achievement Model (CRAM)

68	Article Summary
69	Strengths and limitations of this study
70	• A large dataset of over 478 articles, containing many ideas for assessing researcher
71	performance, was analyzed
72	• A new model combining multiple factors to assess researcher performance is now
73	available
74	• Its strengths include combining quantitative and qualitative components in the one
75	model
76	• The CRAM model, despite being evidence-oriented, is a generic one and now needs
77	to be applied in the field
	to be applied in the field

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78 INTRODUCTION

Judging researchers' achievements and impact continues to be an important means of allocating scarce research funds and assessing candidates for promotion or tenure. It has historically been carried out through some form of expert peer judgement, including numbers and quality of outputs, and in more recent decades, citations to them. This approach requires judgements regarding the weight which should be assigned to the number of publications, their quality, where they were published, and their downstream influence or impact. There are significant questions about the extent to which human judgement based on these criteria is an effective mechanism for making these complex assessments in a consistent and unbiased way.[1-3] Criticisms of peer assessment, even when underpinned by relatively impartial productivity data, include the propensity for bias, inconsistency among reviewers, nepotism, group-think and subjectivity.[4-7]

To compensate for these limitations, approaches have been proposed that rely less on subjective judgement and more on objective indicators.[3, 8-10] Indicators of achievement focus on one or a combination of four aspects: quantity of researcher outputs (*productivity*); value of outputs (quality); outcomes of research outputs (impact); and relations between publications or authors and the wider world (influence).[11-15] Online publishing of journal articles has provided the opportunity to easily track citations and user interactions (e.g., number of article downloads) and thus has provided a new set of indices against which individual researchers, journals and articles can be compared and the relative worth of contributions assessed and valued.[14] These relatively new metrics have been collectively termed *bibliometrics*[16] when based on citations and numbers of publications, or *altmetrics*[17] when calculated by alternative online measures of impact such as number of downloads or social media mentions.[16]

The most established metrics for inferring researcher achievement are the h-index and the Journal Impact Factor (JIF). The JIF measures the average number of citations of an article in the journal over the previous year, and hence is a good indication of journal quality but is increasingly regarded as a primitive measure of quality for individual researchers.[18] The h-index, proposed by Hirsch in 2005, [19] attempts to portray a researcher's productivity and impact in one data point. The h-index is defined as the number (h) of articles published by a researcher that have received a citation count of at least h. Use of the h-index has become widespread, reflected in its inclusion in author profiles on online databases such as Google Scholar and Scopus.

Also influenced by the advent of online databases, there has been a proliferation of other assessment models and metrics,[16] many of which purport to improve upon existing approaches.[20, 21] These include methods that assess the impact of articles measured by: downloads or online views received; practice change related to specific research: take-up by the scientific community; or mentions in social media.

Against the backdrop of growth in metrics and models for assessing researchers' achievements, there is a lack of guidance on the relative strengths and limitations of these different approaches. Understanding them is of fundamental importance to funding bodies that drive the future of research, tenure and promotion committees, and more broadly for providing insights into how we recognize and value the work of medical science and scientists. This review identifies approaches to assessing researchers' achievements published in the academic literature over the last 10 years, considering their relative strengths and limitations.

125 METHOD

126 Search Strategy

Web of Science databases (including Web of Science Core Collection, MEDLINE, and BIOSIS Citation Index) were searched using terms related to researcher achievement (researcher excellence, track record, researcher funding, researcher perform*, relative to opportunity, researcher potential, research* career pathway, academic career pathway, funding system, funding body, researcher impact, scientific* productivity, academic productivity, top researcher, researcher ranking, grant application, researcher output, *h*index, i*index, impact factor, individual researcher*) and approaches to its assessment (model, framework, assess*, evaluat*, *metric*, measur*, criteri*, citation*, unconscious *bias, rank**) with "*" used as an unlimited truncation to capture variation in search terms. These two searches were combined (using "and") and results were downloaded into EndNote, the reference management software.

138 Study Selection

139 After removing duplicate references in EndNote,[22] articles were allocated amongst pairs of

- 140 reviewers (MB-JCL, CP-CB, KL-JH, KC-LAE) for screening against inclusion criteria.
- 141 Following established procedures, [23, 24] each pair was randomly assigned 5% of their
- 142 allocation to review concurrently against inclusion criteria, with inter-rater reliability

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143 assessed using Cohen's Kappa (κ). The κ statistic was calculated for pairs of researchers, with 144 agreement ranging from moderate to almost perfect (0.4848-0.9039).[25] Following the 145 abstract and title screen, selected articles underwent full text review. Reasons for exclusion 146 were recorded.

147 Inclusion Criteria

The following inclusion criteria were operationalized: (1) English language, (2) published in the last 10 years (2007-2017), (3) full text for the article was available, and (4) the article discussed an approach to the assessment of an individual researcher's achievements (at the researcher or singular output-level). The research followed the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) framework.[26] Empirical and non-empirical articles were included, because many articles proposing new approaches to assessment, or discussing the limitations of existing ones, are not level one evidence or research-based.

156 Data Extraction

Data from the included articles were extracted, including: the country of article origin, the characteristics of the models or metrics discussed, the perspective the article presented on the metric or model (positive, negative, indeterminable) including any potential benefits or limitations of the assessment model (and if these were perceived or based on some form of evidence). A custom data extraction sheet was developed in Microsoft Excel, trialed among members of the research team and subsequently refined. This information was synthesized for each model and metric identified through narrative techniques. The publication details and classification of each paper are contained in Appendix 1.

165 Appraisal of the Literature

166 Due to the prevalence of non-empirical articles in this field (e.g., editorial contributions,

167 commentaries), it was determined that a risk of bias tool such as the Quality Assessment Tool

168 could not be applied.[27] Rather, assessors were trained in multiple meetings (October 24,

169 October 30, November 13, 2017) to critically assess the quality of articles. Given the nature

170 of the topic (in relation to the publication process) the type of models and metrics identified

171 (i.e., more metrics that use publication metrics) may influence the cumulative evidence and

- 172 subsequently create a risk of bias. In addition, three researchers (JH, EM, CB) reviewed every
- 173 included article, to extract documented conflicts of interests of authors.

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RESULTS

175 The final dataset consisted of 478 academic articles. The data screening process is presented

176 in **Figure 1**.

177 Figure 1. Data screening and extraction process for academic articles

	Database search output ($n = 7810$)	┝╾	Duplicates deleted ($n = 135$)
	↓		
	Title and abstract review $(n = 7675)$	-	Articles excluded ($n = 6823$)
	_		
	Full text review $(n = 852)$		Articles excluded $(n = 377)^*$
	· · · · ·		
	Articles included $(n = 478)$	<	Articles added by snowballing $(n = 3)$
	6		
*	*Reasons for exclusion are noted below	7	
	*Reasons for exclusion are noted below Reason for exclusion at the full text leve		Number of articles exclude
F			Number of articles excluded
ŀ	Reason for exclusion at the full text lev		
F P F	Reason for exclusion at the full text leve Not in English language	el	62
F N F	Reason for exclusion at the full text leve Not in English language Full text not available	el	47 62
F P F T	Reason for exclusion at the full text leve Not in English language Full text not available Does not discuss assessment of an indiv	el	47 62

Of the 478 included papers (see Appendix 1 for a summary), 295 (61.7%) had an empirical component, which ranged from interventional studies that assessed researcher achievement as an outcome measure (e.g., a study measuring the outcomes of a training program),[28] as a predictor[29-31] (e.g., a study that demonstrated the association between number of citations early in one's career and later career productivity), or reported a descriptive analysis of a new metric. [32, 33] One hundred and sixty-six (34.7%) papers were not empirical, including editorial/opinion contributions that discussed the assessment of research achievement, or proposed models for assessing researcher achievement. Seventeen papers (3.6%) were reviews that considered one or more elements of assessing researcher achievements. The quality of these contributions ranged in terms of the risk of bias in the viewpoint expressed. Only for 19 papers (4.0%) did the authors declare a potential conflict of interest.

to propose largely on of positive individual's The rics). The JIF)pen: first published as 10.1136/bmjopen-2018-025320 on 30 March 2019. Downloaded Superieu Protected by copyright, including for uses related to te
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200	Across the study period, 78 articles (16.3%) involved authors purporting to prop
201	new models or metrics. Most articles described or cited pre-existing metrics and largely
202	discussed their perceived strengths and limitations. Figure 2 shows the proportion of po
203	or negative discussions of five of the most common approaches to assessing an individu
204	research achievement (altmetrics, peer-review, h-index, simple counts, and JIF). The
205	approach with most support was altmetrics (51.0% of articles mentioning altmetrics). T
206	was discussed with mostly negative sentiments in relevant articles (69.4%).
207	
208	Figure 2. Percentages of positive and negative discussion regarding selected comm
209	used metrics for assessing individual researchers (n=478 articles)
210	[Insert Figure 2 here]
211	
212	Citation-Based Metrics
213	Publication and Citation Counts
214	One hundred and fifty-three papers (32.0%) discussed the use of publication and citatio
215	counts for purposes of assessing researcher achievement, with papers describing them a
216	simple "traditional but somewhat crude measure",[34] as well as the building blocks for
217	metrics.[35] A researcher's number of publications, commonly termed an n-index,[36]
218	suggested by some to indicate researcher productivity,[14] rather than quality or influer
219	these papers.[37] On the other hand, the literature suggested that numbers of citations
220	indicated the influence of an individual publication or at researcher-level, as an author's
221	cumulative number received across their body of work or mean citations per article.[38]
222	Some studies found support for the validity of citation counts and publications in that the
223	were correlated with other indications of a researcher's achievement, such as awards an
224	grant funding,[39, 40] and predictive of long term success in a field.[41] For example, of
225	paper argued that having larger numbers of publications and being highly cited early in
226	career predicted later high quality research.[42]
227	A number of limitations of using citation or publication counts was observed. For
228	example, Minasny et al. (2013) highlighted discrepancies between publications and cita
229	counts in different databases because of their differential structures and inputs.[43] Other
230	authors[38, 44, 45] noted that citation patterns vary by discipline, which they suggested
231	make them inappropriate for comparing researchers from different fields. Average citat

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per publication were reported as highly sensitive to change or could be skewed if, for example, a researcher has one heavily-cited article. [46, 47] A further disadvantage is the lag-effect of citations, [48, 49] and that in most models citations and publications count equally for all co-authors, despite potential differential contributions. [50] Some also questioned the extent to which citations actually indicated quality or impact, noting that a paper may influence clinical practice more than academic thinking.[51] Indeed, a paper may be highly cited because it is useful (e.g., a review), controversial, or even by chance, making citations a limited indication of quality or impact. [40, 50, 52] In addition to limitations, numerous authors made the point that focusing on citation and publication counts can have unintended, negative consequences for the assessment of researcher achievement, potentially leading to gaming and manipulation, including self-citations and gratuitous authorship.[53, 54]

243 Singular Output-Level Approaches

Forty-one papers (8.6%) discussed models and metrics at the singular output or article-level that could be used to infer researcher achievement. The components of achievement they reported assessing were typically quality or impact. [55, 56] For example, some papers reported attempts to examine the quality of a single article by assessing its content. [57, 58] Among the metrics identified in the literature, the immediacy index (II) focused on impact by measuring the average number of cites an article received in the year it was published.^[59] Similarly, Finch suggested adapting the Source Normalized Impact per Publication (SNIP: a metric used for journal-level calculations across different fields of research) to an article-level.[21]

Many of the article-level metrics identified could also be upscaled to produce researcher-level indications of achievement. For example, the sCientific currENcy Tokens (CENTs), proposed by Szymanski et al. (2012), involved giving a "cent" for each new non-self-citation a publication received; CENTs are then used as the basis for the researcher-level i-index, which follows a similar approach as the h-index, but removes self-citations.[60] The TAPSIF (Temporally-Averaged Paper-Specific Impact Factor) calculates an article's average number of citations per year combined with bonus cites for the publishing journal's prestige. and can be aggregated to measure the overall relevance of a researcher (Temporally Averaged Author-Specific Impact Factor; TAASIF).[61]

262 Journal impact factor

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The JIF, commonly recognized as a journal-level measure of quality, [59, 62-64] was discussed in 211 (44.1%) of the papers reviewed in relation to assessing singular outputs or individual researchers. A number of papers described the JIF being used informally to assess an individual's research achievement at the singular output-level, and formally in countries such as France and China.[65] It implies article quality because it is typically a more competitive process to publish in journals with high impact factors.[66] Indeed, the JIF was found to be the best predictor of a paper's propensity to receive citations.[67] The JIF has a range of limitations when used to indicate journal quality.[68] including

that it is disproportionally affected by highly cited, outlier articles, [41, 69] and is susceptible to "gaming" by editors.[17, 70] Other criticisms focused on using the JIF to assess individual articles or the researchers who author them.[71] Some critics claimed that using the JIF to measure an individual's achievement encourages researchers to publish in higher-impact but less-appropriate journals for their field—which ultimately means their article may not be read by relevant researchers. [72, 73] Furthermore, the popularity of a journal was argued to be a poor indication of the quality of any one article, with the citation distributions for calculating JIF found to be heavily skewed (i.e., a small subset of papers receive the bulk of the citations while some may receive none).[18] Ultimately, many commentators argued that the JIF is an inappropriate metric to assess individual researchers because it is an aggregate metric of a journal's publication, and expresses nothing about any individual paper. [21, 49, 50, 74] However, Bornmann et al. (2017) suggested one case in which it would be appropriate to use JIF for assessing individual researchers: in relation to their recently published papers that had not had the opportunity to accumulate citations.[75]

Researcher-Level Approaches

286 h-index

The h-index was among the most commonly discussed metrics in the literature (254 [53.1%] of the papers reviewed); in many of these papers, it was described by authors as more sophisticated than citation and publication counts, but still straightforward, logical and intuitive.[76-78] Authors noted its combination of productivity (h publications) and impact indicators (h citations) as being more reliable[79, 80] and stable than average citations per publications[41] because it is not skewed by the influence of one popular article.[81] One study found that the h-index correlated with other metrics more difficult to obtain.[78] It also

showed convergent validity with peer-reviewed assessments[82] and was found to be a goodpredictor of future achievement.[41]

However because of the lag-effect with citations and publications, the h-index increases with a researcher's years of activity in the field, and cannot decrease, even if productivity later declines.[83] Hence, numerous authors suggested it was inappropriate for comparing researchers at different career stages, [84] or those early in their career. [70] The h-index was also noted as being susceptible to many of the critiques leveled against citation counts, including potential for gaming, and inability to reflect differential contributions by co-authors.[85] Because disciplines differ in citation patterns[86] some studies noted variations in author h-indices between different methodologies[87] and within medical subspecialities.[88] Some therefore argued that the h-index should not be used as the sole measure of a researcher's achievement.[88]

h-index variants

A number of modified versions of the h-index were identified; these purported to draw on its basic strengths of balancing productivity with impact while redressing perceived limitations. For example, the g-index measures global citation performance, [89] and was defined similarly to the h-index but with more weight given to highly cited articles by assuming the top g articles have received at least g^2 citations.[90] Azer and Azer (2016) argued it was a more useful measure of researcher productivity.[91] Another variant of the h-index identified, the m-quotient, was suggested to minimize the potential to favor senior academics by accounting for the time passed since a researcher has begun publishing papers. [92, 93] Other h-index variations reported in the articles reviewed attempted to account for author contributions, such as the h-maj index, which includes only articles in which the researcher played a core role (based on author order); and the weighted h-index, which assigns credit points according to author order.[89, 94]

319 Recurring Issues with Citation-Based Metrics

The literature review results suggested that no one citation-based metric was ideal for all purposes. All of the common metrics examined focused on one aspect of an individual's achievement, and thus failed to account for other aspects of achievement. The limitations with some of the frequently used citation-based metrics are listed in **Box 1**.

study

4. The lag-effect of citations

Non-Citation Based Approaches

altmetrics

6. Failure to account for author order

8. Perpetuate "publish or perish" culture

typically measure the "web visibility" of an output.[101]

1. Challenges with reconciling differences in citation patterns across varying fields of

2. Time-dependency issues stemming from differences in career length of researchers

3. Prioritizing impact over merit, or quality over quantity, or vice versa

7. Contributions from publications are viewed as equal when they may not be

In contradistinction with the metrics discussed above, fifty-four papers (11.3%) discussed

altmetrics (or "alternative metrics"), which included a wide range of techniques to measure

non-traditional, non-citation based usage of articles.[17] Altmetric measures included the

algorithms[97] and attention by mainstream news, [65] in books[98] and social media, for

example, in blogs, commentaries, online topic reviews or tweets. [99, 100] These metrics

A strength of altmetrics lies in providing a measure of impact promptly after

publication. [70, 102, 103] Moreover, altmetrics allows tracking of the downloads of multiple

sources (e.g., students, the general public, clinicians, as well as academics) and multiple types

of format (e.g., reports and policy documents),[104] which are useful in gauging a broader

indication of impact or influence, compared to more traditional metrics that solely or largely

have been established by commercial enterprises such as *Altmetrics LLC (London, UK)* and other competitors,[105] and there may be fees levied for their use. The application of these

metrics has also not been standardized.[98] Furthermore, it has been argued that, because

impact or even popularity, [106] instead of quality or productivity. [107] Hence, one study

altmetrics are cumulative and typically at the article-level, they provide more an indication of

Disadvantages noted in the articles reviewed included that altmetrics calculations

measure acknowledgement by experts in the field through citations.[17]

number of online article views, [95] bookmarks, [96] downloads, [41] PageRank

5. Gaming and the ability of self-citation to distort metrics

9. Potential to stifle innovation in favor of what is popular

Box 1. Common limitations in the use of citation-based metrics

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suggested no correlation between attention on Twitter and expert analysis of an article's
originality, significance or rigour.[108] Another showed that Tweets predict citations.[109]
Overall, further work needs to assess the value of altmetric scores in terms of their
association with other traditional indicators of achievement.[110] Notwithstanding this, there
were increasing calls to consider altmetrics alongside more conventional metrics in assessing

researchers and their work.[111]

354 Past Funding

A past record of being funded by national agencies was identified as a common measurement of individual academic achievement in a number of papers, and has been argued to be a reliable method that is consistent across medical research.[112-114] For example, the NIH's (National Institute of Health's) RePORT (Research Portfolio Online Reporting Tools) system encourages public accountability for funding by providing online access to reports, data and NIH-funded research projects.[112, 115]

362 New Metrics and Models identified

The review also identified and assessed new metrics and models that were proposed during the review period, many of which had not gained widespread acceptance or use. While there was considerable heterogeneity and varying degrees of complexity among the 78 new approaches identified, there were also many areas of overlap in their methods and purposes. For example, some papers reported on metrics that used a PageRank algorithm, [116, 117] a form of network analysis based on structural characteristics of publications (e.g., co-authorship or citation patterns).[14] Metrics based on PageRank purported to measure both the direct and indirect impact of a publication or researcher. Other approaches considered the relative contributions of authors to a paper in calculating productivity.[118] Numerous metrics and models that built upon existing approaches were also reported.[119] For example, some developed composite metrics that included a publication's JIF alongside an author contribution measure[120] or other existing metrics.[121] However, each of these approaches reported limitations, in addition to their strengths or improvements upon other methods. For example, in focusing on productivity, a metric necessarily often neglected impact.[122] **Appendix 2** provides a summary of these new or re-fashioned metrics and models, with details of their basis and purpose.

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381	DISCUSSION
382	This systematic review identified a large number of diverse metrics and models for assessing
383	an individual's research achievement that have been developed in the last 10 years (2007-
384	2017), as evidenced in Appendix 2. At the same time, other approaches that pre-dated our
385	study time period were also discussed frequently in the literature reviewed, including the h-
386	index and JIF. All metrics and models proposed had their relative strengths, based on the
387	components of achievement they focused on, and their sophistication or transparency.
388	
389	Strengths and limitations
390	The review also identified and assessed new metrics and Over the past few decades,
391	peer-review has been increasingly criticized for reliance on subjectivity and propensity for
392	bias,[7] and there have been arguments that the use of specific metrics may be a more
393	objective and fair approach for assessing individual research achievement. However, this
394	review has highlighted that even seemingly objective measures have a range of shortcoming
395	For example, there are inadequacies in comparing researchers at different career stages, and
396	across disciplines with different citation patterns.[86] Furthermore, the use of citation-based
397	metrics can lead to gaming and potential ethical misconduct by contributing to a "publish or
398	perish" culture in which researchers are under pressure to maintain or improve their
399	publication records.[123, 124] New methods and adjustments to existing metrics have been
400	proposed to explicitly address some of these limitations; for example, normalizing metrics
401	with "exchange rates" to remove discipline-specific variation in citation patterns, thereby
402	making metric scores more comparable for researchers working in disparate fields.[125, 126
403	Normalization techniques have also been used to assess researchers' metrics with greater
404	recognition of their relative opportunity and career longevity.[127]
405	Other criticisms of traditional approaches center less on how they calculated
406	achievement, and more on what they understood or assumed about its constituent elements.
407	In this review, the measurement of impact or knowledge gain was often exclusively tied to
408	citations.[128] Some articles proposed novel approaches to using citations as a measure of
409	impact, such as giving greater weight to citations from papers that were themselves highly
410	cited[129] or that come from outside the field in which the paper was published.[130]
411	However, even other potential means of considering scientific contributions and achievemen

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 412 413 414 415 416 417 418 419 	such as mentoring, were still ultimately tied to citations because mentoring was measured by the publication output of mentees.[131] A focus only on citations was widely thought to disadvantage certain types of researchers. For example, researchers who aim to publish with a focus on influencing practice may target "lower-impact", more specialized or regional journals that are not necessarily highly cited, where their papers will be read by the appropriate audience and findings
414 415 416 417 418	A focus only on citations was widely thought to disadvantage certain types of researchers. For example, researchers who aim to publish with a focus on influencing practice may target "lower-impact", more specialized or regional journals that are not necessarily highly cited, where their papers will be read by the appropriate audience and findings
415 416 417 418	researchers. For example, researchers who aim to publish with a focus on influencing practice may target "lower-impact", more specialized or regional journals that are not necessarily highly cited, where their papers will be read by the appropriate audience and findings
416 417 418	may target "lower-impact", more specialized or regional journals that are not necessarily highly cited, where their papers will be read by the appropriate audience and findings
417 418	highly cited, where their papers will be read by the appropriate audience and findings
418	
	implemented [51] In this record, established the type of isymptotic which on entires have
419	implemented.[51] In this regard, categorizing the type of journal in which an article has been
117	published, in terms of its focus (e.g., industry, clinical, regional/national), may go some way
420	toward recognizing those publications that have a clear knowledge translation intention.[123]
421	There were only a few other approaches identified that captured broader conceptualizations
422	of knowledge gain, such as practical impact or wealth generation for the economy, and these
423	too were often simplistic, such as including patents and their citations[132] or altmetric
424	data.[98] While altmetrics hold potential in this regard, their use has not been
425	standardized,[98] and they come with their own limitations, with suggestions that they reflect
426	popularity more so than real world impact.[106] Other methodologies have been proposed for
427	assessing knowledge translation, but these can often be labor intensive.[133] For example,
428	Sutherland et al. (2011)[134] suggested that assessing individual research outputs in light of
429	specific policy objectives, through peer-review based scoring, may be a strategy, but this is
430	typically not feasible in situations such as grant funding allocation, where there are time-
431	constraints and large applicant pools to assess.
432	In terms of how one can make sense of the validity of many of these emerging
433	approaches for assessing an individual's research achievements, metrics should demonstrate
434	their legitimacy empirically, as well as having a theoretical basis for their use and clearly
435	differentiating what aspects of quality, achievement or impact they purport to examine.[55,
436	67] If the recent, well-publicized[135-137] San Francisco Declaration on Research
437	Assessment (DORA)[138] is anything to go by, internationally there is a move away from the
438	assessment of individual researchers using the JIF and the journal in which the research has
439	been published.
440	
441	Figure 3. The Comprehensive Researcher Achievement Model (CRAM)
442	[Insert Figure 3 Here]
443	
444	There is momentum, instead, for assessment of researcher achievements on the basis
445	of a wider mix of measures, hence our proposed Comprehensive Researcher Achievement
	15

Model (CRAM) (Figure 3). On the left-hand side of this model is the researcher to be assessed, and key characteristics that influence the assessment. Among these factors, some (i.e., field or discipline, co-authorship, career longevity) can be controlled for depending on the metric, while other components, such as gaming or the research topic (i.e., whether it is "trendy" or innovative) are less amenable to control or even prediction. Online databases, which track citations and downloads and measure other forms of impact, hold much potential and will likely be increasingly used in the future to assess both individual researchers and their outputs. Hence, assessment components (past funding, articles, citations, patents, downloads, and some media traction) included in our model are those primarily accessible online.

The findings of this review suggest assessment components should be used with care, and with recognition of how they can be influenced by other factors, and what aspects of achievement they reflect (i.e., productivity, quality, impact, influence). No metric or model singularly captures all aspects of achievement, and hence use of a range, such as the examples in our model, is advisable. Finally, this model recognizes that the configuration and weighting of assessment methods will depend on the assessors and their purpose, the resources available for the assessment process, and access to assessment components. However, these results must be interpreted in light of our focus only on academic literature in the review; this may have led to a more publication concentrated model.

466 CONCLUSION

There is no ideal model or metric by which to assess individual researcher achievement. We have proposed a generic model, designed to minimize risk of the use of any one or a smaller number of metrics, but it is not proposed as an ultimate solution. The mix of assessment components and metrics will depend on the purpose. Greater transparency in approaches used to assess achievement including their evidence-base is required. [37] Any model used to assess achievement for purposes such as promotion or funding allocation should include some quantitative components, based on robust data, and be able to be rapidly updated, presented with confidence intervals, and normalized.[37] The assessment process should be difficult to manipulate, and explicit about the components of achievement being measured. As such, no current metric suitably fulfills all these criteria. The best strategy to assess an individual's research achievement is likely to involve the use of multiple approaches[139] in order to dilute the influence and potential disadvantages of any one metric, while providing

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479 more rounded picture of a researcher's achievement;[85, 140] this is what the CRAM aims to480 contribute.

All-in-all, achievement in terms of impact and knowledge gain is broader than the number of articles published or their citation rates, and yet most metrics have no means of factoring in these broader issues. Altmetrics hold promise in complementing citation-based metrics and assessing more diverse notions of impact, but usage of this type of tool requires further standardization.[98] Finally, despite the limitations of peer-review, the role of expert judgement should not be discounted.[41] Metrics are perhaps best applied as a complement or check on the peer-review process, rather than the sole means of assessment of an individual's research achievements.[141]

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the decision to publish.
Data sharing statement
All data has been made available as Appendices.
Author Contributions
JB conceptualized and drafted the manuscript, revised it critically for important intellectual
content, and led the study.
JH, KC and JCL made substantial contributions to the design, analysis and revision of the
work and critically reviewed the manuscript for important intellectual content.
CP, CB, MB, RC-W, FR, PS, AH, LAE, KL, EA, RS and EM carried out the initial
investigation, sourced and analyzed the data and revised the manuscript for important
intellectual content.
PH and JIW critically commented on the manuscript, contributed to the revision and editing
of the final manuscript and reviewed the work for important intellectual content.
All authors approved the final manuscript as submitted and agree to be accountable for all
aspects of the work.
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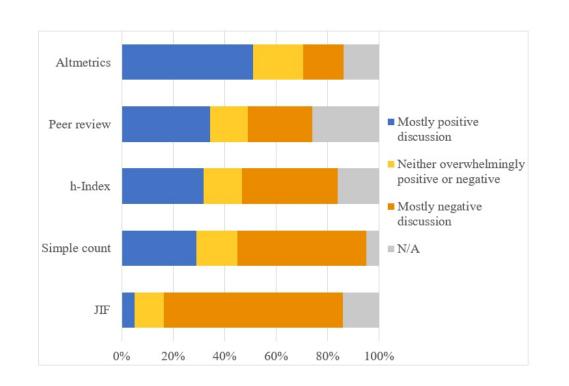
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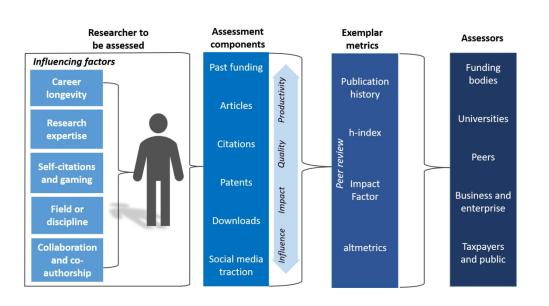
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Appendix 1: Summary table of included articles and the metrics or models they discuss

First author	Year	Journal name	Format^	Peer- review	Simple Counts	h- index	JIF	Other	Alt- metrics	New
Abramo	2016	Scientometrics	ED				_	Y		_
Agarwal	2016	Asian Journal of Andrology	ED		Y	Y	Y	Y	Y	
Ahmad	2013	Anesthesia and Analgesia	EM		Y					
Aixela	2015	Perspectives: Studies in Translatology	ED	Y		Y	Y	Y		
Akl	2012	Canadian Medical Association Journal	EM	Y						
Albion	2012	Australian Educational Researcher	EM			Y	Y	Y		
Alguliyev	2016	Journal of Scientometric Research	EM				Y	Y		
Allen	2010	ScienceAsia	ED			Y	Y			
Anderson	2008	Scientometrics	ED			Y				Y
Anderson	2017	Applied Economics	EM	Y		Y	Y			
Anfossi	2015	International Journal of Dermatology	EM				Y			
Antunes	2015	Revista do Colegio Brasileiro de Cirurgioes	EM	Y	6	Y				
Aoun	2013	World Neurosurgery	RE	Y		Y	Y			
Aragon	2013	Nature Scientific Reports	EM							Y
Armado	2017	Transinformação	EM			Y		Y		
Assimakis	2010	Scientometrics	EM							Y
Azer	2016	Education Forum				Y	Y	Y		
Babineau	2014	The Western Journal of Emergency Medicine	EM			Y				

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adar	2016	Aslib Journal of Information Management	EM	Y			Y		
ai	2016	PLOS One	EM		Y	Y	Y	Y	Y
ala	2013	Journal of Clinical Epidemiology	EM				Y		
alaban	2013	Journal of General Physiology	ED	Y					
alandin	2009	Augmentative and Alternative Communication	ED			Y	Y		
arczynski	2009	Journal of Human Kinetics	ED				Y	Y	
astian	2017	Journal of Bone and Joint Surgery-American Volume	EM			Y			
aum	2011	SAGE	EM	Y			Y		
eck	2017	Research Evaluation	EM	Y					
eirlant	2010	Scandinavian Journal of Statistics	EM			Y			
elikov	2015	f1000 Research	EM			Y			Y
ellini	2012	The Lancet	ED		Y	Y	Y		
elter	2015	Journal of The Medical Library Association	ED	Y		Y			
enchimol-Barbosa	2011	Arquivos Brasileiros de Cardiologia	ED				Y		
enway	2009	Urology	ED	Y	Y	Y			
ertuzzi	2013	Molecular Biology of the Cell	ED				Y		
harathi	2013	PLOS One	ED		9	Y			
ini	2008	Electronic Transactions on Numerical Analysis	EM						Y
irks	2014	Health Services Research & Policy	EM	Y		Y			
iswal	2013	PLOS One	ED			Y		Y	
loch	2016	Research Evaluation	EM					Y	
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Baccini	2014	Scientometrics	EM			Y	Y	Y	
Badar	2016	Aslib Journal of Information Management	EM	Y			Y		
Bai	2016	PLOS One	EM		Y	Y	Y	Y	Y
Bala	2013	Journal of Clinical Epidemiology	EM				Y		
Balaban	2013	Journal of General Physiology	ED	Y					
Balandin	2009	Augmentative and Alternative Communication	ED			Y	Y		
Barczynski	2009	Journal of Human Kinetics	ED				Y	Y	
Bastian	2017	Journal of Bone and Joint Surgery-American Volume	EM			Y			
Baum	2011	SAGE	EM	Y			Y		
Beck	2017	Research Evaluation	EM	Y					
Beirlant	2010	Scandinavian Journal of Statistics	EM			Y			
Belikov	2015	f1000 Research	EM			Y			Y
Bellini	2012	The Lancet	ED		Y	Y	Y		
Belter	2015	Journal of The Medical Library Association	ED	Y		Y			
Benchimol-Barbosa	2011	Arquivos Brasileiros de Cardiologia	ED				Y		
Benway	2009	Urology	ED	Y	Ŷ	Y			
Bertuzzi	2013	Molecular Biology of the Cell	ED				Y		
Bharathi	2013	PLOS One	ED			Y			
Bini	2008	Electronic Transactions on Numerical Analysis	EM						Y
Birks	2014	Health Services Research & Policy	EM	Y		Y			
Biswal	2013	PLOS One	ED			Y		Y	
Bloch	2016	Research Evaluation	EM					Y	

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Bloching	2013	South African Journal of Science	EM	Y						Y
Bollen	2016	Scientometrics	ED	Y						Y
Bolli	2014	Circulation Research	ED							
Bornmann	2009	EMBO Reports	ED			Y	Y			
Bornmann	2015	Journal of Informetrics	EM	Y	Y	Y	Y			
Bornmann	2016	EMBO Reports	ED		Y	Y	Y			
Bornmann	2014	Scientometrics	EM		Y	Y				
Bornmann	2008	Research Evaluation	EM	Y	Y	Y	Y	Y		
Bornmann	2017	Journal of Informetrics	EM		Y	Y	Y	Y		
Bornmann	2017	Journal of Korean Medical Science	ED				Y	Y		
Bould	2011	British Journal of Anaesthesia	EM			Y				
Bradshaw	2016	PLOS One	EM		Y	Y	Y	Y		
Brown	2011	American Journal of Occupational Therapy	ED			Y	Y	Y		
Buela-Casal	2012	Scientometrics	EM	1			Y			
Buela-Casal	2010	Revista de Psicodidáctica	ED		Y	Y	Y	Y	Y	
Butler	2017	Clinical Spine Surgery	ED		5				Y	
Cabazas Clavijo	2013	Medicina Intensiva (English edition)	RE		Y	Y	Y			
Cagan	2013	Disease Models & Mechanisms	ED				Y			
Callaway	2016	Nature	ED				Y			
Calver	2013	Grumpy Scientists	ED		Y	Y	Y	Y		
Calver	2015	Australian Universities Review	ED					Y		
Caminiti	2015	BMC Health Services Research	RE							Y

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Cantin	2015	International Journal of Morphology	EM			Y				
Carpenter	2014	Academic Emergency Medicine	ED			Y	Y	Y	Y	
Carpenter	2014	Information Service and Use	ED				Y		Y	
Castelnuovo	2010	Clinical Practice & Epidemiology in Mental Health	RE			Y	Y		Y	Y
Castillo	2010	American Journal of Neuroradiology	ED			Y		Y		
Chiari	2016	Nurse Education Today	EM	Y						
Choi	2014	Journal of Radiation Oncology	EM	Y		Y		Y		Y
Choi	2009	International Journal of Radiation Oncology, Biology, Physics	EM		Y	Y				
Chopra	2016	Aesthetic Surgery Journal	EM			Y				
Choudhri	2015	Radiographics	ED		Y	Y	Y			
Chowdhury	2015	PLOS One	EM	Y		Y				
Christopher	2015	Journal of Veterinary Cardiology	ED				Y			
Chung	2012	Scientometrics	EM						Y	
Ciriminna	2013	Chemistry Central Journal	ED	1	Y	Y	Y	Y		
Claro	2011	Scientometrics	EM							
Cleary	2010	International Journal of Mental Health Nursing	ED	— (ケ	Y				
Cone	2013	Academic Emergency Medicine	ED		-77	Y				
Cone	2012	Academic Emergency Medicine	ED				Y			
Cordero-Villafafila	2015	Revista de Psiquiatría y Salud Mental (English Edition)	ED			Y	Y	Y		Y
Costas	2011	Scientometrics	EM		Y			Y		
	2009	Journal of the American Society for Information Science and Technology	EM		Y		Y			

Crespo	2013	PLOS One	EM		Y	Y				Y
Cress	2014	Aesthetic Surgery Journal	ED				Y		Y	
Crotty		European Heart Journal	ED			Y				
Culley	2014	Anesthesia & Analgesia	EM		Y	Y		Y		
Cynical Geographers Collective	2011	Antipode	ED		Y		Y			
Czarnecki	2013	Bulletin of the Polish Academy of Sciences	EM			Y	·			
da Silva	2017	Scientometrics	ED				Y	Y	Y	
Danell	2011	Journal of the American Society for Information Science and Technology	EM		Y					
Danielson	2013	American Journal of Pharmaceutical Education	EM		Y	Y		Y		
de Granda-Orive	2014	Archivos de Bronconeumología	ED		Y			Y		
De Gregori	2016	Journal of Pain Research	EM						Y	
De la Flor-Martínez M	2017	Medicina Oral Patologia Oral Y Cirugia Bucal	EM	Y		Y				
De Marchi	2016	Scientometrics	EM	И,			Y			
De Witte	2010	Scientometrics	EM	Y						Y
Delgadillo	2016	Family & Consumer Sciences research journal	RE	C	5	Y				Y
DeLuca	2013	Academic Emergency Medicine	EM	Y		Y				
Devos	2011	Clinics and Research in Hepatology and Gastroenterology	ED		J	Y				
Diamandis	2017	BMC Medicine	ED				Y			
DiBartola	2017	Journal of Veterinary Internal Medicine	ED			Y	Y	Y		
Diem	2013	Research in Higher Education	EM				Y			
Ding	2011	Information Processing and Management	EM		Y	Y	Y	Y	Y	
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Ding	2011	Journal of the American Society for Information Science and Technology	EM			Y	Y		Y	
Diniz-Filho	2016	Journal of Informetrics	EM	Y	Y		Y			,
Dinsmore	2014	PLOS Biology	ED						Y	
Dodson	2012	Biochemical and Biophysical Research Communications	EM	Y		Y	Y			Y
Donato	2014	Revista Portuguesa De Pneumologia	ED				Y			
Doyle 2015	Molecular Psy	chiatry EM	Y							
Duffy	2011	Scientometrics	EM		Y	Y		Y		
Duffy	2008	Journal of Counseling Psychology	EM		Y	Y		Y		Y
Durieux	2010	Radiology	RE			Y	Y	Y	Y	
Ebadi	2016	Scientometrics	EM					Y		Y
Eblen	2016	PLOS One	EM	Y						
Efron	2011	Clinical and Experimental Optometry	EM		Y	Y		Y		
Ekpo	2016	Journal of Medical Imaging and Radiation Sciences	EM			Y	Y	Y		Y
El Emam	2012	Journal of Medical Internet Research	EM		Y	Y	Y			
Ellson	2009	Journal of Business Research	ED							
Eloy	2014	Otolaryngology-Head and Neck Surgery	EM	Y		Y	Y	Y		
Eloy	2013	Laryngoscope	EM			Y				
Esposito	2010	European Journal of Oral Implantology.	ED			Y				
Eyre-Walker	2013	PLOS Biology	EM	Y	Y		Y			
Eysenbach	2011	Journal of Medical Internet Research	EM		Y	Y	Y		Y	
Fabry	2017	GMS Journal for Medical Education	ED	Y			Y		Y	
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Fang	2016	eLIFE	EM	Y						
Fazel	2017	Evidence-based Mental Health	EM	Y				Y	Y	
Fedderke	2015	Research Policy	EM		Y	Y				
Feethman	2015	Veterinary Record	ED				Y			
Ferrer-Sapena	2016	Research Evaluation	ED		Y		Y	Y	Y	Y
Filler	2014	Academic Medicine	EM					Y		
Finch	2010	Bioessays	ED			Y	Y	Y		
Flaatten	2016	Acta Anaesthesiologica Scandinavica	ED			Y	Y			
Franceschet	2010	Journal of Informetrics	EM				Y	Y		
Franceschini	2012	Scientometrics	EM					Y		Y
Franceschini	2012	Scientometrics	EM			Y	Y	Y		Y
Franceschini	2012	Scientometrics	EM		Y	Y		Y		
Frittelli	2016	Journal of the Association for Information Science and Technology	EM			Y	Y			Y
Frixione	2016	PLOS One	EM	Y					Y	
Fujita	2017	IEEE 41st Annual Computer Software and Applications Conference (COMPSAC)	EM	Y	Ŷ					
Gambadauro	2007	European Journal of Obstetrics & Gynecology and Reproductive Biology	ED				Y			
Gao	2016	PLOS One	ED			Y				Y
Garcia-Perez	2015	Scientometrics	EM		Y			Y		
Garcia-Perez	2009	Spanish Journal of Psychology	EM		Y	Y				
Garner	2017	Journal of Neurointerventional Surgery	RE		Y	Y				
		B ອວກອອກໄຫກ່ຽ <mark>ງທີ່ມີຫຼີງ ແຫຼ່ງ ແຫຼ່ງ ເ</mark> ຮັດ ເຮັດ ເດີຍ ເລີຍ Agence Bi) . ata mining, Al training, and similar technologies.	b bns ixət ot bə	relar səsu	l 101 gribu	ight, incl	λ cobλι	d bətəəto	чd	

Gasparyan Gast	2017	Journal of Korean Medical Science Plastic and Reconstructive Surgery	ED EM		Y	Y	Y	Y	Y	
					1					
Gast	2014	Plastic & Reconstructive Surgery	EM			Y		Y		
Gaughan	2008	Research Evaluation	EM					Y		
Gefen	2011	Journal of Biomechanics	LE	Y		Y				
Giminez-Toledo	2016	Scientometrics	EM					Y		
Glänzel	2014	Transinformação	ED			Y		Y		
Good	2015	Research Evaluation	ED					Y		
Gorraiz	2010	LIBER Quarterly	ED		Y		Y		Y	
Gracza	2008	Library Collections Acquisitions & Technical Services	ED			Y	Y			
Grisso	2017	Journal of Women's Health	EM	Y						
Grzybowski	2017	Clinics in Dermatology	ED				Y			
Gumpenberger	2016	Scientometrics.	ED	Y		Y	Y		Y	
Haddad	2014	The Bone and Joint Journal	ED	1.			Y			
Haddow	2015	Research Evaluation	EM							
Haeffner-Cavaillon	2009	Archivum Immunologiae et Therapiae Experimentalis	ED	Y	5	Y	Y	Y		
Halbach	2011	Annals of Anatomy	EM		Y	Y		Y		
Hall	2015	Tourism Management	ED				Y			
Halvorson	2016	Implications for Training in the Health Professions	EM		Y	Y				
Iamidreza	2013	Acta Informatica Medica	EM			Y				
Hammarfelt	2017	Research Evaluation	EM	Y		Y	Y			
Han	2013	ISSI	EM	Y			Y			Y
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Ian	2010	Journal of Animal and Veterinary Advances	EM		Y	Y			
Iaslam	2009	Research Evaluation	EM	,	Y Y	Y			
Iaslam	2010	European Journal of Social Psychology	EM		Y	Y	Y	Y	
Iealy	2011	Breast Cancer Research and Treatment	EM		Y				
Ieinzl	2012	AIP Conference Proceedings	ED		Y	Y	Y		
Ienrekson	2011	The Manchester School	EM		Y Y	Y	Y		
Ierteliu	2017	Publications	EM		Y				
Iew	2017	Telematics and Informatics	EM		Y Y	Y			
licks	2015	Nature	ED		Y	Y			
licks	2015	Nature	ED		Y	Y			
loffman	2014	47th Hawaii International Conference on System Sciences	0		Y	Y		Y	
Iolliday	2010	International Journal of General Medicine	EM	Y		Y			Y
Iouser	2017	Leukos	ED		Y	Y			
lughes	2015	International Journal of Radiation Oncology Biology Physics NB Conference supplement	s EM	4	Y Y				
Iunt	2011	Acta Neuropsychiatrica	ED		Y	Y			
Iutchins	2016	PLOS Biology	EM		77.				Y
Iyman	2014	Molecular Biology of the Cell	ED						
brahim	2015	New Library World	EM	Y	Y Y				Y
oannidis	2016	PLOS Biology	EM		Y Y				Y
on	2017	Chirurgia	RE		Y	Y	Y		
yendar	2009	Academic Medicine	EM			Y			Y

ackson	2015	Medical Journal of Australia	ED	Y						
ackson	2011	PLOS One	EM					Y		
acob	2007	Scientometrics	EM		Y		Y			
acso	2010	Online Information Review	EM				Y	Y		
acso	2008	Online Information Review	ED			Y				
alil	2013	IEEE International Conference on Teaching, Assessment and Learning for Engineering (TALE)	EM				Y			
amjoom	2015	Neurosciences	EM			Y				
amjoom	2016	World Neurosurgery	EM			Y				
an	2016	Journal of Scientometric Research	EM			Y		Y		
avey	2012	American Chemical Society	ED			Y	Y			
eang	2008	Retrovirology	ED			Y				Y
okic	2009	Biochemia Medica	ED		Y	Y	Y			
oshi	2014	The Journal of Contemporary Dental Practice	ED			Y		Y		
oynson	2015	f1000 Research	EM							
laatz	2015	Academic Medicine	EM	Y						
laatz	2016	Academic Medicine	EM	Y						
ali	2015	Indian Journal of Pharmacology	ED		Y				Y	
alra	2013	Journal of Neurosurgery-Pediatrics	EM			Y		Y		
altman	2014	Circulation Research	EM		Y					
lapoor	2013	The Annals of Medical and Health Sciences Research	ED				Y			
lellner	2008	Anais Da Academia Brasileira De Ciencias	EM			Y				
		ata data mining, AI training, and similar technologies.	12 1XƏ1 O1 DƏ	isia) sasu	յու ճաթու	ວບເ 'ານດີ	νλ cobλι	ງ ກອງວອງດ	I.A	
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Khan	2013	World Neurology	EM				Y				
Knudson	2015	Quest	EM			Y					
Kosmulski	2012	Research Evaluation	ED			Y		Y			
Krapivin	2009	Complex Sciences	EM			Y	Y			Y	Y
Kreiman	2011	Frontiers in Computational Neuroscience	ED	Y		Y		Y		Y	
Kreines	2016	Journal of Computer and Systems Sciences International	EM								Y
Kshettry	2013	World Neurosurgery	ED				Y		Y		
Kulasagareh	2010	European Archives of Oto-Rhino-Laryngology	EM				Y				
Kulczycki	2017	Journal of Informetrics	ED				Y				
Kumar	2009	Iete Technical Review	ED			Y	Y	Y			
Kuo	2017	Computers in Human Behavior	EM							Y	
ando	2014	PLOS One	EM			Y	Y				Y
Lariviere	2010	Journal of the American Society for Information Science and Technology	EM					Y			
ariviere	2016	PLOS One	EM	4	•	Y					
ariviere	2011	Journal of Informetrics	EM		$\overline{\mathbf{O}}$				Y		
Lauer	2015	The New England Journal of Medicine	ED	Y		77					
Law	2013	Asia Pacific Journal of Tourism Research	EM	Y		Y		Y			
Lee	2009	Journal of neurosurgery	EM				Y				
Leff	2009	International Journal of COPD	ED					Y			
Leydesdorff	2016	Scientometrics	ED				Y	Y	Y		
j	2015	Science	EM	Y							
		nd data mining, Pankeon, ລຸກລຸມູຫຼອດ 3. 2025 at Agence Bi עוםבל) מומן data mining, Al training, and similar technologies.	s txət ot k	erelated	ior use	t gnibul:	ight, inc	λ cobλι	d betced b	Ч	

Li	2016	In: Nah FFH, Tan CH, eds. Hci in Business, Government, and Organizations: Ecommerce and Innovation, Pt I. Vol 97512016:61-71.	EM	Y						
Liang	2015	IEEE International Conference on Smart City/SocialCom/SustainCom	EM							Y
Liao	2011	Decision Support Systems	EM		Y		Y			
Lindner	2015	PLOS One	EM	Y	Y					
Lindner	2016	American Journal of Evaluation	EM	Y						
Lippi	2009	Clinical Chemistry and Laboratory Medicine	ED			Y	Y			
Lippi	2013	Clinica Chimica Acta	EM			Y	Y			
Lippi	2017	Annals of Translational Medicine	EM			Y	Y			Y
Lissoni	2011	Industrial and Corporate Change	EM				Y			
Littman	2017	Medical Education Online	EM		Y	Y	Y			
Liu	2011	Management Information Systems	EM		Y			Y	Y	
Lopez	2015	Journal of Surgical Education	EM	Y		Y				
Lopez	2015	Journal of Hand Surgery America	EM		Y	Y				
Lortie	2013	Scientometrics	EM	Ť (Y		Y			
Lovegrove	2008	BioScience	EM	Y	-77	Y		Y		<u></u>
Lozano	2017	Current Science	ED		Y	Y		Y		
MacMasters	2017	Academic Psychiatry	EM		Y	Y				
Maggio	2017	Academic Medicine	EM			Y			Y	
Mali	2017	Science & Public Policy	EM							
Markel	2017	Journal of Pediatric Surgery	EM		Y	Y		Y		
		liB eonega ts ՇՀՕ∑«էլեցցրէշ,ությունգրգգյաց, 2025 at Agence Bil . (ՀՅՅՀ) t and data mining, AI training, and similar technologies.) to text ∍d to text	565 relate	su tot gribi	ght, incli	λ cobλιί	d bətəəto	ЪЧ	

Aarkpin	2008	Scientometrics	EM				Y			Y
Aarsh	2008	American Psychologist	EM	Y						
Marshall	2017	Otolaryngology—Head and Neck Surgery	EM				Y			
Aarzolla	2016	Journal of Informetrics	EM	Y		Y		Y		
Aas-Bleder	2013	Scientometrics	EM		Y			Y		
Matsas	2012	Brazilian Journal of Physics	EM							Y
Maunder	2007	La Revue Canadienne de Psychiatrie	EM				Y	Y		Y
Maximin	2014	RadioGraphics	ED	Y	Y		Y		Y	
Mazloumian	2011	PLOS One	EM							Y
Mazmanian	2014	Evaluation & the Health Professions	RE					Y		
McAlister	2011	American Heart Association Journals	ED		Y		Y			
AcGovern	2013	Academic Medicine	EM	Y	Y			Y		
Aedo	2016	Physical Review	EM			Y		Y		
Meho	2008	Journal of the American Society for Information Science and Technology	EM	4	Y	Y				
Aester	2016	Interdisciplinary Description of Complex Systems	ED	- (Y	Y	Y			
Metcalf	2010	Radiologic Technology	EM							
Milone	2016	American Journal of Orthopedics	EM	Y		Y				Y
Minasny	2013	PeerJ	EM		Y	Y				
Mingers	2015	European Journal of Operational Research	ED		Y	Y		Y		
Mingers	2009	Journal of the Operational Research Society	EM		Y	Y				
Aingers	2017	Scientometrics	EM		Y					
		banapa fa 2025 گېل ان (بېزېم) پېرې کې 2025 at Agence Bi BES) bradata mining, Al training, and similar technologies. https://www.action.com/action/actio	s îxeî oî b	uses relate	10î gribu	ight, incl	λ cobλι	otected b	μ	

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Science and Public Policy

The Journal of Cell Biology

British Journal of Anaesthesia

PLOS Neglected Tropic Diseases

Irish Journal of Medical Science

Zeitschrift fur Psychologie

Critical Care Medicine

Research Evaluation

Technology

Scientometrics

PLOS One

Nature

Technology

Technology

Nature Letters

PLOS Biology

Nature

Journal of the Association for Information Science and

Archivum Immunologiae et Therapia Experimentalis

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Journal of the Association for Information Science and

Journal of The American Society for Information Science and

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Nature Editorial

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Nicol	2007	Medical Journal of Australia	EM	Y	Y		Y			
Nicolini	2008	Scientometrics	EM				Y	Y		
Niederkrotenthaler	2011	BMC Public Health	EM							Y
Nielsen	2017	Studies in Higher Education	EM				Y	Y		
Nigam	2012	Indian Journal of Dermatology, Venerology and Leprology	ED			Y				
Nightingale	2013	Nurse Education in Practice	EM		Y	Y	Y		Y	
Nosek	2010	Personality and Social Psychology Bulletin	EM			Y				Y
Nykl	2015	Journal of Informetrics	EM	Y		Y	Y			. <u></u>
O'Brien	2012	Oikos	ED							. <u></u>
O'Connor	2010	European Journal of Cancer Care	ED				Y	Y		. <u></u>
Okhovati	2016	Global Journal of Health Science	EM	Y	Y	Y	Y	Y		. <u></u>
Oliveira	2013	Revista Paulista de Pediatria	EM		Y	Y	Y	Y		
Oliveira	2011	Arquivos Brasileiros de Cardiologia	EM		Y	Y	Y			
Oliveira	2013	Scientometrics	EM	11.	Y	Y	Y	Y		
Opthof	2009	Netherlands Heart Journal	EM			Y	Y			
Orduna-Malea	2015	El Profesional de la Información	ED	Y	Y	Y	Y		Y	Y
Osterloh	2015	Evaluation Review	EM	Y	Y		Y			
Ouimet	2011	Scientometrics	EM			Y		Y		
Pagani	2015	Scientometrics	RE		Y		Y			Y
Pagel	2011	British Journal of Anaesthesia	EM			Y				
Pagel	2011	Anaesthesia	EM			Y		Y		
Pagel	2015	Original Investigations in Education	EM		Y	Y		Y		

Y Surgical Education EM Paik 2014 Science Reports Y Pan 2014 EM Υ Υ Pandit 2011 ED Y Y Y Anaesthesia Journal of the Royal Society of Medicine EM Y Y Y Y Y Patel 2013 Y Y Journal of the Royal Society of Medicine Y Y Y Patel 2011 RE Journal of Postgraduate Medicine ED Y Patrow 2011 2012 PLOS One EM Y Y Pepe Pereyra-Rojas 2017 Frontiers in Psychology EM Y Y Y Y Y Perlin 2017 Journal of Informetrics ΕM Y Persson 2014 Acta Physiologica ED Peters Y 2017 ED Journal of Infometrics Petersen 2013 EM Journal of Informetrics Y 2010 Physical Review EM Petersen Y Y Pinnock 2012 Nurse Education Today ED Põder 2017 Trames-Journal of the Humanities and Social Sciences Υ EM Y Y Y Y Y 2017 World Neurosurgery ED Prabhu Y 2016 Scientometrics EM Y Prathap Prathap Y Y 2012 Scientometrics EM Υ Y 2014 EM Prathap Scientometrics Y Y Current Science Y Y Prathap 2017 ED Y Y Pringle Y Y Y 2008 Learned Publishing ED Journal of the American Board of Family Medicine EM Y Y Pshetizky 2009

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Pugh Jr	2013	Journal of General Physiology	ED				Y			
Pulina	2007	Italian Journal of Animal Science	EM		Y	Y	Y	Y		
Pyke	2015	BioScience	ED							Y
Qi	2016	Scientometrics	EM		Y					
Quigley	2012	Journal of Cancer Education	EM			Y				
Rad	2012	Academic Radiology	EM			Y				
Radicchi	2008	Proceedings of the National Academy of Sciences of the United States of America	EM		Y	Y		Y		Y
Radicchi	2012	Journal of Informetrics	EM		Y			Y		
Raj	2016	Academic Medicine	EM		Y	Y		Y		
Ramasesha	2011	Current Science	ED		Y	Y	Y	Y		
Rana	2013	Journal of Cancer Education	EM		Y	Y				
Ravenscroft	2017	PLOS One	EM			Y	Y	Y	Y	
Rey-Rocha	2015	Scientometrics	EM		Y					
Rezek	2011	Academic Radiology	EM	$\overline{\mathbf{v}}$						
Ribas	2015	Proceedings of the 24th International Conference on World Wide Web	0	Y	Y	Y				Y
Ribas	2015	arXiv	ED							Y
Ricker	2009	Interciencia	ED	Y			Y			Y
Rieder	2010	Langenbeck's Archives of Surgery	ED			Y		Y		
Robinson	2011	Journal of School Psychology	ED				Y			
Rodriguez-Navarro	2011	PLOS One	EM							Y
Ronai	2012	Pigment Cell and Melanoma research	ED	Y	Y					

2009	Research Evaluation	EM						
2016	Journal of Cardiac Surgery	EM		Y				
2009	Scientometrics	EM	Y	Y				-
2010	Scientometrics	EM		Y				-
2015	Society for Academic Emergency Medicine (SAEM)	EM Y						-
2011	Science Translational Medicine	ED	Y	Y	Y			-
2017	Omega	EM	Y	Y	Y			
2011	Internal Archives of Medicine	ED		Y	Y			
2008	Current Science	ED		Y	Y			-
2017	Molecular Biology of the Cell	ED			Y	Y		
2017	Academic Psychiatry	EM		Y				-
2016	Missouri Medicine	ED			Y	Y	Y	-
2008	Indian Journal of Medical Research	ED		Y	Y			
2013	Journal of Pharmacology Pharmacotherapeutics	EM		Y	Y	Y		

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Rosati

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Satyanarayana

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Scientometrics

Research Policy

Science

Management Decision

Journal of Medical Physics

Ultrasound in Obstetrics and Gynaecology

Journal of the Medical Library Association

MEDINFO 2015: eHealth-enabled Health

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Slim	2017	Anaesthesia, Critical Care & Pain Medicine	ED			Y	Y		Y	
Slyder	2011	Scientometrics	EM		Y					
Smeyers	2011	Journal of Philosophy of Education	ED		Y		Y			
Smith	2008	Bone & Joint Journal	ED				Y			
Soares de Araujo	2011	Revista Brasileira de Medicina do Esporte	EM			Y	Y	Y		
Sobhy	2016	Embo Reports	ED				Y			
Sobkowicz	2015	Journal of Artificial Societies and Social Simulation	EM	Y						
Solarino	2012	Annals of Geophysics	RE		Y	Y	Y			Y
Sood	2015	Eplasty	EM			Y				
Sorenson	2011	Journal of Parkinson's Disease	EM		Y	Y				Y
Spaan	2009	Medical & Biological Engineering & Computing	ED			Y	Y			
Spearman	2010	Journal of Neurosurgery	EM			Y				
Spreckelsen	2011	BMC Medical Informatics and Decision Making	EM			Y	Y	Y		
Staller	2017	Qualitative Social Work	ED	1	Y	Y			Y	
Stallings	2013	Proceedings of the National Academy of Sciences of the United States of America	EM		Y	Y				Y
Street	2009	Health Research Policy and System	EM	Y		/.				
Stroebe	2010	American Psychologist	ED		Y			Y		
Stroobants	2013	Nature	ED							
Sturmer	2013	Revista Brasileira De Fisioterapia	EM		Y	Y				
Suiter	2015	The Journal of Academic Librarianship	EM			Y	Y	Y	Y	
Suminski	2012	The Journal of the American Osteopathic Association	EM		Y		Y	Y		
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Surla Susarla	2017	The Electronic Library Plastic and Reconstructive surgery	ED EM		Y Y	Y	Y			Y
				X 7	I					
Susarla	2015	Journal of Dental Education	EM	Y		Y				
Sutherland	2011	PLOS One	EM	Y			Y			
vider	2013	Laryngoscope	EM			Y				
vider	2014	Ophthalmology	EM	Y		Y				
vider	2013	Laryngoscope	EM	Y		Y				
Svider	2013	Laryngoscope	EM			Y		Y		
Swanson	2016	Annals of Plastic Surgery	EM			Y				
Szklo	2008	Epidemiology	ED				Y			
zymanski	2012	Information Sciences	EM			Y	Y	Y		Y
aborsky	2007	International Journal of Behavioural Biology	ED	Y						
`an	2016	The Annals of Applied Statistics	EM		Y	Y	Y		Y	Y
andon	2015	National Academy Science Letters-India	ED	1.			Y			
aylor	2015	Poultry Science	ED			Y	Y		Y	
eixeira	2013	PLOS One	EM		75	Y				
Cenreiro Machado	2017	Entropy	EM	Y				Y		
Thelwall	2017	Aslib Journal of Information Management	EM						Y	
Therattil	2016	Annals of Plastic Surgery	EM			Y				
homaz	2011	Arquivos Brasileiros De Cardiologia	ED			Y	Y	Y		
Thorngate	2014	Advances in Social Simulation	EM	Y						
ĵijdink	2016	BMJ Open	EM							
		B əənəgA ts შ202.5 at Agence B S) data mining, Al training, and similar technologies.	bns ixei oi bei	slər səzı	i 10î gnibu	ight, incl	λ cobλι	d bətəəto	۲۹	

BMJ Open

Гimothy	2015	Tourism Management	ED				Y			
Forrisi	2014	Scientometrics	EM	Y		Y	Y	Y		
Tricco	2017	PLOS One	RE	Y						
Trueger	2015	Annals of Emergency Medicine	ED			Y	Y		Y	
ſschudy	2016	Journal of Pediatrics	EM			Y		Y		
Гse	2008	Nature	ED			Y	Y			Y
Fuitt	2011	Canadian Journal of Gastroenterology	EM			Y	Y	Y		
Usmani	2011	Sudanese Journal of Paediatrics	ED			Y	Y			
Valsangkar	2016	Surgery	EM		Y	Y		Y		
van Arensbergen	2012	Higher Education Policy	EM	Y						
van den Besselaar	2009	Research Evaluation	EM	Y	Y					
van Eck	2013	PLOS One	EM		Y					
van Leeuwen	2008	Research Evaluation	EM			Y				
van Leeuwen	2012	Research Evaluation	EM	Y						
van Noorden	2010	Nature	ED	-		Y	Y	Y	Y	
van Wesel	2016	Science and Engineering Ethics	EM	ļ	フト					
Vaughan	2017	Scientometrics	EM			$\overline{\Lambda}$			Y	
Verma	2015	Proceedings of the National Academy of Sciences of the United States of America	ED	Y	-		Y			
Vico	2015	Prometheus	EM	Y						
Vieira	2011	Scientometrics	EM							Y
Vinkler	2012	Journal of Informetrics	ED					Y		
		t and data mining, IA ,وpniniar technologies. در and data technologies.								

on Bartheld	2015	PeerJ	EM				Y	Y	Y		
Vacogne	2016	Archives of Disease in Childhood-Education and Practice Edition	ED				Y	Y	Y	Y	
Vagner	2012	Research Evaluation	ED			Y					Y
Vaisbren	2008	Journal of Women's Health	EM								
Walijee	2015	Plastic and Reconstructive Surgery	ED							Y	
Walker	2010	BMC Medical Education	EM			Y		Y	Y		
Wallace	2012	PLOS One	EM	Y		Y					
Walters	2011	Journal of the American Society for Information Science and Technology	EM	Y		Y		Y			
Valtman	2013	In: Gorraiz J, Schiebel E, Gumpenberger C, Horlesberger M, Moed H, eds. 14th International Society of Scientometrics and Informetrics Conference	EM			Y	Y				Y
Valtman	2013	Journal of Informetrics	EM			Y					
Wang	2013	Science	EM	1			Y	Y	Y		Y
Vard	2012	Anaesthesia	ED								
Vatson	2015	Journal of Pediatric Surgery	EM			Y	Y				
Velk	2014	Research Quarterly for Exercise and Sport	ED					Y			
Wieczorek	2016	Financial Environment and Business Development	ED			Y	Y	Y			
Wildgaard	2014	Scientometrics	RE			Y	Y	Y	Y		
Villiamson	2008	Family Medicine	EM								Y
Wootton	2013	Health Research Policy and Systems	EM	Y				Y			Y
Würtz	2016	Annals of Epidemiology	RE				Y				
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Wykes	2013	Journal of Mental Health	ED			Y	Y			
aminfirooz	2015	The Electronic Library	EM			Y				Y
lang	2013	Journal of Informetrics	EM	Y		Y				Y
ates	2015	Source Code for Biology and Medicine	EM	Y						
″u	2016	Computers in Human Behaviour	EM						Y	
le	2012	International Conference on Intelligent Computing	EM		Y	Y				
Thang	2012	Scientometrics	EM							Y
Thang	2017	PLOS One	EM		Y		Y			
hang	2012	Scientometrics	EM		Y	Y		Y		
hao	2014	Scientometrics	EM	Y			Y	Y		
hou	2012	New Journal of Physics	EM			Y				Y
hu	2015	arXiv	EM							Y
huo	2008	Molecular Pain	EM	Y		Y				Y
ima	2008	Biochemia Medica	ED	1.		Y	Y			
lou	2016	Scientometrics	EM		Y	Y				Y
lupetic	2017	Academic Radiology	EM		Y					
lycxkowski	2010	Scientometrics	ED							Y
^Empirical	(EM); Edito	orial/Opinion (ED); Review (RE); Other (O).								
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Appendix 2: New models and metrics for assessing an individual researcher's achievement (2007-2017)

Anderson	2008	Scientometrics	Researcher	Metric	Tapered h- index	h-index	It accounts for the tapered distribution of citations.
Aragon	2013	Nature Scientific Reports	Both	Metric	Scientist impact (Φ)	Author contribution s and citation counts	Instead of the total number of citations, the proposed measure Φ (Scientist Impact) aims at discerning the genuine number of people (specifically lead authors) the paper (or first author) has had an impact upon by removing self-citation. In other words, Φ aims at measuring the paper's reach.
Assimakis	2010	Scientometrics	Researcher	Metric	The Golden Productivity Index	Author contribution and publication count	A rank dependent index that measures the productivity of an individual researcher by evaluating the number of papers as well as the rank of co-authorship. It emphasizes the first author's contribution.
Bai	2016	PLOS One	Researcher	Metric	COIRank algorithm	Network analysis	Quantifies scientific impact by reproducing the accumulated COI relationship in the scientific community. COIRank focuses on improving PageRank though setting a weight for PageRank algorithm and promotes the performance in identifying influential articles. It therefore accounts for self-citation and citation by others at the same institution.
Belikov	2015	f1000 Research	Researcher	Metric	L-index	h-index and author contribution	Accounts for co-author contribution by designating citations to each individual author according to their order on a paper. It also considers the age of publications, favoring newer ones. However, if a scientist has made a significant scientific breakthrough and ceases publications, his or her L-index will remain high regardless. It ranges from 0.0-9.9.
Bini	2008	Electronic Transactions on Numerical Analysis	Both	Metric	Information not available	Citation count	Proposes to integrate models for evaluating papers, authors, and journals based on citations, co-authorship and publications. After the one-class model for ranking scientific publications, they introduced the two-class model which ranks papers and authors, and the three-class model for ranking papers, authors, and journals.

Bollen					impact factor	;	factor from the publication year. Annual TAPSIF values of all the papers by an author can be combined to measure the overall scientific relevance of that author (temporally averaged author- specific impact factor TAASIF).
	2016	Scientometrics	Researcher	Model	Equal Allocation Model	Peer-review	A novel model in which each researcher is allocated funding and is required to donate a proportion of that funding to other researchers-hence uses crowd wisdom to fund scientists.
Caminiti	2015	BMC Health Services Research	Researcher	Metric	Information not available	Citation count	This work in progress suggests a mixture of 12 easily retrievable indicators (bibliometric and citation parameters, as well as "hidden" activities such as teaching, mentoring etc). The weighting system was constructed considering the hypothesized effort for all indicators. The chosen indicators and attributed scores still remain to be validated. Modified from Wooton, Health Res Policy Syst. 2013;11:2; Smith, Br Med J. 2001;323(7312):528–8.; and Mezrich J Am Coll Radiol. 2007;4(7):471–8.
Castelnuovo	2010	Clinical Practice & Epidemiology in Mental Health	Researcher	Metric	Single Researcher Impact Factor	F	This metric takes into account publications (journal articles, books, oral and poster presentations in scientific meetings); products (e.g., software, CD-ROM, videos, databases); and activities (reported scientific activities such as scientific positions or positions in conferences organization, participation in journal editorial boards, activities on human resources education, and participation in international funding projects). Minimum and maximum values are assigned to each task for national and international impact.
Claro	2011	Scientometrics	Researcher	Metric	The x-index	IF and author contribution	Aims to enable cross-disciplinary comparison and uses indicators of both quality and quantity, taking into account the number of publications a researcher has published, and then calculating a publication score for each. This considers number of authors on the paper and the journal's 5-year impact factor; it is also normalized by the journals in which the author tends to publish (rather than top-down classification of a field). Also uses a co-authorship share coefficient. Therefore, aims to determine relative contribution to a paper and normalize by field. While requiring only modest data extraction and processing efforts, it is not based on individual article citations but that of the journal (JIF), which can have limitations.

Cordero- Villafafila	2015	Revista de Psiquiatría y Salud Mental (English Edition)	Both	Metric	RC Algorithim	IF	The first English-language publication of this metric, it quantitatively evaluates the personal impact factor of the scientific production of isolated researchers. It also an individual form (RC γ) and group form (RC γ G), and is able to assess personal impact of individual publications, 2 or a group of them. It also provides a procedure to classify research centers of different types based on the impact (FRC γ G) made by their results amongst researchers of the same field. One of the limitations of the RC algorithm is, precisely, its dependence on said bibliographic databases, which have a strong pre-eminence of studies published in English.
Crespo	2015	PLOS One	Other	Metric	Exchange Rate	Citation count	This is an average-based indicator that is used to explore differential citation rates between disciplines by using it as a normalization factor. It is not suitable for assessing individual researchers but provides insight into comparison across disciplines.
De Witte	2010	Scientometrics	Researcher	Metric	RES-score - Research Evaluation Score	Data Envelopmen t Analysis	Authors present a methodology to aggregate multidimensional research output, using a tailored version of the non-parametric Data Envelopment Analysis model. This they claim is a more accurate representation of a research performance.
Delgadillo	2016	Family & Consumer Sciences Research Journal	Both	Metric	HLA-index	h-index	This index, actually originally published in a book by Harzing (2011), normalizes the h-index to take into account career stage and discipline.
Dodson	2012	Biochemical and Biophysical Research Communications	Researcher	Metric	SP-index	IF	This metric is said to quantify the scientific production of researchers, representing the product of the annual citation number by the accumulated impact factors of the journals in which the papers are published, divided by the annual number of published papers.
Duffy	2008	Journal of Counseling Psychology	Both	Metric	IRPI - Integrated Research Productivity Index	Citation count	This metric statistically combines an individual's author-weighted publications (AWS), average times cited by other publications (MC), and years since first publication (Y) into a comprehensive score, calculated as (AWS x MC)/Y. It thereby accounts for differences in career length.
Ebadi	2016	Scientometrics	Researcher	Model	iSEER	Machine learning	An intelligent machine learning framework for scientific evaluation of researchers (iSEER) considers various "influencing factors of different types" (e.g., funding, collaboration pattern, performance such as quantity and impact of papers, efficiency). It can be used as a complementary tool to overcome limitations in peer-review.

Ekpo	2016	Journal of Medical Imaging and Radiation Sciences	Researcher	Metric	TotalImpact	Author contribution, publication count and citation count	For each of the authors, the total number of publications in peer- reviewed journals (P), total number of citations (C), international collaboration metrics, number of citations per publication (CPP), h- index, and i10-index are extracted (using SciVal). This metric assessed whether authors were leading the research or coauthoring by judging their position in the list of authors for each article. Authors listed as first, second, or last (FSL) were classified as lead researchers, and those listed in-between as coauthors. Each author's total impact was then quantified by: TotalImpact=P×C×FSL.
Franceschini	2012	Scientometrics	Both	Metric	Information not available	Citation counts and h-index	A study specific measurement that includes the number of publications/patents and their citations and also quantifies average number of co-authors relating to publications/patents of one researcher (an indicator of tendency for co-authorship). It also uses the minimum and maximum years: the oldest publication/patent and the year relating to their latest one. This provide an indication of the temporal extension of the publishing or patenting activity of a researcher. They also use the most-cited is publication/patent of a researcher, representing the "jewel in the crown" in terms of impact/diffusion. These metrics are also scalable to teams though, where the h-spectrum is h-values to a group of researchers (including average and medium), and the h-group is the h-index of the union of publications patents associated with publications/patents.
Franceschini	2012	Scientometrics	Researcher	Metric	The Success- Index	Citation counts, NSP-index by Komulski (2011)	This metric is based on Komulski's (2011) NSP (number of successful papers) index, with the exception that for each publication the comparison term is sometimes replaced by a more appropriate indicator of propensity to cite, determined on the basis of a representative sample of publications. While it is more complicated than the original, it is insensitive to differential propensity to cite and therefore suitable for comparisons between authors of different fields.
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Frittelli	2016	Journal of the Association for Information Science and Technology	Researcher	Metric	SRM - Scientific Research Measures	h-index and calculus	Proposes a novel class of measures (SRM) based on calculus principles that rank a scientist's research performance by taking into account the whole citation curve of a researcher (their performance curve - number of citations of each publication, in decreasing order of citations). The performance cures can be chosen flexibly (e.g., to reflect seniority, characteristics of a field). They extend this idea by proposing Dual SRMs, which are based on theories of risk-measures. It better distinguishes researchers with the same citation curve.
Gao	2016	PLOS One	Both	Metric	PR-index - PageRank Index	Network analysis and h-index	This metric uses PageRank score calculation combined with h- index calculation to measure author impact. It considers publication and citation quantity but also takes a publication's citation network into consideration. This means the index will rank majority authors higher by applying PageRank based on the publication citation relationship (distinguishing higher quality citations from lower ones).
Han	2013	Institute of Strategic Studies Islamabad	Both	Metric	New Evaluation Index	Network analysis	The new evaluation index takes into account direct and indirect references, direct and indirect citations, and citation network.
Holliday	2010	International Journal of General Medicine	Article	Model	Modified Delphi technique of peer-review	Peer-review	This paper reports using the modified Delphi process to appraise and rank research applications, with experts rating each application's scientific merit, originality, the adequacy of the study design to achieve the research goals, and whether the potential impact of the study would warrant its funding. While its ease of administration, reproducibility, and accessibility makes this a useful adjunct to the traditional processes of grant selection, it does not directly assess individual researcher's but their work.
Hutchins	2016	PLOS Biology	Both	Metric	iCite	Citation count	This is used for individual articles and normalizes their citation score by adding in co-citation metrics.
Ibrahim	2015	New Library World	Both	Metric	Hx	h-index and author contribution	This metric is a hybridization of two indicators based on the individual h-index (weighted by the average number of co-authors for each paper) and h-index contemporary weighted by qualitative factors (conferences and journal in which a researcher participated or published). It accounts for the period of citations and number of authors on a paper, is applicable at all levels and for any discipline of research, takes conferences into consideration, and is thought to reduce unscientific practices such as integration of authors who have not genuinely contributed.

Ioannidis	2016	PLOS Biology	Researcher	Metric	Composite	Citation count, h- index and author contribution	A study-specific composite metric based: on total number of citations in, for example, 2013 (NC), total number of citations received in 2013 to papers for which the researcher is single author (NS), total number of citations received in 2013 to papers for which the author is single or first author (NSF), total number of citations received in 2013 to papers for which the researcher is single, first, or last author (NSFL). Added to these are the h-index and modified h-index. The indicators are standardized (NC, H, Hm, NS, NSF, NSFL), giving each a standardized value from 0 to 1, where 1 is given to the researcher with the highest raw value for the respective indicator. The six standardized indicators are then summed to generate the composite index C. Well-tested and validated using factor analysis, which yielded two factors: bulk impact (NC and H), author order and co-authorship-adjusted impact (Hm, NS, NSF, and NSFL).
Iyendar	2009	Academic Medicine	Researcher	Model	RD - Research Density and Individual Impact Factor	IF	RD measures the ability to obtain grants at a point in time, while IFF reflects the quality of research. The adopted methodology compares the impact factor of an investigator's articles with those of the top journals within their own field. Each investigator identified the top three journals in his or her field. The average impact factor of these three journals was used as the benchmark for that investigator. Each faculty member was then asked to calculate his or her own individual impact factor (IIF) for two consecutive years, using 75% of their benchmark as target. This benchmark was selected after reviewing results of comparisons of investigators' IIFs with their self-defined benchmarks at several multiples (50%, 75%, and 100%). We used 75% of the self-defined benchmark as the target, because it is unlikely for every paper to be published in the best journal in the field, and yet 75% reflects the reasonably high standard of the research quality that MSSM strives for. The data were collated and the IIF of each faculty member was computed as the ratio of his or her impact factor to 75% of his or her self-defined benchmark, expressed as a percentage.
Jeang	2008	Retrovirology	Researcher	Metric	Mentoring Index	h-index	Argues that good mentoring should be a significant consideration of one's contribution to science. It focuses on using the h-index of previous trainees in evaluating established researchers. It is thought this index could encourage the development of long-lasting mentoring relationships.
ji∋sn∃ I ∋b e	graphiquo	at Agence Biblio nologies.	یاµ9وئا€ی⊊202 d simiar tech	ະທາງ ເອກາດອີ ເອັກເອັນ	يْشام يېتىچېر ۇرىتېنىڭ) - 14 ,puinim a ،	gtirhmovibea Vieur (SBBA) Vieur stat teb bns txst o	

						P linked by pages L where L has few outgoing links are considered more important than pages P cited by pages L where L has many outgoing links). PaperRank (PR) applies page rank to papers by considering papers as web pages and citations as links, and hence trying to consider not only citations when ranking papers, but also taking into account the rank of the citing paper and the density of outgoing citations from the citing paper. The PR-Hirsch is a modification of the H-index based on the same PageRank approach. PR and PR-Hirsch are complementary to citation-based metrics, capable of capturing information present in the whole citation network, namely the "weight" (the reputation or authority) of a citing paper.
2016	Journal of Computer and Systems Sciences International	Article	Model	Information not available	Citation count and IF	Proposes a model for assessing quality in the content of individual articles using computational analysis with bibliometric and scientometric data (number of citations and the journal's IF).
2014	PLOS One	Article	Metric	l-index	h-index	This index considers the most elite papers and rewards papers of high impact and based on the form of the citation distribution. It is thought to outperform the h-index in terms of accuracy and sensitivity to the form of the citation distribution, while being strongly correlated with other important h-type indices. It rewards the more regular and reliable researchers.
2015	IEEE International Conference on Smart City/SocialCom/ SustainCom	Both	Model	Temporal tracking model		The temporal research evolution model takes into account individual output, researcher profile and experiences
abuuda 16	ondra sonega as seigoloni	loet nslimis l	bns ,gnini	An http://www.	erieur (SBBA) Stieur (SBBA) Steb bus txet og	Protected by copyright, including for use of the second states related by copyright, including for uses related the second states of the second states and
	2014	2016 Journal of Computer and Systems Sciences International 2014 PLOS One 2015 IEEE International Conference on Smart City/SocialCom/ SustainCom	2016 Journal of Computer and Systems Sciences International 2014 PLOS One Article 2015 IEEE Both International Conference on Smart City/SocialCom/ SustainCom	Computer and Systems Sciences International 2014 PLOS One Article Metric 2015 IEEE Both Model International Conference on Smart City/SocialCom/ SustainCom	2016 Journal of Computer and Systems Sciences International Article Model Information not available 2014 PLOS One Article Metric I-index 2015 IEEE International Conference on Smart City/SocialCom/ SustainCom Both Model Temporal tracking model	2016 Journal of Computer and Systems Sciences International Article Model Information not available Citation count and IF 2014 PLOS One Article Metric I-index h-index 2015 IEEE International Conference on Smart City/SocialCom/ Both Model Temporal tracking model

Lippi	2017	Annals of Translational Medicine	Researcher	Metric	SIF-Scientist Impact Factor	IF	This metric is calculated as all citations of articles published in the two years following the publication year of the articles, divided by the overall number of articles published in that year. For example, the SIF for the year 2017 would be obtained by dividing all citations in the years 2015–2016 to articles published in the year 2014, divided by the overall number of articles published in the year 2014. The total number of recent citations is normalized according to the number of recently published articles, limiting the bias emerging from publishing a large number of scarcely cited articles; and the output measure reliably reflects the recent scientific impact of the scientist, so complementing an overall career indicator, such as the h-index.
Markpin	2008	Scientometrics	Other	Metric	Article-Count Impact Factor	IF	This is proposed as a journal-level metric that is calculated as the total number of articles cited in the current year divided by the number of articles published in 1st and 2nd year. Note that is based on the number of articles that were cited, rather than the times cited of the cited articles. However, it could be used for individual researchers.
Matsas	2012	Brazilian Journal of Physics	Both	Metric	NIF - Normalized Impact Factor	IF	Introduces a normalized impact factor that looks at the researchers influence on their scientific community by assessing the degree to which they have been influenced by their community. Looks each of an author's publications, the number of co-authors, references in the article and citations it has received. From the way it is calculated: "in a closed community of identical individuals (i.e., who publish, reference and are cited by each other at the same rate), all members have NIF = 1." Leaders in a field are then those with a NIF greater than or equal to 1 i.e., they influence their peers at least as much as they are influenced by them.
Maunder	2007	La Revue Canadienne de Psychiatrie	Article	Metric	Citation Ratio	Citation count	This metric is designed to overcome systematic differences amongst niche fields by comparing the impact of a particular paper to the average impact of a paper in its journal. A ratio above 1 indicates relatively greater success.
Mazloumian	2011	PLOS One	Article	Metric	Boost Factor	Citation count	This metric calculates when a particular research gains scientific authority, that is, they publish some groundbreaking work that then leads to an upswing in citations of their earlier papers. It is able to model the trend of the "rich get richer", a cascade of citations and is too improve the "signal-to-noise" ratio in citation rates by detecting sudden changes in citations.

Milone	2016	American Journal of Orthopedics	Article	Metric	Information not available	Publication count	A study specific measurement simply calculated by taking the mean of first and last authored publications.
Моојі	2014	Scientometrics	Both	Model	Information not available	Peer-review, altmetrics, citation count	This paper proposes a comprehensive and new framework for assessing research quality assessment which utilizes intrinsic (i.e., the internal quality of a publication) and extrinsic indicators (i.e., citation counts, web-based influence). It uses peer-review ratings for the former and bibliometric and altmetric data at the individual article and author levels for the latter. One limit includes that the assessment of extrinsic factors is still biased in terms of multi- author papers. This framework builds in a quality check on peer- review.
Moreira	2015	PLOS One	Researcher	Metric	μ Q	Information not available	Suggests accumulated citations from an author's aggregated publications follow an asymptotic number, and then use a lognormal model. Creates μ as a scale of expected citability of a researcher's publication. It is able to be used at all career stages and indicates more of quality over quantity.
Morel	2009	PLOS Neglected Tropic Diseases	Researcher	Metric	Information not available	Network Analysis	Co-citation networks generated using SNA of publications, to identify groups and individuals with high collaboration rates.
Niederkroten thaler	2011	BMC Public Health	Article	Model	Information not available	Information not available	A tool designed to measure the societal impact of research publications. It consists of three quantitative dimensions: (1) the aim of a publication, (2) the efforts of the authors to translate their research results, and, if translation was accomplished, (3) (a) the size of the area where translation was accomplished (regional, national or international), (b) its status (preliminary versus permanent) and (c) the target group of the translation (individuals, subgroup of population, total population).
Nosek	2010	Personality and Social Psychology Bulletin	Researcher	Metric	Ics- Individual researcher career-stage impact	Citation count	Produces career-stage metric of scientific impact based on citation counts. Its development was based on extensive data collection to produce a regression of expected growth of impact over time. It, therefore, reflects the distance from one's expected impact at a given career stage.
Pagani	2015	Scientometrics	Article	Metric	Methodi Ordinatio	IF	Based on IF, number of citations and year of publication in a normalized, weighted mathematical equation. It is a potential way to define scientific relevance.

Pan	2014	Science Reports	Researcher	Metric	Author Impact Factor (AIF)		Defined as the AIF of an author A in year t is the average number of citations given by papers published in year t to papers published by A in a period of Δt years before year t. Uses a time window of years for calculation.
Patel	2013	Journal of the Royal Society of Medicine	Researcher	Model	sRM - statistical Regression Model	Citation count	Used to estimate the number of high visibility (based on citation count) publications of each researcher.
Рере	2012	PLOS One	Researcher	Metric	TORI - Total Research Impact	Citation count	Includes non-self-citations accrued by the researcher, number of authors on cited paper, and number of bibliographic references to generate the cumulative output of a scholar by summing the impact of every external citation accrued in his/her career. This removes biases associated with citation counts.
Petersen	2013	Journal of Informetrics	Researcher	Metric	Z	h-index	Z is aimed at correcting the h-index's penalty (which in some cases neglects 75% of an author's body of work) by including the total number of citations for their work in the metric.
Põder	2017	Trames-Journal of the Humanities and Social Sciences	Researcher	Metric	(Current or predicted) impact rate of researcher		Based on the citations per year squared, this metric provides a means of assessing acceleration/impact and is based on time series data. This is more sensitive to productivity overtime and can go down unlike the h-index.
Prathap	2014	Scientometrics	Researcher	Metric	Z-index	h-index	Purporting to include quality, quantity and consistency, it accounts for the high-end of research performance, while compensating for the skewness of citation-publication distributions.
Radicchi	2008	Proceedings of the National Academy of Sciences of the United States of America	Article	Metric	Relative Indicator - cf	Citation count	The relative indicator is used to deal with the fact that different fields have different citation patterns and allows for comparisons of the success of articles in different fields.
Ribas	2015	Proceedings of the 24th International Conference on World Wide Web	Both	Metric	P-score	Citation count	It associates a reputation with publication venues based on the publication patterns of reference groups, composed by researchers, in a given area of knowledge. Although the choice of reference groups can be made by using available citation data, the P-score metric itself does not depend on citation data. It uses just publication records of researchers and research groups; that is, the papers and the venues where they published in.

Ricker	2009	Interciencia	Researcher	Model	Rule-based peer-review	Peer-review	Computer generated peer-review, which is positive as researchers get peer-review feedback. Can also measure evaluators select certain criteria of interest, important journals of interest based on field.
Ruane	2009	Scientometrics	Both	Metric	h1-index	h-index	A measure of supervision quality, it gives the supervisor h1 index calculated by the h-indexes of their PhD students.
Sahoo	2017	Omega	Researcher	Model	Composite indicator	h-index, IF, citation counts	Calculated based on the relative weight of the six indicators of journal tier, total citations, author h-index, number of papers, impact factor, and journal h-index.
Saxena	2013	Journal of Pharmacology Pharmacotherape utics	Researcher	Metric	ORPI - Original Research Publication Index	Citation count	Indicates originality, productivity, and visibility, by including total number of original articles, citations, accounting for self-citations, and the total number of citable articles (i.e., including reviews and case reports). Also accounts for author order and career length.
Sibbald	2015	Journal of the Medical Library Association	Both	Model	Modified approach to citation analysis	Citation count	Includes grey literature in the citation analysis search process and involves quantitative and qualitative methods of analysis to gain a better understanding of how a research paper was used. However, this is more expensive and time consuming than traditional metrics.
Sittig	2015	MEDINFO 2015: eHealth- enabled Health	Researcher	Model	The Biomedical Informatics Researchers ranking website	Information not available	This new system was developed to overcome previous scientific productivity ranking strategies. However, it is limited to biomedical informatics.
Sorenson	2011	Journal of Parkinson's Disease	Both	Metric	"Broad impact" citations	Citation count	Citations from those outside the field are used as a measure of broader impact.
Surla	2017	The Electronic Library	Researcher	Metric	Research Impact Factor	IF	Allows a measure of scientific influence of a researcher in their relative scientific area.
Szymanski	2012	Information Sciences	Both	Metric	CENTs - sCientific currENcy Tokens and the I-index	Citation count and h- index	An accumulation of "cents" based on the number of non-self- citations. This is also the premise behind the i-index, whereby papers a ranked according to CENTs rather than just all citations.

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Гаn	2016	The Annals of Applied Statistics	Article	Model	Information not available	Citation count	Proposes to use two established models in the creation of a third. The proposed model provides a structural understanding of the field variation in citation behavior and a measure of visibility for individual articles adjusted for citation probabilities within/between topics.
Vieira	2011	Scientometrics	Researcher	Metric	hnf-index	h-index	Considers the different cultures of citation of each field and the number of authors per publication, and hence can be used to measure researcher performance.
Wagner	2012	Research Evaluation	Researcher	Metric	I3 - Integrated impact indicator	Citation count	A framework for integrating citations and non-parametric statistics of percentiles, which allow highly cited papers to be weighted more than less-cited ones.
Waltman	2013		Article	Metric	HCP – Highly cited publications index	Citation count	A simple model in which the number of citations of a publication depends not only on the scientific impact of the publication but also on other 'random' factors. Does not account for productivity.
Wang	2013	Science	Article	Model	Mechanistic model for citation dynamics	Citation count	Authors demonstrate a predictable course for citations of single articles over time, purporting, therefore, to create more reliable predictive index of individual impact.
Williamson	2008	Family Medicine	Researcher	Metric	Information not available	Too broad to classify	Quantifies activities within three domains: teaching, service and research and scholarly activity. A time intensive- process that is suitable for promotion within institutions, but not grant funding or more macro-scale assessments.
Wootton	2013	Health Research Policy and Systems	Researcher	Metric	R - Simple indicator of researcher output		Formula is R=g+p+s and comprises grant income (g), publications (peer-reviewed and weighted by JIF; p) and numbers of PhD students supervised (no credit for submission after the due date of submission; s).
Yaminfirooz	2015	The Electronic Library	Both	Metric	mh-index	h-index	Use to identify differences in the impact of authors with the same h-index, and differences between the outputs of influential researchers working in a certain field and the ones publishing only a few papers during a year, can track the impact of highly cited papers.
Yang	2013	Journal of Informetrics	Researcher	Metric	A-index - Axiomatic approach	Citation count and author contribution	Allows for evaluation of individual researcher in the team context (i.e., co-authorship networks).

Zhang	2012	Scientometrics	Both	Model	Scientometric age pyramid	Information not available	Accounts for the different ages of academics, different fields, co- authorship patterns and analysis of journals. The pyramid represents the number of publications on one side and number of citations on the other side.
Zhou	2012	New Journal of Physics	Both	Metric	AP Algorithm	Citation count	Considers the prestige of the scientists citing the article but assumes equal contribution of each author to the paper.
Zhu	2015	arXiv	Researcher	Metric	The hip index - Influence- primed h- index	h-index	The hip-index weights citations by how many times a reference is mentioned, which is thought to make it a better indicator of researcher performance.
Zhuo	2008	Omega	Other	Metric	Z factor	IF	Uses both the number of publications and the impact factors of the journals in which they were published.
Zou	2016	Scientometrics	Researcher	Metric	S-ZP index	IF	Metric based on journal impact factor of publications and author order.
Zycxkowski	2010	Scientometrics	Both	Metric	C - Citation matrix	h-index	A scheme based on weighing the citation based on previous
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Reporting checklist for systematic review and Based on the PRISMA guidelines. Instructions to authors Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below. Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" an provide a short explanation. Upload your completed checklist as an extra file when you submit to a journal. In your methods section, say that you used the PRISMA reporting guidelines, and cite them as: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement Reporting Item Page Num

meta-analysis.

29	Systematic Revie	ws all	u Mela-Analyses. The PRISMA Statement		and
30 31			Reporting Item	Page Nu	m
32 33 34 35		<u>#1</u>	Identify the report as a systematic review, meta- analysis, or both.	Title page	mining, Al tı
36 37 38 39 40 41 42 43 44 45 46	Structured summary	<u>#2</u>	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number	2	nining, Al training, and similar technologies
47 48 49 50	Rationale	<u>#3</u>	Describe the rationale for the review in the context of what is already known.	4	ÿ.
51 52 53 54 55 56 57	Objectives	<u>#4</u>	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4-5	
58 59 60	Protocol and	<u>#5</u> For	Indicate if a review protocol exists, if and where it r peer review only - http://bmjopen.bmj.com/site/about/guidelines.xh	Review protocol	

<u>#6</u> <u>#7</u>	can be accessed (e.g., Web address) and, if available, provide registration information including the registration number. Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rational	exists but is unpublished as 10.1136/bm/open-2018-025320 on 30 March 2019. Downloaded from Superieur (AB 4 4 4 4-6
	follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rational	5-6 5-6
<u>#7</u>		tec
	Describe all information sources in the search (e.g., databases with dates of coverage, contact with study authors to identify additional studies) and date last searched.	/bmjopen-2018-025320 on 30 March 2019. I Protected by copyright, including for uses 4 4 4
<u>#8</u>	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	uding for uses i 4
<u>#9</u>	State the process for selecting studies (i.e., for screening, for determining eligibility, for inclusion in the systematic review, and, if applicable, for inclusion in the meta-analysis).	
<u>#10</u>	Describe the method of data extraction from reports (e.g., piloted forms, independently by two reviewers) and any processes for obtaining and confirming data from investigators.	5-6 and Appendix 1 mining, Al training, Al training Page 5 and Appendar
<u>#11</u>	List and define all variables for which data were sought (e.g., PICOS, funding sources), and any assumptions and simplifications made.	Page 5 and Appendix on June 1 1 3,
<u>#12</u>	Describe methods used for assessing risk of bias in individual studies (including specification of whether this was done at the study or outcome level, or both), and how this information is to be used in any data synthesis.	g, Al trainingPage 5 and Appendiand155The primary outcomemeasure wasmethods to assess
<u>#13</u>	State the principal summary measures (e.g., risk ratio, difference in means).	The primary outcome measure was methods to assess research achievement.
	#9 #10 #11 #12 #13	 last searched. #8 Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated. #9 State the process for selecting studies (i.e., for screening, for determining eligibility, for inclusion in the systematic review, and, if applicable, for inclusion in the meta-analysis). #10 Describe the method of data extraction from reports (e.g., piloted forms, independently by two reviewers) and any processes for obtaining and confirming data from investigators. #11 List and define all variables for which data were sought (e.g., PICOS, funding sources), and any assumptions and simplifications made. #12 Describe methods used for assessing risk of bias in individual studies (including specification of whether this was done at the study or outcome level, or both), and how this information is to be used in any data synthesis. #13 State the principal summary measures (e.g., risk

Page 71 of 71			BMJ Open)pen: fir
1 2 3 4 5 6 7	Planned methods of analyis	<u>#14</u>	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I2) for each meta- analysis.	5-6Superieur (ABES) - Superieur (ABES) - 7-11Protected by copyright, including for uses related to text and data mining, Al training, and similar technologies.6-77-11557-11Not applicable to this review.5Not applicable to this review.
7 8 9 10 11 12	Risk of bias across studies	<u>#15</u>	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	36/bmjopen-20 Protected by 5
13 14 15 16 17	Additional analyses	<u>#16</u>	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	7-11 7-11 7-11
18 19 20 21 22 23 24	Study selection	<u>#17</u>	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	Dompiopen-2018-025320 on 30 March 2019. Download Protected by copyright, including for uses related to 6-7 7-11 7-11
25 26 27 28 29	Study characteristics	<u>#18</u>	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citation.	7-11 7-11
30 31 32 33 34 35	Risk of bias within studies	<u>#19</u>	Present data on risk of bias of each study and, if available, any outcome-level assessment (see Item 12).	data mining, A
36 37 38 39 40 41	Results of individual studies	<u>#20</u>	For all outcomes considered (benefits and harms), present, for each study: (a) simple summary data for each intervention group and (b) effect estimates and confidence intervals, ideally with a forest plot.	7-11 7-11 Not applicable to the chnologies. review.
42 43 44 45 46 47 48 49 50	Synthesis of results	<u>#21</u>	Present the main results of the review. If meta- analyses are done, include for each, confidence intervals and measures of consistency.	Not applicable to the chnologies
	Risk of bias across studies	<u>#22</u>	Present results of any assessment of risk of bias across studies (see Item 15).	5 s
51 52 53 54 55 56	Additional analysis	<u>#23</u>	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	Not applicable to this review.
57 58 59 60	Summary of Evidence	<u>#24</u> For	Summarize the main findings, including the strength of evidence for each main outcome; consider their peer review only - http://bmjopen.bmj.com/site/about/guidelines.xh	13-16 Enseignement

relevance to key groups (e.g., health care providers,

		users, and policy makers	
Limitations	<u>#25</u>	Discuss limitations at study and outcome level (e.g., risk of bias), and at review level (e.g., incomplete retrieval of identified research, reporting bias).	16
Conclusions	<u>#26</u>	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	16-17
Funding	<u>#27</u>	Describe sources of funding or other support (e.g., supply of data) for the systematic review; role of funders for the systematic review.	18
CC-BY. This chec	cklist c	s distributed under the terms of the Creative Commons an be completed online using <u>https://www.goodreports</u> in collaboration with <u>Penelope.ai</u>	

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BMJ Open

The Comprehensive Researcher Achievement Model (CRAM):

a framework for measuring researcher achievement, impact and influence derived from a systematic literature review of metrics and models

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Primary Subject Heading :	Research methods
Secondary Subject Heading:	Health services research
Keywords:	Researcher assessment, Research metrics, h-index, Journal impact factor, Comprehensive Researcher Achievement Model (CRAM), Citat
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1	The Comprehensive Researcher Achievement Model (CRAM):		
2	a framework for measuring researcher achievement, impact and influence derived from		
3	a systematic literature review of metrics and models		
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1 2		
- 3 4	34	ABSTRACT
5	35	Objectives Effective researcher assessment is key to decisions about funding allocations,
6 7	36	promotion and tenure. We aimed to identify what is known about methods for assessing
8 9	37	researcher achievements, leading to a new composite assessment model.
10 11	38	Design We systematically reviewed the literature via the Preferred Reporting Items for
12	39	Systematic Review and Meta-Analysis Protocols (PRISMA-P) framework.
13 14	40	Data sources All Web of Science databases (including Core Collection, MEDLINE, and
15 16	41	BIOSIS Citation Index) to the end of 2017.
17 18	42	Eligibility criteria (1) English language, (2) published in the last 10 years (2007-2017), (3)
19 20	43	full text was available, and (4) the article discussed an approach to the assessment of an
21	44	individual researcher's achievements.
22 23	45	Data extraction and synthesis Articles were allocated amongst four pairs of reviewers for
24 25	46	screening, with each pair was randomly assigned 5% of their allocation to review
26 27	47	concurrently against inclusion criteria, with inter-rater reliability assessed using Cohen's
28	48	Kappa (κ). The κ statistic showed agreement ranged from moderate to almost perfect
29 30	49	(0.4848-0.9039). Following screening, selected articles underwent full text review and bias
31 32	50	assessed.
33 34	51	Results Four hundred and seventy-eight articles were included in the final review.
35	52	Established approaches developed prior to our inclusion period (e.g., citations and outputs, h-
36 37 38 39 40 41	53	index, journal impact factor), remained dominant in the literature and in practice. New
	54	bibliometric methods and models emerged in the last 10 years including: measures based on
	55	PageRank algorithms or "altmetric" data, methods to apply peer judgement, and techniques to
42	56	assign values to publication quantity and quality. Each assessment method tended to
43 44	57	prioritize certain aspects of achievement over others.
45 46	58	Conclusions All metrics and models focus on an element or elements, at the expense of
47 48	59	others. A new composite design, the Comprehensive Researcher Achievement Model
49	60	(CRAM) is presented which supersedes past anachronistic models. The CRAM is modifiable
50 51	61	to a range of applications.
52 53	62	Keywords: Researcher assessment; Research metrics; h-index; Journal impact factor;
54 55	63	citations; outputs; Comprehensive Researcher Achievement Model (CRAM)
56	64	
57 58	65	Article Summary
59 60	66	Strengths and limitations of this study

1 2		
2 3 4	67	• A large, diverse dataset of over 478 articles, containing many ideas for assessing
5	68	researcher performance, was analyzed
6 7	69	• Strengths of the review include executing a wide-ranging search strategy, and the
8 9	70	consequent high number of included articles for review; the results are limited by the
10 11	71	literature itself, e.g., new metrics were not mentioned in the articles, and therefore not
12	72	captured in the results
13 14	73	• A new model combining multiple factors to assess researcher performance is now
15 16	74	available
17 18	75	• Its strengths include combining quantitative and qualitative components in the one
19	76	model
20 21	77	• The CRAM model, despite being evidence-oriented, is a generic one and now needs
22 23	78	to be applied in the field
24 25		to be applied in the field
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79 INTRODUCTION

Judging researchers' achievements and academic impact continues to be an important means of allocating scarce research funds and assessing candidates for promotion or tenure. It has historically been carried out through some form of expert peer judgement, to assess the number and quality of outputs, and in more recent decades, citations to them. This approach requires judgements regarding the weight which should be assigned to the number of publications, their quality, where they were published, and their downstream influence or impact. There are significant questions about the extent to which human judgement based on these criteria is an effective mechanism for making these complex assessments in a consistent and unbiased way.(1-3) Criticisms of peer assessment, even when underpinned by relatively impartial productivity data, include the propensity for bias, inconsistency among reviewers, nepotism, group-think and subjectivity.(4-7)

To compensate for these limitations, approaches have been proposed that rely less on subjective judgement and more on objective indicators.(3, 8-10) Indicators of achievement focus on one or a combination of four aspects: quantity of researcher outputs (*productivity*); value of outputs (*quality*); outcomes of research outputs (*impact*); and relations between publications or authors and the wider world (influence).(11-15) Online publishing of journal articles has provided the opportunity to easily track citations and user interactions (e.g., number of article downloads) and thus has provided a new set of indices against which individual researchers, journals and articles can be compared and the relative worth of contributions assessed and valued.(14) These relatively new metrics have been collectively termed *bibliometrics*(16) when based on citations and numbers of publications, or *altmetrics*(17) when calculated by alternative online measures of impact such as number of downloads or social media mentions.(16)

The most established metrics for inferring researcher achievement are the h-index and the Journal Impact Factor (JIF). The JIF measures the average number of citations of an article in the journal over the previous year, and hence is a good indication of journal quality but is increasingly regarded as a primitive measure of quality for individual researchers.(18) The h-index, proposed by Hirsch in 2005,(19) attempts to portray a researcher's productivity and impact in one data point. The h-index is defined as the number (h) of articles published by a researcher that have received a citation count of at least h. Use of the h-index has become widespread, reflected in its inclusion in author profiles on online databases such as Google Scholar and Scopus.

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Also influenced by the advent of online databases, there has been a proliferation of other assessment models and metrics,(16) many of which purport to improve upon existing approaches.(20, 21) These include methods that assess the impact of articles measured by: downloads or online views received; practice change related to specific research; take-up by the scientific community; or mentions in social media.

Against the backdrop of growth in metrics and models for assessing researchers' achievements, there is a lack of guidance on the relative strengths and limitations of these different approaches. Understanding them is of fundamental importance to funding bodies that drive the future of research, tenure and promotion committees, and more broadly for providing insights into how we recognize and value the work of science and scientists, particularly those researching in medicine and healthcare. This review aimed to identify approaches to assessing researchers' achievements published in the academic literature over the last 10 years, considering their relative strengths and limitations and drawing on this to propose a new composite assessment model.

30 127 **METHOD**

128 Search Strategy

All Web of Science databases (eight in total, including Web of Science Core Collection, MEDLINE, and BIOSIS Citation Index) were searched using terms related to researcher achievement (researcher excellence, track record, researcher funding, researcher perform*, relative to opportunity, researcher potential, research* career pathway, academic career pathway, funding system, funding body, researcher impact, scientific* productivity, academic productivity, top researcher, researcher ranking, grant application, researcher output, *h*index, i*index, impact factor, individual researcher*) and approaches to its assessment (model, framework, assess*, evaluat*, *metric*, measur*, criteri*, citation*, unconscious bias, rank*) with "*" used as an unlimited truncation to capture variation in search terms, as seen in Appendix 1. These two searches were combined (using "and") and results were downloaded into EndNote, the reference management software.

5455140 Study Selection

After removing duplicate references in EndNote,(22) articles were allocated amongst pairs of
reviewers (MB-JCL, CP-CB, KL-JH, KC-LAE) for screening against inclusion criteria.
Following established procedures,(23, 24) each pair was randomly assigned 5% of their

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allocation to review concurrently against inclusion criteria, with inter-rater reliability assessed using Cohen's Kappa (κ). The κ statistic was calculated for pairs of researchers, with agreement ranging from moderate to almost perfect (0.4848-0.9039).(25) Following the abstract and title screen, selected articles underwent full text review. Reasons for exclusion were recorded.

13 149 Inclusion Criteria

The following inclusion criteria were operationalized: (1) English language, (2) published in the last 10 years (2007-2017), (3) full text for the article was available, and (4) the article discussed an approach to the assessment of an individual researcher's achievements (at the researcher or singular output-level). The research followed the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) framework.(26) Empirical and non-empirical articles were included, because many articles proposing new approaches to assessment, or discussing the limitations of existing ones, are not level one evidence or research-based.

158 **Data Extraction**

Data from the included articles were extracted, including: the country of article origin, the characteristics of the models or metrics discussed, the perspective the article presented on the metric or model (positive, negative, indeterminable) including any potential benefits or limitations of the assessment model (and if these were perceived or based on some form of evidence). A customised data extraction sheet was developed in Microsoft Excel, trialed among members of the research team and subsequently refined. This information was synthesized for each model and metric identified through narrative techniques. The publication details and classification of each paper are contained in **Appendix 2**.

167 Appraisal of the Literature

Due to the prevalence of non-empirical articles in this field (e.g., editorial contributions, commentaries), it was determined that a risk of bias tool such as the Quality Assessment Tool could not be applied.(27) Rather, assessors were trained in multiple meetings (October 24, October 30, November 13, 2017) to critically assess the quality of articles. Given the topic of the review (focusing on the publication process), the type of models and metrics identified (i.e., more metrics that use publication metrics) may influence the cumulative evidence and

- 174 subsequently create a risk of bias. In addition, three researchers (JH, EM, CB) reviewed every
- 175 included article, to extract documented conflicts of interests of authors.
- 176 Patient and public involvement

177 Patients and the public were not involved in this systematic review.

12 178 **RESULTS**

 179 The final dataset consisted of 478 academic articles. The data screening process is presented180 in Figure 1.

181 Figure 1. Data screening and extraction process for academic articles 182 <Insert Figure 1>

Of the 478 included papers (see Appendix 2 for a summary), 295 (61.7%) had an empirical component, which ranged from interventional studies that assessed researcher achievement as an outcome measure (e.g., a study measuring the outcomes of a training program),(28) as a predictor(29-31) (e.g., a study that demonstrated the association between number of citations early in one's career and later career productivity), or reported a descriptive analysis of a new metric. (32, 33) One hundred and sixty-six (34.7%) papers were not empirical, including editorial or opinion contributions that discussed the assessment of research achievement, or proposed models for assessing researcher achievement. Seventeen papers (3.6%) were reviews that considered one or more elements of assessing researcher achievements. The quality of these contributions ranged in terms of the risk of bias in the viewpoint expressed. Only for 19 papers (4.0%) did the authors declare a potential conflict of interest.

Across the study period, 78 articles (16.3%) involved authors purporting to propose new models or metrics. Most articles described or cited pre-existing metrics and largely discussed their perceived strengths and limitations. Figure 2 shows the proportion of positive or negative discussions of five of the most common approaches to assessing an individual's research achievement (altmetrics, peer-review, h-index, simple counts, and JIF). The approach with most support was altmetrics (51.0% of articles mentioning altmetrics). The JIF was discussed with mostly negative sentiments in relevant articles (69.4%).

Figure 2. Percentages of positive and negative discussion regarding selected commonly
 used metrics for assessing individual researchers (n=478 articles)

59 205 <Insert Figure 2>

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Legend: Positive discussion refers to articles that discuss the metric in a favorable light or focus on the strengthsof the metric; negative discussion refers to articles that focus on the limitations or shortcomings of the metric.

208 Citation-Based Metrics

Publication and Citation Counts

One hundred and fifty-three papers (32.0%) discussed the use of publication and citation counts for purposes of assessing researcher achievement, with papers describing them as a simple "traditional but somewhat crude measure",(34) as well as the building blocks for other metrics.(35) A researcher's number of publications, commonly termed an n-index,(36) was suggested by some to indicate researcher productivity, (14) rather than quality, impact or influence of these papers.(37) On the other hand, the literature suggested that numbers of citations indicated the academic impact of an individual publication or researcher's body of work, calculated as an author's cumulative or mean citations per article.(38) Some studies found support for the validity of citation counts and publications in that they were correlated with other indications of a researcher's achievement, such as awards and grant funding, (39, 40) and predictive of long term success in a field.(41) For example, one paper argued that having larger numbers of publications and being highly cited early in one's career predicted later high quality research.(42)

A number of limitations of using citation or publication counts was observed. For example, Minasny et al. (2013) highlighted discrepancies between publications and citations counts in different databases because of their differential structures and inputs.(43) Other authors(38, 44, 45) noted that citation patterns vary by discipline, which they suggested can make them inappropriate for comparing researchers from different fields. Average citations per publication were reported as highly sensitive to change or could be skewed if, for example, a researcher has one heavily-cited article. (46, 47) A further disadvantage is the lag-effect of citations. (48, 49) and that in most models citations and publications count equally for all co-authors, despite potential differential contributions.(50) Some also guestioned the extent to which citations actually indicated quality or impact, noting that a paper may influence clinical practice more than academic thinking.(51) Indeed, a paper may be highly cited because it is useful (e.g., a review), controversial, or even by chance, making citations a limited indication of quality or impact.(40, 50, 52) In addition to limitations, numerous authors made the point that focusing on citation and publication counts can have unintended, negative consequences for the assessment of researcher achievement, potentially leading to gaming and manipulation, including self-citations and gratuitous authorship.(53, 54)

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Singular Output-Level Approaches

Forty-one papers (8.6%) discussed models and metrics at the singular output or article-level that could be used to infer researcher achievement. The components of achievement they reported assessing were typically quality or impact. (55, 56) For example, some papers reported attempts to examine the quality of a single article by assessing its content.(57, 58) Among the metrics identified in the literature, the immediacy index (II) focused on impact by measuring the average number of cites an article received in the year it was published.⁽⁵⁹⁾ Similarly, Finch suggested adapting the Source Normalized Impact per Publication (SNIP; a metric used for journal-level calculations across different fields of research) to the article-level.(21)

Many of the article-level metrics identified could also be upscaled to produce researcher-level indications of academic impact. For example, the sCientific currENcy Tokens (CENTs), proposed by Szymanski et al. (2012), involved giving a "cent" for each new non-self-citation a publication received; CENTs are then used as the basis for the researcher-level i-index, which follows a similar approach as the h-index, but removes self-citations.⁽⁶⁰⁾ The TAPSIF (Temporally-Averaged Paper-Specific Impact Factor) calculates an article's average number of citations per year combined with bonus cites for the publishing journal's prestige, and can be aggregated to measure the overall relevance of a researcher (Temporally Averaged Author-Specific Impact Factor; TAASIF).(61)

Journal impact factor

The JIF, commonly recognized as a journal-level measure of quality,(59, 62-64) was discussed in 211 (44.1%) of the papers reviewed in relation to assessing singular outputs or individual researchers. A number of papers described the JIF being used informally to assess an individual's research achievement at the singular output-level, and formally in countries such as France and China.(65) It implies article quality because it is typically a more competitive process to publish in journals with high impact factors.(66) Indeed, the JIF was found to be the best predictor of a paper's propensity to receive citations.(67)

The JIF has a range of limitations when used to indicate journal quality.(68) including that it is disproportionally affected by highly cited, outlier articles, (41, 69) and is susceptible to "gaming" by editors.(17, 70) Other criticisms focused on using the JIF to assess individual articles or the researchers who author them.(71) Some critics claimed that using the JIF to measure an individual's achievement encourages researchers to publish in higher-impact but

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less-appropriate journals for their field—which ultimately means their article may not be read by relevant researchers.(72, 73) Furthermore, the popularity of a journal was argued to be a poor indication of the quality of any one article, with the citation distributions for calculating JIF found to be heavily skewed (i.e., a small subset of papers receive the bulk of the citations while some may receive none).(18) Ultimately, many commentators argued that the JIF is an inappropriate metric to assess individual researchers because it is an aggregate metric of a journal's publication, and expresses nothing about any individual paper.(21, 49, 50, 74) However, Bornmann et al. (2017) suggested one case in which it would be appropriate to use JIF for assessing individual researchers: in relation to their recently published papers that had not had the opportunity to accumulate citations.(75) Researcher-Level Approaches h-index

The h-index was among the most commonly discussed metrics in the literature (254 [53.1%] of the papers reviewed); in many of these papers, it was described by authors as more sophisticated than citation and publication counts, but still straightforward, logical and intuitive.(76-78) Authors noted its combination of productivity (h publications) and impact indicators (h citations) as being more reliable(79, 80) and stable than average citations per publications(41) because it is not skewed by the influence of one popular article.(81) One study found that the h-index correlated with other metrics more difficult to obtain.(78) It also showed convergent validity with peer-reviewed assessments(82) and was found to be a good predictor of future achievement.(41)

However because of the lag-effect with citations and publications, the h-index increases with a researcher's years of activity in the field, and cannot decrease, even if productivity later declines.(83) Hence, numerous authors suggested it was inappropriate for comparing researchers at different career stages,(84) or those early in their career.(70) The h-index was also noted as being susceptible to many of the critiques leveled against citation counts, including potential for gaming, and inability to reflect differential contributions by co-authors.(85) Because disciplines differ in citation patterns(86) some studies noted variations in author h-indices between different methodologies(87) and within medical subspecialties.(88) Some therefore argued that the h-index should not be used as the sole measure of a researcher's achievement.(88)

h-index variants

1 2						
3	303	A number of modified versions of the h-index were identified; these purported to draw on its				
4 5	304	basic strengths of balancing productivity with impact while redressing perceived limitations.				
6 7	305	For example, the g-index measures global citation performance,(89) and was defined				
8 9	306	similarly to the h-index but with more weight given to highly cited articles by assuming the				
10	307	top g articles have received at least g ² citations.(90) Azer and Azer (2016) argued it was a				
11 12	308	more useful measure of researcher productivity.(91) Another variant of the h-index identified,				
13 14	309	the m-quotient, was suggested to minimize the potential to favor senior academics by				
15 16	310	accounting for the time passed since a researcher has begun publishing papers.(92, 93) Other				
17	311	h-index variations reported in the articles reviewed attempted to account for author				
18 19	312	contributions, such as the h-maj index, which includes only articles in which the researcher				
20 21	313	played a core role (based on author order); and the weighted h-index, which assigns credit				
22 23	314	points according to author order.(89, 94)				
24 25 26	215	Description Lange of which Citation Barred Matrice				
	315	Recurring Issues with Citation-Based Metrics				
27 28	316	The literature review results suggested that no one citation-based metric was ideal for all				
29 30	317	purposes. All of the common metrics examined focused on one aspect of an individual's				
31	318	achievement, and thus failed to account for other aspects of achievement. The limitations				
32 33	319	with some of the frequently used citation-based metrics are listed in Box 1.				
34 35	320					
36	321	Box 1. Common limitations in the use of citation-based metrics				
37 38		1. Challenges with reconciling differences in citation patterns across varying fields of				
39 40		study				
41		 Time-dependency issues stemming from differences in career length of researchers Prioritizing impact over merit, or quality over quantity, or vice versa 				
42 43		4. The lag-effect of citations				
44		5. Gaming and the ability of self-citation to distort metrics				
45 46		6. Failure to account for author order				
47		7. Contributions from authors to a publication are viewed as equal when they may not				
48 49		be				
50		8. Perpetuate "publish or perish" culture				
51 52	222	9. Potential to stifle innovation in favor of what is popular				
53 54	322					
55 56	323	Non-Citation Based Approaches				
57 58	324	altmetrics				
59 60						

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In contradistinction with the metrics discussed above, fifty-four papers (11.3%) discussed altmetrics (or "alternative metrics"), which included a wide range of techniques to measure non-traditional, non-citation based usage of articles, that is, influence.(17) Altmetric measures included the number of online article views, (95) bookmarks, (96) downloads, (41) PageRank algorithms(97) and attention by mainstream news.(65) in books(98) and social media, for example, in blogs, commentaries, online topic reviews or tweets. (99, 100) These metrics typically measure the "web visibility" of an output.(101) A notable example is the social networking site for researchers and scientists, ResearchGate, which uses an algorithm to score researchers based on the use of their outputs, including citations, reads, and recommendations.(102)

A strength of altmetrics lies in providing a measure of influence promptly after publication.(70, 103, 104) Moreover, altmetrics allows tracking of the downloads of multiple sources (e.g., students, the general public, clinicians, as well as academics) and multiple types of format (e.g., reports and policy documents),(105) which are useful in gauging a broader indication of impact or influence, compared to more traditional metrics that solely or largely measure acknowledgement by experts in the field through citations.(17)

Disadvantages noted in the articles reviewed included that altmetrics calculations have been established by commercial enterprises such as Altmetrics LLC (London, UK) and other competitors, (106) and there may be fees levied for their use. The application of these metrics has also not been standardized. (98) Furthermore, it has been argued that, because altmetrics are cumulative and typically at the article-level, they provide more an indication of influence or even popularity,(107) instead of quality or productivity.(108) Hence, one study suggested no correlation between attention on Twitter and expert analysis of an article's originality, significance or rigour.(109) Another showed that Tweets predict citations.(110) Overall, further work needs to assess the value of altmetric scores in terms of their association with other traditional indicators of achievement.(111) Notwithstanding this, there were increasing calls to consider altmetrics alongside more conventional metrics in assessing researchers and their work.(112)

Past Funding

A past record of being funded by national agencies was identified as a common measurement of individual academic achievement (particularly productivity, quality and impact) in a number of papers, and has been argued to be a reliable method that is consistent across

medical research.(113-115) For example, the NIH's (National Institute of Health's) RePORT
(Research Portfolio Online Reporting Tools) system encourages public accountability for
funding by providing online access to reports, data and NIH-funded research projects.(113,
116)

9 361 10 362

363 New Metrics and Models Identified

The review also identified and assessed new metrics and models that were proposed during the review period, many of which had not gained widespread acceptance or use. While there was considerable heterogeneity and varying degrees of complexity among the 78 new approaches identified, there were also many areas of overlap in their methods and purposes. For example, some papers reported on metrics that used a PageRank algorithm, (117, 118) a form of network analysis based on structural characteristics of publications (e.g., co-authorship or citation patterns).(14) Metrics based on PageRank purported to measure both the direct and indirect impact of a publication or researcher. Other approaches considered the relative contributions of authors to a paper in calculating productivity.(119) Numerous metrics and models that built upon existing approaches were also reported.(120) For example, some developed composite metrics that included a publication's JIF alongside an author contribution measure(121) or other existing metrics.(122) However, each of these approaches reported limitations, in addition to their strengths or improvements upon other methods. For example, in focusing on productivity, a metric necessarily often neglected impact.(123) Appendix 3 provides a summary of these new or re-fashioned metrics and models, with details of their basis and purpose.

DISCUSSION

This systematic review identified a large number of diverse metrics and models for assessing an individual's research achievement that have been developed in the last 10 years (2007-2017), as evidenced in Appendix 3. At the same time, other approaches that pre-dated our study time period of 2007-2017 were also discussed frequently in the literature reviewed, including the h-index and JIF. All metrics and models proposed had their relative strengths, based on the components of achievement they focused on, and their sophistication or transparency.

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The review also identified and assessed new metrics and over the past few decades. Peer-review has been increasingly criticized for reliance on subjectivity and propensity for bias, (7) and there have been arguments that the use of specific metrics may be a more objective and fair approach for assessing individual research achievement. However, this review has highlighted that even seemingly objective measures have a range of shortcomings. For example, there are inadequacies in comparing researchers at different career stages, and across disciplines with different citation patterns.(86) Furthermore, the use of citation-based metrics can lead to gaming and potential ethical misconduct by contributing to a "publish or perish" culture in which researchers are under pressure to maintain or improve their publication records. (124, 125) New methods and adjustments to existing metrics have been proposed to explicitly address some of these limitations; for example, normalizing metrics with "exchange rates" to remove discipline-specific variation in citation patterns, thereby making metric scores more comparable for researchers working in disparate fields.(126, 127) Normalization techniques have also been used to assess researchers' metrics with greater recognition of their relative opportunity and career longevity.(128)

Other criticisms of traditional approaches center less on how they calculated achievement, and more on what they understood or assumed about its constituent elements. In this review, the measurement of impact or knowledge gain was often exclusively tied to citations.(129) Some articles proposed novel approaches to using citations as a measure of impact, such as giving greater weight to citations from papers that were themselves highly cited(130) or that come from outside the field in which the paper was published.(131) However, even other potential means of considering scientific contributions and achievement, such as mentoring, were still ultimately tied to citations because mentoring was measured by the publication output of mentees.(132)

A focus only on citations was widely thought to disadvantage certain types of researchers. For example, researchers who aim to publish with a focus on influencing practice may target more specialized or regional journals that do not have high JIFs, where their papers will be read by the appropriate audience and findings implemented, but they may not be well-cited.(51) In this regard, categorizing the type of journal in which an article has been published in terms of its focus (e.g., industry, clinical, regional/national) may go some way toward recognizing those publications that have a clear knowledge translation intention, and therefore prioritize real-world impact over academic impact. (124) There were only a few other approaches identified that captured broader conceptualizations of knowledge gain, such as practical impact or wealth generation for the economy, and these too were often simplistic,

such as including patents and their citations(133) or altmetric data.(98) While altmetrics hold potential in this regard, their use has not been standardized,(98) and they come with their own limitations, with suggestions that they reflect popularity more so than real world impact.(107) Other methodologies have been proposed for assessing knowledge translation and real-world impact, but these can often be labor intensive.(134) For example, Sutherland et al. (2011)(135) suggested that assessing individual research outputs in light of specific policy objectives, through peer-review based scoring, may be a strategy, but this is typically not feasible in situations such as grant funding allocation, where there are time-constraints and large applicant pools to assess. In terms of how one can make sense of the validity of many of these emerging approaches for assessing an individual's research achievements, metrics should demonstrate their legitimacy empirically, as well as having a theoretical basis for their use and clearly differentiating what aspects of quality, achievement or impact they purport to examine.(55, 67) If the recent, well-publicized (136-138) San Francisco Declaration on Research Assessment (DORA)(139) is anything to go by, internationally there is a move away from the assessment of individual researchers using the JIF and the journal in which the research has been published. Figure 3. The Comprehensive Researcher Achievement Model (CRAM) <Insert Figure 3> There is momentum, instead, for assessment of researcher achievements on the basis of a wider mix of measures, hence our proposed Comprehensive Researcher Achievement Model (CRAM) (Figure 3). On the left-hand side of this model is the researcher to be assessed, and key characteristics that influence the assessment. Among these factors, some (i.e., field or discipline, co-authorship, career longevity) can be controlled for depending on the metric, while other components, such as gaming or the research topic (i.e., whether it is "trendy" or innovative) are less amenable to control or even prediction. Online databases, which track citations and downloads and measure other forms of impact, hold much potential and will likely be increasingly used in the future to assess both individual researchers and

- their outputs. Hence, assessment components (past funding, articles, citations, patents,
- downloads, and some media traction) included in our model are those primarily accessible online.
- **Strengths and Limitations**

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The findings of this review suggest assessment components should be used with care, and with recognition of how they can be influenced by other factors, and what aspects of achievement they reflect (i.e., productivity, quality, impact, influence). No metric or model singularly captures all aspects of achievement, and hence use of a range, such as the examples in our model, is advisable. CRAM recognizes that the configuration and weighting of assessment methods will depend on the assessors and their purpose, the resources available for the assessment process, and access to assessment components. Our results must be interpreted in light of our focus on academic literature. The limits of our focus on peer-reviewed literature were evident in the fact some new metrics were not mentioned in articles, and therefore not captured in our results. While we defined impact broadly at the outset, overwhelmingly the literature we reviewed focused on academic, citation-based impact. Furthermore, although we assessed bias in the ways documented, the study design limited our ability to apply a standardized quality assessment tool.

CONCLUSION

There is no ideal model or metric by which to assess individual researcher achievement. We have proposed a generic model, designed to minimize risk of the use of any one or a smaller number of metrics, but it is not proposed as an ultimate solution. The mix of assessment components and metrics will depend on the purpose. Greater transparency in approaches used to assess achievement including their evidence-base is required.(37) Any model used to assess achievement for purposes such as promotion or funding allocation should include some quantitative components, based on robust data, and be able to be rapidly updated, presented with confidence intervals, and normalized.(37) The assessment process should be difficult to manipulate, and explicit about the components of achievement being measured. As such, no current metric suitably fulfills all these criteria. The best strategy to assess an individual's research achievement is likely to involve the use of multiple approaches(140) in order to dilute the influence and potential disadvantages of any one metric, while providing more rounded picture of a researcher's achievement; (85, 141) this is what the CRAM aims to contribute.

All-in-all, achievement in terms of impact and knowledge gain is broader than the number of articles published or their citation rates, and yet most metrics have no means of factoring in these broader issues. Altmetrics hold promise in complementing citation-based metrics and assessing more diverse notions of impact, but usage of this type of tool requires

further standardization.(98) Finally, despite the limitations of peer-review, the role of expert
judgement should not be discounted.(41) Metrics are perhaps best applied as a complement or
check on the peer-review process, rather than the sole means of assessment of an individual's
research achievements.(142)

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, }	508	Data sharing statement
)	509	All data has been made available as Appendices.
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<u>}</u> }	511	Author Contributions
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; ,	513	content, and led the study. JH, KC and JCL made substantial contributions to the design,
3	514	analysis and revision of the work and critically reviewed the manuscript for important
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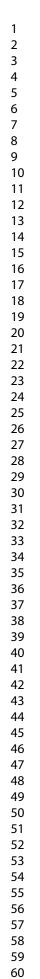
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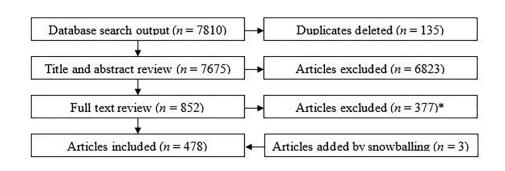
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31	843		ranking of researchers performance. <i>Scientometrics</i> . 2011;86(1):113-23.
32 33	844	100	doi:10.1007/s11192-010-0241-5
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38	849	104	10.1038/srep01649. doi:10.1038/srep01649
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57	866		discipline, institution, and individual. <i>Scientometrics</i> . 2011;89(3):955-66.
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4 5	869		distinguishing between prestige and popularity. New J Phys. 2012;14: doi:
6	870		10.1088/367-2630/14/3/033033. doi:10.1088/1367-2630/14/3/033033
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23	885		Declaration on Research Assessment. <i>Nature</i> . 2017;544(7651):394.
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27	888		of Research Assessment: Robert Balaban's editorial. <i>J Gen Physiol</i> . 2013;142(3):175.
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30	891		by its wrapping: revisiting Seglen's work on journal impact and research evaluation.
31 32	892 893		<i>PLOS One</i> . 2017;12(3): doi: 10.1371/journal.pone.0174205.
33	893 894	139.	doi:10.1371/journal.pone.0174205
34	894 895	139.	San Francisco Declaration on Research Assessment (DORA). DORA—ASCB San
35	895 896	140.	Francisco, US2016 [Available from: <u>http://www.ascb.org/dora/</u> . Cabezas-Clavijo A, Delgado-Lopez-Cozar E. Google Scholar and the h-index in
36	890 897	140.	biomedicine: the popularization of bibliometric assessment. <i>Med Intensiva</i> .
37	898		2013;37(5):343-54. doi:10.1016/j.medin.2013.01.008
38 39	899	141.	Iyengar R, Wang Y, Chow J, et al. An integrated approach to evaluate faculty
40	900	171.	members' research performance. <i>Acad Med.</i> 2009;84(11):1610-6.
41	901		doi:10.1097/ACM.0b013e3181bb2364
42	902	142.	Jacso P. Eigenfactor and article influence scores in the journal citation reports. <i>Online</i>
43	903		<i>Inform Rev.</i> 2010;34(2):339-48. doi:10.1108/14684521011037034
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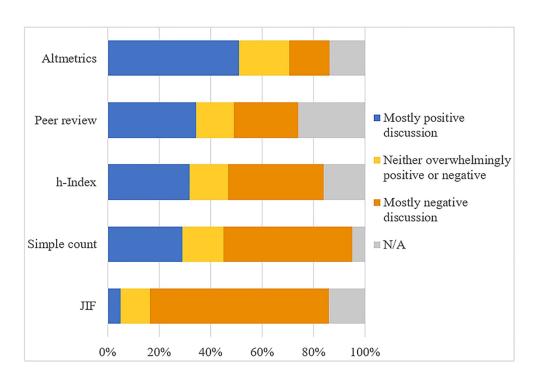


*Reasons for exclusion are noted below

Reason for exclusion at the full text level	Number of articles excluded
Not in English language	47
Full text not available	62
Does not discuss assessment of an individual researcher	268
Total	377

Data screening and extraction process for academic articles

279x188mm (300 x 300 DPI)



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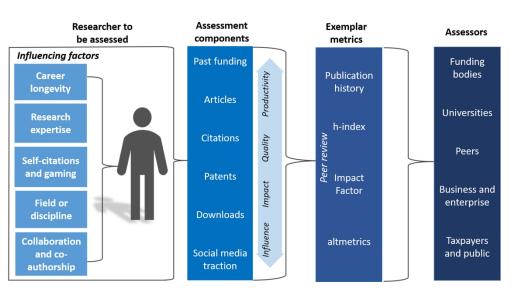
2025 at Agence Bibliographique de l Enseignement

Percentages of positive and negative discussion regarding selected commonly used metrics for assessing individual researchers (n=478 articles)

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The Comprehensive Researcher Achievement Model (CRAM)

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Appendix 1: Full Search Strategy		30 March 2 cluding for	
Name of database	Web of Science Core Collection, BIOSIS Citation In	d 🖗 x, 🕅	edline
Platform	Web of Science [Clarivate Analytics]		, ,
Database coverage	2007-2017		
Date exported to Reference Management Software (EndNote)	19 th October 2017	Superior Superior Superior	
Search strategy	Model OR framework OR assess* OR evaluat*OR *metric*OR measur* OR criteri*OR citation*OR unconscious bias OR rank*	led from http: feur (ABE <mark>S)</mark> text and <mark>da</mark> t	Results: 13,282,151
	AND researcher excellence OR track record OR researcher funding OR researcher perform* OR relative to oppo OR researcher potential OR research* career pathwa academic career pathway OR funding system OR fun body OR researcher impact OR scientific* productive academic productivity OR top researcher OR research ranking OR grant application OR researcher output O h*index OR i*index OR impact factor OR individua researcher	a menitopen.bezi.com/	Results: 11,616
	Combined sets [Auto select language based on searchanguage]	ne 13, simila	Results: 7,530
		25 at Agence Bibliographique hnologies.	
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Appendix 2:	Summar	y table of included articles and the metrics or mode	ls they disc		on 30 March 2019					
First author	Year	Publication Details Journal name	Format^	Metric or Peer- review	Model A	h- index	JIF	Other	earch Achie Alt- metrics	New
Abramo	2016	Scientometrics	ED		aded fr erieur to tex			Y		_
Agarwal	2016	Asian Journal of Andrology	ED		r (AB Yanc	Y	Y	Y	Y	
Ahmad	2013	Anesthesia and Analgesia	EM		d data					
Aixela	2015	Perspectives: Studies in Translatology	ED	Y	://bmj ta min	Y	Y	Y		
Akl	2012	Canadian Medical Association Journal	EM	Y	ning,					
Albion	2012	Australian Educational Researcher	EM		, Al tra	Y	Y	Y		
Alguliyev	2016	Journal of Scientometric Research	EM		nj.com rainin		Y	Y		
Allen	2010	ScienceAsia	ED		n∕ on ıg, an	Y	Y			
Anderson	2008	Scientometrics	ED		nd sin	Y				Y
Anderson	2017	Applied Economics	EM	Y	e 13, milar	Y	Y			
Anfossi	2015	International Journal of Dermatology	EM	0	2025 tech		Y			
Antunes	2015	Revista do Colegio Brasileiro de Cirurgioes	EM	Y	iat Ag	Y				
Aoun	2013	World Neurosurgery	RE	Y	gies.	Y	Y			
Aragon	2013	Nature Scientific Reports	EM							Y
Armado	2017	Transinformação	EM		Bibliogr	Y		Y		
Assimakis	2010	Scientometrics	EM		raphi					Y
Azer	2016	Education Forum			ique	Y	Y	Y		
Babineau	2014	The Western Journal of Emergency Medicine - For peer review only - http://bmjopen.bmj.c	EM		del	Y				

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1 2 3 4	Baccini	2014	Scientometrics	EM		30 March cluding fc	Y	Y	Y	
5	Badar	2016	Aslib Journal of Information Management	EM	Y	2019 or use		Y		
6 7	Bai	2016	PLOS One	EM		Yere	Y	Y	Y	Y
8 9	Bala	2013	Journal of Clinical Epidemiology	EM		Wnloz Sup lated		Y		
10	Balaban	2013	Journal of General Physiology	ED	Y	aded berieu I to te				
11 12	Balandin	2009	Augmentative and Alternative Communication	ED		ext a	Y	Y		
13 14	Barczynski	2009	Journal of Human Kinetics	ED		from http: ur (ABES) ext and date		Y	Y	
15	Bastian	2017	Journal of Bone and Joint Surgery-American Volume	EM		o://bm ata mi	Y			
16 17	Baum	2011	SAGE	EM	Y	njope iihing		Y		
18 19	Beck	2017	Research Evaluation	EM	Y					
20	Beirlant	2010	Scandinavian Journal of Statistics	EM		ı.bmj.con Al trainin	Y			
21 22	Belikov	2015	f1000 Research	EM		ing, a	Y			Y
23 24	Bellini	2012	The Lancet	ED		n June Yand si	Y	Y		
25	Belter	2015	Journal of The Medical Library Association	ED	Y	he 13, similar	Y			
26 27	Benchimol-Barbosa	2011	Arquivos Brasileiros de Cardiologia	ED		, 2025 ir tech		Y		
28 29	Benway	2009	Urology	ED	Y		Y			
30	Bertuzzi	2013	Molecular Biology of the Cell	ED		5 at Agenc		Y		
31 32	Bharathi	2013	PLOS One	ED		ë	Y			
33 34	Bini	2008	Electronic Transactions on Numerical Analysis	EM		Bibliog				Y
35	Birks	2014	Health Services Research & Policy	EM	Y	grap	Y			
36 37	Biswal	2013	PLOS One	ED		hique	Y		Y	
38 39	Bloch	2016	Research Evaluation	EM		e de l			Y	
40 41 42 43 44 45 46			For peer review only - http://bmjopen.	bmj.com/site/abo	out/guideli	Enseignement nes.xhtment				

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Bloching	2013	South African Journal of Science	EM	Y	ng fo	March				Y
Bollen	2016	Scientometrics	ED	Y	orus	2019				Y
Bolli	2014	Circulation Research	ED		s re	Do				
Bornmann	2009	EMBO Reports	ED		Sup	Y Y	Y			
Bornmann	2015	Journal of Informetrics	EM	Y	Superieu lated to te	Y Y	Y			
Bornmann	2016	EMBO Reports	ED		Y ar ⊇	Ϋ́Υ	Y			
Bornmann	2014	Scientometrics	EM		Hd dai	Y				
Bornmann	2008	Research Evaluation	EM	Y	نف ^ر <u>ع</u>	Y	Y	Y		
Bornmann	2017	Journal of Informetrics	EM		ning	Y	Y	Y		
Bornmann	2017	Journal of Korean Medical Science	ED			5	Y	Y		
Bould	2011	British Journal of Anaesthesia	EM			Y				
Bradshaw	2016	PLOS One	EM		<u>م</u>	Y	Y	Y		
Brown	2011	American Journal of Occupational Therapy	ED		nd si	Y	Y	Y		
Buela-Casal	2012	Scientometrics	EM				Y			
Buela-Casal	2010	Revista de Psicodidáctica	ED		Yech	Y Y	Y	Y	Y	
Butler	2017	Clinical Spine Surgery	ED		nolo				Y	
Cabazas Clavijo	2013	Medicina Intensiva (English edition)	RE		gies	Y	Y			
Cagan	2013	Disease Models & Mechanisms	ED			P Ri	Y			
Callaway	2016	Nature	ED			Riblion	Y			
Calver	2013	Grumpy Scientists	ED		Y	Y Y	Y	Y		
Calver	2015	Australian Universities Review	ED		1			Y		
Caminiti	2015	BMC Health Services Research	RE							Y
		For peer review only - http://br	njopen.bmj.com/site/abr	out/guide		Enseignemer				
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Page 35	of 72		BMJ Open			-025320 on 30 March opyright, including fo					
1 2 3 4	Cantin	2015	International Journal of Morphology	EM		30 March Icluding fc	Y				
5	Carpenter	2014	Academic Emergency Medicine	ED		2019 or use	Y	Y	Y	Y	
6 7	Carpenter	2014	Information Service and Use	ED		9. Dov es re		Y		Y	
8 9	Castelnuovo	2010	Clinical Practice & Epidemiology in Mental Health	RE		wnloa Supe lated t	Y	Y		Y	Y
10	Castillo	2010	American Journal of Neuroradiology	ED		aded perieu 1 to te	Y		Y		
11 12	Chiari	2016	Nurse Education Today	EM	Y	l from http: ur (ABES) ext and dat					
13 14	Choi	2014	Journal of Radiation Oncology	EM	Y	nd da	Y		Y		Y
15	Choi	2009	International Journal of Radiation Oncology, Biology, Physics	EM		Yani Yani	Y				
16 17	Chopra	2016	Aesthetic Surgery Journal	EM		njope iining	Y				
18 19	Choudhri	2015	Radiographics	ED		YÞ 🛃	Y	Y			
20	Chowdhury	2015	PLOS One	EM	Y	l training,	Y				
21 22	Christopher	2015	Journal of Veterinary Cardiology	ED		ng, a		Y			
23 24	Chung	2012	Scientometrics	EM		n Jun und si				Y	
25	Ciriminna	2013	Chemistry Central Journal	ED	1,	ingila	Y	Y	Y		
26 27	Claro	2011	Scientometrics	EM	0	, 2025 Ir tech					
28 29	Cleary	2010	International Journal of Mental Health Nursing	ED		5 at .	Y				
30	Cone	2013	Academic Emergency Medicine	ED		5 at Agend Inologies	Y				
31 32	Cone	2012	Academic Emergency Medicine	ED		e		Y			
33 34	Cordero-Villafafila	2015	Revista de Psiquiatría y Salud Mental (English Edition)	ED		Bibliog	Y	Y	Y		Y
35	Costas	2011	Scientometrics	EM		Y aph			Y		
36 37 38	Costas	2009	Journal of the American Society for Information Science and Technology	EM		Y de		Y			
39 40 41 42 43 44 45 46			For peer review only - http://bmjopen.bmj.cc	om/site/a	bout/guideli						

Crespo	2013	PLOS One	EM		opyright, including fo	30 March				Y
Cress	2014	Aesthetic Surgery Journal	ED		or use	2019	Y		Y	
Crotty		European Heart Journal	ED		<i>(</i> ^ -	py V				
Culley	2014	Anesthesia & Analgesia	EM		Yesu	Y Y		Y		
Cynical Geographers Collective	2011	Antipode	ED		d to text and data i	variant fr	Y			
Czarnecki	2013	Bulletin of the Polish Academy of Sciences	EM		and	B Y				
da Silva	2017	Scientometrics	ED		s) data	*	Y	Y	Y	
Danell	2011	Journal of the American Society for Information Science and Technology	EM		nining,	bmioper				
Danielson	2013	American Journal of Pharmaceutical Education	EM		Y⊉ f	Y		Y		
de Granda-Orive	2014	Archivos de Bronconeumología	ED			6		Y		
De Gregori	2016	Journal of Pain Research	EM		ig, ar	on on			Y	
De la Flor-Martínez M	2017	Medicina Oral Patologia Oral Y Cirugia Bucal	EM	Y		Y Y				
De Marchi	2016	Scientometrics	EM	1	nilar	n 13 3	Y			
De Witte	2010	Scientometrics	EM	Y	tech	2025				Y
Delgadillo	2016	Family & Consumer Sciences research journal	RE		nolo	a¥ Y A				Y
DeLuca	2013	Academic Emergency Medicine	EM	Y	gies.	Y Y				
Devos	2011	Clinics and Research in Hepatology and Gastroenterology	ED		(Bin Y				
Diamandis	2017	BMC Medicine	ED			bliogr	Y			
DiBartola	2017	Journal of Veterinary Internal Medicine	ED		2	Y	Y	Y		
Diem	2013	Research in Higher Education	EM		2	D D	Y			
Ding	2011	Information Processing and Management	EM		Y	P Y	Y	Y	Y	

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Ding	2011	Journal of the American Society for Information Science and Technology	EM		March 20 ding for u		Y		Y	
Diniz-Filho	2016	Journal of Informetrics	EM	Y	Yes		Y			
Dinsmore	2014	PLOS Biology	ED		Downli Su relate				Y	
Dodson	2012	Biochemical and Biophysical Research Communications	EM	Y	oad d to	Y	Y			•
Donato	2014	Revista Portuguesa De Pneumologia	ED		ed from ht ieur (ABES text and o		Y			
Doyle 2015	Molecular Psy	chiatry EM	Y		and					
Duffy	2011	Scientometrics	EM		data ·	Y		Y	<u> </u>	
Duffy	2008	Journal of Counseling Psychology	EM		in i	Y		Y		
Durieux	2010	Radiology	RE		ing, A	Y	Y	Y	Y	
Ebadi	2016	Scientometrics	EM		Al train			Y		•
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Efron	2011	Clinical and Experimental Optometry	EM		, and	Y		Y		
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El Emam	2012	Journal of Medical Internet Research	EM		iiar,2 ¥r,2		Y			
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Eloy	2014	Otolaryngology-Head and Neck Surgery	EM	Y	at Agenc ologies.		Y	Y		
Eloy	2013	Laryngoscope	EM		ies.	Y				
Esposito	2010	European Journal of Oral Implantology.	ED		Bibl	Y				
Eyre-Walker	2013	PLOS Biology	EM	Y	Y gra		Y			
Eysenbach	2011	Journal of Medical Internet Research	EM		Y hig	Y	Y		Y	
Fabry	2017	GMS Journal for Medical Education	ED	Y	lue d		Y		Y	
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Fazel	2017	Evidence-based Mental Health	EM	Y	or use			Y	Y	
Fedderke	2015	Research Policy	EM		Yrel					
Feethman	2015	Veterinary Record	ED		yvnloa Supe elated		Y			
Ferrer-Sapena	2016	Research Evaluation	ED		berieu 4 to te		Y	Y	Y	Y
Filler	2014	Academic Medicine	EM		ur (A	, ,		Y		
Finch	2010	Bioessays	ED		rr (ABES) ar (ABES) ext and dat	Y	Y	Y		
Flaatten	2016	Acta Anaesthesiologica Scandinavica	ED		ata m		Y			
Franceschet	2010	Journal of Informetrics	EM		njope nining		Y	Y		
Franceschini	2012	Scientometrics	EM		eh.bm g, Al tr			Y		Y
Franceschini	2012	Scientometrics	EM		nj.com trainin		Y	Y		Y
Franceschini	2012	Scientometrics	EM		ya or	Y		Y		
Frittelli	2016	Journal of the Association for Information Science and Technology	EM	Λ.	n June 1 and simil	Y	Y			Y
Frixione	2016	PLOS One	EM	Y	з, ar			·	Y	
Fujita	2017	IEEE 41st Annual Computer Software and Applications Conference (COMPSAC)	EM	Y	25 at A chn <u>o</u> lo					
Gambadauro	2007	European Journal of Obstetrics & Gynecology and Reproductive Biology	ED		vgies.	-	Y			
Gao	2016	PLOS One	ED		Biblio	Y				Y
Garcia-Perez	2015	Scientometrics	EM		Y grap			Y		
Garcia-Perez	2009	Spanish Journal of Psychology	EM		Y hiqu	Y				
Garner	2017	Journal of Neurointerventional Surgery	RE		Y de	Y				
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1 2 3 4	Gasparyan	2017	Journal of Korean Medical Science	ED		-025320 on 30 March opyright, including fo		Y	Y	Y	
5	Gast	2014	Plastic and Reconstructive Surgery	EM		2019. ^{or} Yse	Y				
6 7	Gast	2014	Plastic & Reconstructive Surgery	EM		9, Do es re	Y		Y		
8 9	Gaughan	2008	Research Evaluation	EM). Downloa Supe es related			Y		
10	Gefen	2011	Journal of Biomechanics	LE	Y	adec berie	Y				
11 12	Giminez-Toledo	2016	Scientometrics	EM		ur (A ext a			Y		
13 14	Glänzel	2014	Transinformação	ED		baded from http: perieur (ABES) I to text and dat	Y		Y		
15	Good	2015	Research Evaluation	ED		ata mi			Y		
16 17	Gorraiz	2010	LIBER Quarterly	ED		njope Ying		Y		Y	
18 19	Gracza	2008	Library Collections Acquisitions & Technical Services	ED			Y	Y			
20	Grisso	2017	Journal of Women's Health	EM	Y	Al training,					
21 22	Grzybowski	2017	Clinics in Dermatology	ED		ing, a		Y			
23 24	Gumpenberger	2016	Scientometrics.	ED	Y	n June and si	Y	Y		Y	
25	Haddad	2014	The Bone and Joint Journal	ED	1/	ne 13, simila		Y			
26 27	Haddow	2015	Research Evaluation	EM		, 2025 Ir tech					
28 29	Haeffner-Cavaillon	2009	Archivum Immunologiae et Therapiae Experimentalis	ED	Y		Y	Y	Y		
30	Halbach	2011	Annals of Anatomy	EM		i at Agend nologies	Y		Y		
31 32	Hall	2015	Tourism Management	ED		, e		Y			
33	Halvorson	2016	Implications for Training in the Health Professions	EM		Bibliog	Y				
34 35	Hamidreza	2013	Acta Informatica Medica	EM		grap	Y				
36 37	Hammarfelt	2017	Research Evaluation	EM	Y	hique	Y	Y			
38	Han	2013	ISSI	EM	Y	e de l		Y			Y
 39 40 41 42 43 44 45 46 			For peer review only - http://bmjopen.bn	nj.com/site/ab	out/guideli	l Enseignement					

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Han	2010	Journal of Animal and Veterinary Advances	EM		cluding	30	Y			
Haslam	2009	Research Evaluation	EM		for use		Y			
Haslam	2010	European Journal of Social Psychology	EM		10	P Y	Y	Y	Y	
Healy	2011	Breast Cancer Research and Treatment	EM		Sup					
Heinzl	2012	AIP Conference Proceedings	ED		erie to to	Y	Y	Y		
Henrekson	2011	The Manchester School	EM			Υ	Y	Y		
Herteliu	2017	Publications	EM		ur (ABES)	Y				
Hew	2017	Telematics and Informatics	EM		Yai. Yai.		Y			
Hicks	2015	Nature	ED		ining	Y	Y			
Hicks	2015	Nature	ED		Alt	Y	Y			
Hoffman	2014	47th Hawaii International Conference on System Sciences	0		raini	Y	Y		Y	
Holliday	2010	International Journal of General Medicine	EM	Y	ng, ai	2	Y			Y
Houser	2017	Leukos	ED		nd si	Y	Y			
Hughes	2015	International Journal of Radiation Oncology Biology Physics NB Conference supplement	EM	V	e I.3, zo mila <u>r</u> te	ש א _V				
Hunt	2011	Acta Neuropsychiatrica	ED		echno	y Y Y	Y			
Hutchins	2016	PLOS Biology	EM		ologie	+				Y
Hyman	2014	Molecular Biology of the Cell	ED		s.					
Ibrahim	2015	New Library World	EM	Y	Y D	Rin Y				Y
Ioannidis	2016	PLOS Biology	EM		Y G	Y				Y
Ion	2017	Chirurgia	RE		buide	Y	Y	Y		
Iyendar	2009	Academic Medicine	EM		ā		Y			Y

Page 41	of 72		BMJ O	pen		-025320 on 30 March opyright, including fo					
1 2 3	Jackson	2015	Medical Journal of Australia	ED	Y	1 30 March ncluding fo					
4 5	Jackson	2011	PLOS One	EM		or use			Y		
6 7	Jacob	2007	Scientometrics	EM		<u>9</u> . Dov		Y			
8	Jacso	2010	Online Information Review	EM		synloa Sup elated		Y	Y		
9 10	Jacso	2008	Online Information Review	ED		d to t	Y				
11 12 13	Jalil	2013	IEEE International Conference on Teaching, Assessment a Learning for Engineering (TALE)	nd EM		aded from http perieur (ABES) I to text and da		Y			
14 15	Jamjoom	2015	Neurosciences	EM		ita · 🟅	Y				
16	Jamjoom	2016	World Neurosurgery	EM		minin	Y				
17 18	Jan	2016	Journal of Scientometric Research	EM		ng, A	Y		Y		
19 20	Javey	2012	American Chemical Society	ED			Y	Y			
21	Jeang	2008	Retrovirology	ED		mj.com/ (training,	Y				Y
22 23	Jokic	2009	Biochemia Medica	ED		on Ju And	Y	Y			
24 25	Joshi	2014	The Journal of Contemporary Dental Practice	ED	1.	une 13, I similar	Y		Y		
26	Joynson	2015	f1000 Research	EM		13, 20 ilar te					
27 28	Kaatz	2015	Academic Medicine	EM	Y	2025 at techno					
29 30	Kaatz	2016	Academic Medicine	EM	Y	log					
31	Kali	2015	Indian Journal of Pharmacology	ED		ies. Y.				Y	
32 33	Kalra	2013	Journal of Neurosurgery-Pediatrics	EM		Bibli	Y		Y		
34 35	Kaltman	2014	Circulation Research	EM		Y gra					
36	Kapoor	2013	The Annals of Medical and Health Sciences Research	ED		iphiq		Y			
37 38	Kellner	2008	Anais Da Academia Brasileira De Ciencias	EM		ue d	Y				
 39 40 41 42 43 44 45 46 			For peer review only - http://bmjopen.k	omj.com/site/ab	out/guidel	e I Enseignement					

Knudson2015Kosmulski2012Krapivin2009Kreiman2011Kreines2016Kshettry2013Kulasagareh2010Kulczycki2017Kumar2009Kuo2017Lando2014Lariviere2016Lariviere2016Lariviere2016Lariviere2011	World Neurology Quest Research Evaluation Complex Sciences Frontiers in Computational Neuroscience Journal of Computer and Systems Sciences International World Neurosurgery European Archives of Oto-Rhino-Laryngology Journal of Informetrics Iete Technical Review Computers in Human Behavior PLOS One	EM ED ED ED EM ED ED ED ED ED ED	Y	-025320 on 30 March 2019. Downloaded from http://bmjopen.bm Superieur (ABES) . opyright, including for uses related to text and data mining Al t	Y Y Y Y	Y Y Y Y	Y	Y Y	Y Y
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Kulczycki2017Kumar2009Kuo2017Lando2014Lariviere2010Lariviere2016Lariviere2011	Journal of Informetrics Iete Technical Review Computers in Human Behavior	ED ED EM		a mining, Al t	Y Y	Y			
Kumar2009Kuo2017Lando2014Lariviere2010Lariviere2016Lariviere2011	Iete Technical Review Computers in Human Behavior	ED EM		ining, Al t	Y	Y			
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Lando2014Lariviere2010Lariviere2016Lariviere2011					x				
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Lariviere 2011	Journal of the American Society for Information Science and Technology	EM	1.	and simi		Y			
	PLOS One	EM	V	بن آم ر					
	Journal of Informetrics	EM		techno	2 7 7		Y		
Lauer 2015	The New England Journal of Medicine	ED	Y	alogies.	*				
Law 2013	Asia Pacific Journal of Tourism Research	EM	Y	Y. Y.	2	Y			
Lee 2009	Journal of neurosurgery	EM		Вірі	Y				
Leff 2009	International Journal of COPD	ED		logra	`	Y			
Leydesdorff 2016	Scientometrics	ED			3	Y	Y		
Li 2015	Science	EM	Y	ue de	5				

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Li		2016	In: Nah FFH, Tan CH, eds. Hci in Business, Government, and Organizations: Ecommerce and Innovation, Pt I. Vol 97512016:61-71.	EM	Y	n 30 March 2019. ncluding for use					
			IEEE International Conference on Smart			<u>.</u>					
Liar	ng	2015	City/SocialCom/SustainCom	EM		Downloaded Superie related to t					Y
Liac	0	2011	Decision Support Systems	EM		d to		Y			
Linc	dner	2015	PLOS One	EM	Y	Yxt of fro					
Line	dner	2016	American Journal of Evaluation	EM	Y	ied from http ieur (ABES) b text and de					
Lipp	pi	2009	Clinical Chemistry and Laboratory Medicine	ED		b) · lata m	Y	Y			
Lipp	pi	2013	Clinica Chimica Acta	EM		mining,	Y	Y			
Lipp	pi	2017	Annals of Translational Medicine	EM		ng, Al	Y	Y			Y
Liss	soni	2011	Industrial and Corporate Change	EM		l train		Y			
Litti	man	2017	Medical Education Online	EM		ning,	Y	Y			
Liu		2011	Management Information Systems	EM		ynd Ynd			Y	Y	
Lop	Dez	2015	Journal of Surgical Education	EM	Y	une 13 simila	Y				
Lop	Dez	2015	Journal of Hand Surgery America	EM	0	T T	Y				
Lort	tie	2013	Scientometrics	EM	0	2025 at Technol		Y			
Lov	vegrove	2008	BioScience	EM	Y	t Ager blogie	Y		Y		
Loz	zano	2017	Current Science	ED		Y ^{es} Ce	Y		Y		
Mac	cMasters	2017	Academic Psychiatry	EM		Y Biblio	Y				
Mag	ggio	2017	Academic Medicine	EM		gra	Y			Y	
Mal	li	2017	Science & Public Policy	EM		phiq					
Mar	rkel	2017	Journal of Pediatric Surgery	EM		Y de	Y		Y		
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Markpin	2008	Scientometrics	EM		-025320 on 30 March opyright, including fo		Y			Y
Marsh	2008	American Psychologist	EM	Y	or use					
Marshall	2017	Otolaryngology—Head and Neck Surgery	EM		9. Do		Y			
Marzolla	2016	Journal of Informetrics	EM	Y	Sup Sup	Y		Y		
Mas-Bleder	2013	Scientometrics	EM		Yo te	•		Y		
Matsas	2012	Brazilian Journal of Physics	EM		r (Al	·				Y
Maunder	2007	La Revue Canadienne de Psychiatrie	EM		I from http: ur (ABES) ext and dat		Y	Y		Y
Maximin	2014	RadioGraphics	ED	Y	Yaa . Mon		Y		Y	
Mazloumian	2011	PLOS One	EM		njope					Y
Mazmanian	2014	Evaluation & the Health Professions	RE		g, Al t			Y		
McAlister	2011	American Heart Association Journals	ED		Yaini		Y			
McGovern	2013	Academic Medicine	EM	Y	ing or Ya or			Y		
Medo	2016	Physical Review	EM		n Jun and si	· Y		Y		
Meho	2008	Journal of the American Society for Information Science and Technology	EM	V_	e 13, milar	Y				
Mester	2016	Interdisciplinary Description of Complex Systems	ED		2025 a		Y			
Metcalf	2010	Radiologic Technology	EM		ıt Age ologie					
Milone	2016	American Journal of Orthopedics	EM	Y	ence les.	Y				Y
Minasny	2013	PeerJ	EM		Y Bibli	Y				
Mingers	2015	European Journal of Operational Research	ED		Y gra	Y		Y		
Mingers	2009	Journal of the Operational Research Society	EM		Y hiqu	Y				
Mingers	2017	Scientometrics	EM		Y e de					

 $\begin{array}{c} 11\\ 12\\ 13\\ 14\\ 15\\ 16\\ 17\\ 18\\ 19\\ 20\\ 21\\ 22\\ 23\\ 24\\ 25\\ 26\\ 27\\ 28\\ 29\\ 30\\ 31\\ 32\\ 33\\ 34\\ 5\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ \end{array}$

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Mirnezami	2016	Science and Public Policy	EM		-025320 on 30 March opyright, including fo			Y		
Misteli	2013	The Journal of Cell Biology	ED		or use		Y			
Moed	2015	Journal of the Association for Information Science and Technology	RE		9. Downloade Superie es related to				Y	
Moed	2009	Archivum Immunologiae et Therapia Experimentalis	ED		uper ed to	Y	Y	Y		
Mooij	2014	Scientometrics	EM		ed from ht ieur (ABES b text and c			Y		Y
Moppett	2011	British Journal of Anaesthesia	EM	Y		Y		Y	Y	
Moreira	2015	PLOS One	EM		b) . lata	Y	Y		Y	Y
Morel	2009	PLOS Neglected Tropic Diseases	EM		minir	Y				Y
Moustafa	2016	Accountability in Research-Policies and Quality Assurance	ED		ing, A					
Murphy	2011	Irish Journal of Medical Science	EM				Y			
Murphy	2017	Nature	ED		mj.com/ (training,			Y		
Mutz	2015	Journal of the Association for Information Science and Technology	EM	Y	on June 13, , and similar					
Mutz	2012	Zeitschrift fur Psychologie	EM	Y	e 13, mila					
Nah	2009	Journal of The American Society for Information Science and Technology	EM	C	2025 at r technol		Y	Y		
Napolitano	2016	Critical Care Medicine	ED		t Ager ologie			Y		
Nature Editorial Office	2013	Nature Letters	ED		Y Bib		Y			
Nature Editorial Office	2017	Nature	ED		liograp		Y			
Neufeld	2011	Research Evaluation	EM	Y	hique	Y				
Neylon	2009	PLOS Biology	ED		Y de		Y			
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Nicol	2007	Medical Journal of Australia	EM	Y	-023320 on 30 march opyright, including fo		Y			
Nicolini	2008	Scientometrics	EM		or use		Y	Y		
Niederkrotenthaler	2011	BMC Public Health	EM		. עט s re	}				Y
Nielsen	2017	Studies in Higher Education	EM		Superieu lated to te	<u>,</u>	Y	Y		
Nigam	2012	Indian Journal of Dermatology, Venerology and Leprology	ED		to te	Y				
Nightingale	2013	Nurse Education in Practice	EM		Ytt and	Y	Y		Y	
Nosek	2010	Personality and Social Psychology Bulletin	EM		BES)	Y				Y
Nykl	2015	Journal of Informetrics	EM	Y	ta m	Y	Y			
O'Brien	2012	Oikos	ED		ining					
O'Connor	2010	European Journal of Cancer Care	ED		Alt		Y	Y		
Okhovati	2016	Global Journal of Health Science	EM	Y	Ynir	Y	Y	Y		
Oliveira	2013	Revista Paulista de Pediatria	EM		no Ya o		Y	Y		
Oliveira	2011	Arquivos Brasileiros de Cardiologia	EM		nd si	Y	Y			
Oliveira	2013	Scientometrics	EM		Yila ,	Y	Y	Y		
Opthof	2009	Netherlands Heart Journal	EM		r tech	Y Y	Y			
Orduna-Malea	2015	El Profesional de la Información	ED	Y	n ar n		Y		Y	Y
Osterloh	2015	Evaluation Review	EM	Y) gies		Y			
Ouimet	2011	Scientometrics	EM		- c			Y		
Pagani	2015	Scientometrics	RE		Y III	<u>,</u>	Y			Y
Pagel	2011	British Journal of Anaesthesia	EM		gi apri	Y				
Pagel	2011	Anaesthesia	EM		Indre			Y		
Pagel	2015	Original Investigations in Education	EM		Y C	-		Y		

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1 2 3 4	Paik	2014	Surgical Education	EM		30 March cluding fc	Y				
5	Pan	2014	Science Reports	EM		2019 or use	Y	Y			Y
6 7	Pandit	2011	Anaesthesia	ED		Yre Yre	Y		Y		
8 9	Patel	2013	Journal of the Royal Society of Medicine	EM	Y	Wnlo Sup Yec	Y	Y	Y		Y
10	Patel	2011	Journal of the Royal Society of Medicine	RE		Yo te	Y	Y	Y		
11 12	Patrow	2011	Journal of Postgraduate Medicine	ED		ur (A	Y				
13 14	Pepe	2012	PLOS One	EM		aded from http: perieur (ABES) I to text and dat	Y				Y
15	Pereyra-Rojas	2017	Frontiers in Psychology	EM	Y	p://bm) . ata mi	Y		Y		
16 17	Perlin	2017	Journal of Informetrics	EM		njope vinjng		Y			
18	Persson	2014	Acta Physiologica	ED		<mark>eh.bm</mark> g _i Al tr				Y	
19 20	Peters	2017	Journal of Infometrics	ED		nj.co traini		Y			
21 22	Petersen	2013	Journal of Informetrics	EM		rj.com/ or					Y
23	Petersen	2010	Physical Review	EM		n Jun and si					
24 25	Pinnock	2012	Nurse Education Today	ED	1,	ne 13, Yinjila		Y			
26 27	Põder	2017	Trames-Journal of the Humanities and Social Sciences	EM	0	8, 2025 ur tech	Y				Y
28	Prabhu	2017	World Neurosurgery	ED		5 at	Y	Y	Y	Y	
29 30	Prathap	2016	Scientometrics	EM		Agen ogjes		Y			
31 32	Prathap	2012	Scientometrics	EM		C	Y	Y	Y		
33	Prathap	2014	Scientometrics	EM		Biblio	Y				Y
34 35	Prathap	2017	Current Science	ED		Y ap	Y	Y			Y
36 37	Pringle	2008	Learned Publishing	ED		Y qu	Y	Y	Y		
38	Pshetizky	2009	Journal of the American Board of Family Medicine	EM		Y Q		Y			
39 40 41 42 43 44 45			For peer review only - http://bmjopen	ı.bmj.com/site/ab	pout/guidelir	Enseignement					
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Pugh Jr	2013	Journal of General Physiology	ED			rch		Y			
Pulina	2007	Italian Journal of Animal Science	EM		ruse	2019	Y	Y	Y		
Pyke	2015	BioScience	ED		is rel	. Do					Y
Qi	2016	Scientometrics	EM		Yed	/nlo					
Quigley	2012	Journal of Cancer Education	EM		to te	wnloaded Superieu	Y				
Rad	2012	Academic Radiology	EM		Xt a	r (A	Y				
Radicchi	2008	Proceedings of the National Academy of Sciences of the United States of America	EM		d data Yata	http:// ES) .	Y		Y		Y
Radicchi	2012	Journal of Informetrics	EM		Ynin	omjo			Y		
Raj	2016	Academic Medicine	EM		 ¥g. A	ĕ	Y		Y		
Ramasesha	2011	Current Science	ED		Ytra	bmj.c	Y	Y	Y		
Rana	2013	Journal of Cancer Education	EM		Yraining,	bm/	Y				
Ravenscroft	2017	PLOS One	EM		, and	ر no	Y	Y	Y	Y	
Rey-Rocha	2015	Scientometrics	EM	1.	Ysimi	June					
Rezek	2011	Academic Radiology	EM		lar te	13, 20					
Ribas	2015	Proceedings of the 24th International Conference on World Wide Web	0	Y	schnglo	2025 at A	Y				Y
Ribas	2015	arXiv	ED		gies	genc					Y
Ricker	2009	Interciencia	ED	Y		ce Bib		Y			Y
Rieder	2010	Langenbeck's Archives of Surgery	ED			bliogr	Y		Y		
Robinson	2011	Journal of School Psychology	ED			Iraphi		Y			
Rodriguez-Navarro	2011	PLOS One	EM			ique					Y
Ronai	2012	Pigment Cell and Melanoma research	ED	Y	Y	de I E					
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1 2					n 30 M: ncludii					
3 4	Rons	2009	Research Evaluation	EM	March Iding fo					
5	Rosati	2016	Journal of Cardiac Surgery	EM	2019 r use	Y				
6 7	Ruane	2009	Scientometrics	EM	. Do	Y				Y
8 9	Saad	2010	Scientometrics	EM	Wnloa Supe lated	Y				
10	Safdar	2015	Society for Academic Emergency Medicine (SAEM)	EM Y						
11 12	Sahel	2011	Science Translational Medicine	ED	from Y and Y and	Y	Y			
13 14	Sahoo	2017	Omega	EM		Y	Y			Y
15	Saleem	2011	Internal Archives of Medicine	ED		Y	Y			
16 17	Sangam	2008	Current Science	ED	://bmjope :a mining	Y	Y			
18 19	Santangelo	2017	Molecular Biology of the Cell	ED			Y	Y		
20	Saraykar	2017	Academic Psychiatry	EM	bmj.com/ (Al training,	Y				
21 22	Sarli	2016	Missouri Medicine	ED	ing, a		Y	Y	Y	
23 24	Satyanarayana	2008	Indian Journal of Medical Research	ED	n June and sir	Y	Y			
25	Saxena	2013	Journal of Pharmacology Pharmacotherapeutics	EM	imila	Y	Y	Y		Y
26 27	Sebire	2008	Ultrasound in Obstetrics and Gynaecology	ED	, 202t	Y		Y	Y	
28 29	Selek	2014	Scientometrics	EM	5 at , hpol	Y		Y		
30	Seo	2017	Management Decision	EM	5 at Agend		Y			
31 32	Shanta	2013	Journal of Medical Physics	ED	γö	Y	Y			
33 34	Shibayama	2015	Research Policy	EM	Y Dio		Y			
35	Sibbald	2015	Journal of the Medical Library Association	ED	grap					Y
36 37	Simons	2008	Science	ED	hique		Y			
38	Sittig	2015	MEDINFO 2015: eHealth-enabled Health	EM	Y C	Y				Y
39 40			-		Ens					
41 42					nseigne					
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44 45				-	nt					
46										

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Slim	2017	Anaesthesia, Critical Care & Pain Medicine	ED			y for		Y		Y	
Slyder	2011	Scientometrics	EM			2019. r <u>Y</u> use					
Smeyers	2011	Journal of Philosophy of Education	ED			S rela	'	Y			
Smith	2008	Bone & Joint Journal	ED			/nloa Sup ated	ļ.	Y			
Soares de Araujo	2011	Revista Brasileira de Medicina do Esporte	EM			aded erieu to te	Y	Y	Y		
Sobhy	2016	Embo Reports	ED			r (A)	1	Y			
Sobkowicz	2015	Journal of Artificial Societies and Social Simulation	EM	Y		wnloaded from http: Superieur (ABES) . lated to text and data					
Solarino	2012	Annals of Geophysics	RE			Yani	Y	Y			Y
Sood	2015	Eplasty	EM			ining					
Sorenson	2011	Journal of Parkinson's Disease	EM			Y <u>></u>	Y				Y
Spaan	2009	Medical & Biological Engineering & Computing	ED			mj.con trainin	Y	Y			
Spearman	2010	Journal of Neurosurgery	EM			ing, a					
Spreckelsen	2011	BMC Medical Informatics and Decision Making	EM	•		n Jun and si	· Y	Y	Y		
Staller	2017	Qualitative Social Work	ED	1		ingilar	37			Y	
Stallings	2013	Proceedings of the National Academy of Sciences of the United States of America	EM	" (7	r techno	Y				Y
Street	2009	Health Research Policy and System	EM	Y		t Age alogie	•				
Stroebe	2010	American Psychologist	ED			Y. ence	<u> </u>		Y		
Stroobants	2013	Nature	ED			Bibli					
Sturmer	2013	Revista Brasileira De Fisioterapia	EM			Y gra	Y				
Suiter	2015	The Journal of Academic Librarianship	EM			phiq	Y	Y	Y	Y	
Suminski	2012	The Journal of the American Osteopathic Association	EM			Y e		Y	Y		
Suminski		*									

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1 2 3	Surla	2017	The Electronic Library	ED		on 30 March , including fc		Y			Y
4	Susarla	2017	Plastic and Reconstructive surgery	EM		fory	Y	I			
5 6			Journal of Dental Education		Y	2019. ryses	T Y				
7 8	Susarla	2015		EM). Downloa Supe es related	Y	**			
8 9	Sutherland	2011	PLOS One	EM	Y	nloa Supe ted t		Y			
10 11	Svider	2013	Laryngoscope	EM		ded brieu to te	Y				
12	Svider	2014	Ophthalmology	EM	Y	fron r (Al xt ar	Y				
13 14	Svider	2013	Laryngoscope	EM	Y	aded from http: berieur (ABES) I to text and dat	Y				
15	Svider	2013	Laryngoscope	EM		ata mi	Y		Y		
16 17	Swanson	2016	Annals of Plastic Surgery	EM		njope	Y				
18	Szklo	2008	Epidemiology	ED				Y			
19 20	Szymanski	2012	Information Sciences	EM		Al trainin	Y	Y	Y		Y
21 22	Taborsky	2007	International Journal of Behavioural Biology	ED	Y	Ģ, Z					
23	Tan	2016	The Annals of Applied Statistics	EM		and si	Y	Y		Y	Y
24 25	Tandon	2015	National Academy Science Letters-India	ED		une 13, simila		Y			
26 27	Taylor	2015	Poultry Science	ED		3, 2025 ar tech	Y	Y		Y	
28	Teixeira	2013	PLOS One	EM		25 at A chnolo	Y				
29 30	Tenreiro Machado	2017	Entropy	EM	Y	Ageno			Y		
31 32	Thelwall	2017	Aslib Journal of Information Management	EM		6				Y	
33	Therattil	2016	Annals of Plastic Surgery	EM		Biblio	Y				
34 35	Thomaz	2011	Arquivos Brasileiros De Cardiologia	ED		ograp	Y	Y	Y		
36	Thorngate	2014	Advances in Social Simulation	EM	Y	ohique					
37 38	Tijdink	2016	BMJ Open	EM		Je de					
39 40		2010									
41 42 43 44			For peer review only - http://br	njopen.bmj.com/site/abc	out/guidel	nseignement					
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Timothy	2015	Tourism Management	ED		opyright, including fo	-025320 on 30 March		Y			
Torrisi	2014	Scientometrics	EM	Y	or us	2019	Y	Y	Y		
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Trueger	2015	Annals of Emergency Medicine	ED		lated to te	oluv	Y	Y		Y	
Tschudy	2016	Journal of Pediatrics	EM		to te	aded	Y		Y		
Tse	2008	Nature	ED		xt an	from	Y	Y			Y
Tuitt	2011	Canadian Journal of Gastroenterology	EM		ext and dat	http	Y	Y	Y		
Usmani	2011	Sudanese Journal of Paediatrics	ED		a. mi	//bn	Y	Y			
Valsangkar	2016	Surgery	EM		ning.	jope	Y		Y		
van Arensbergen	2012	Higher Education Policy	EM	Y	A	n.bm					
van den Besselaar	2009	Research Evaluation	EM	Y	training,	j.cor					
van Eck	2013	PLOS One	EM		ຍ	n/ on					
van Leeuwen	2008	Research Evaluation	EM		nd si	Jun	Y				
van Leeuwen	2012	Research Evaluation	EM	Y		e 13,					
van Noorden	2010	Nature	ED		tech	2025	Y	Y	Y	Y	
van Wesel	2016	Science and Engineering Ethics	EM		nologies	at A					
Vaughan	2017	Scientometrics	EM		gies.	geno				Y	
Verma	2015	Proceedings of the National Academy of Sciences of the United States of America	ED	Y		e Bibli		Y			
Vico	2015	Prometheus	EM	Y		ogra					
Vieira	2011	Scientometrics	EM			phiqu					Y
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Vinyard	2016	Computers in libraries	ED		iding fo	Y	Y		Y	
von Bartheld	2015	PeerJ	EM		or use		Y	Y		
Wacogne	2016	Archives of Disease in Childhood-Education and Practice Edition	ED		s. Downin Su es relate		Y	Y	Y	
Wagner	2012	Research Evaluation	ED							Y
Waisbren	2008	Journal of Women's Health	EM		d to text	<u> </u>				
Walijee	2015	Plastic and Reconstructive Surgery	ED		text and c	-			Y	
Walker	2010	BMC Medical Education	EM				Y	Y		
Wallace	2012	PLOS One	EM	Y	- mainin Yinin					
Walters	2011	Journal of the American Society for Information Science and Technology	EM	Y	ġ,		Y			
Waltman	2013	In: Gorraiz J, Schiebel E, Gumpenberger C, Horlesberger M, Moed H, eds. 14th International Society of Scientometrics and Informetrics Conference	EM		Al training _Y an	Y				Y
Waltman	2013	Journal of Informetrics	EM		June Ysim					
Wang	2013	Science	EM		ilar	Y	Y	Y		Y
Ward	2012	Anaesthesia	ED	Ċ	techr	2 2 2 1				
Watson	2015	Journal of Pediatric Surgery	EM			v				
Welk	2014	Research Quarterly for Exercise and Sport	ED		nologies.		Y			
Wieczorek	2016	Financial Environment and Business Development	ED		Y B	Y	Y			
Wildgaard	2014	Scientometrics	RE		Y og	Y	Y	Y		
Williamson	2008	Family Medicine	EM		apni					Y
Wootton	2013	Health Research Policy and Systems	EM	Y	que		Y			Y
Würtz	2016	Annals of Epidemiology	RE		а е г	Y				
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First author	Year	Journal name	Level	Metric or Model	Name	Basis	It accounts for the teoperated distribution of citations.
Anderson	2008	Scientometrics	Researcher	Metric	Tapered h- index	h-index	=
Aragon	2013	Nature Scientific Reports	Both	Metric	Scientist impact (Φ)	Author contribution s and citation counts	Instead of the total $\mathbf{a}_{\mathbf{p}}$ for of citations, the proposed measure Φ (Scientist Impact) $\mathbf{a}_{\mathbf{p}}$ is a discerning the genuine number of people (specifically lead author) the paper (or first author) has had an impact upon by renewing self-citation. In other words, Φ aims at measuring the paper is reach.
Assimakis	2010	Scientometrics	Researcher	Metric	The Golden Productivity Index	Author contribution and publication count	A rank dependent index that measures the productivity of an individual researcher by evaluating the number of papers as well as the rank of co-auther ship. It emphasizes the first author's contribution.
Bai	2016	PLOS One	Researcher	Metric	COIRank algorithm	Network analysis	Quantifies scientific impact by reproducing the accumulated COI relationship in the generative community. COIRank focuses on improving PageRant though setting a weight for PageRank algorithm and promotes the performance in identifying influential articles. It therefore accounts for self-citation and citation by others at the same institution.
Belikov	2015	f1000 Research	Researcher	Metric	L-index	h-index and author contribution	Accounts for co-author contribution by designating citations to each individual author according to their order on a paper. It also considers the age oppublications, favoring newer ones. However, if a scientist has made a significant scientific breakthrough and ceases publications, his or her bindex will remain high regardless. It ranges from 0.0-9.9.
Bini	2008	Electronic Transactions on Numerical Analysis	Both	Metric	Information not available	Citation count	Proposes to integrate models for evaluating papers, authors, and journals based on citations, co-authorship and publications. After the one-class model for manking scientific publications, they introduced the two-class model which ranks papers and authors, and the three-class model for ranking papers, authors, and journals.
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Bloching	2013	South African Journal of Science	Article	Metric	TAPSIF- temporally averaged paper-specific impact factor	Citation count and IF	Calculated from a press average number of citations per year (including the publication year) combined with bonus cites for the publishing journal' pressige—which is taken as the journal impact factor from the publication year. Annual TAPSIF values of all the papers by an authomic and be combined to measure the overall scientific relevance to the problem of the pr
Bollen	2016	Scientometrics	Researcher	Model	Equal Allocation Model	Peer-review	A novel model in which heach researcher is allocated funding and is required to donate appropriate funding to other researchers- hence uses crowd will be model for the funding to the searchers.
Caminiti	2015	BMC Health Services Research	Researcher	Metric	Information not available	Citation count	This work in progressing gests a mixture of 12 easily retrievable indicators (bibliometric and citation parameters, as well as "hidden" activities such as teaching, mentoring etc). The weighting system was constructed considering the hypothesized effort for all indicators. The chore in iddicators and attributed scores still remain to be validated. Modifier from Wooton, Health Res Policy Syst. 2013;11:2; Smith, Br Med J. 2001;323(7312):528–8.; and Mezrich J Am Coll Radiol. 2007;4(7):471–8.
Castelnuovo	2010	Clinical Practice & Epidemiology in Mental Health	Researcher	Metric	Single Researcher Impact Factor	IF	This metric takes into a count publications (journal articles, books, oral and poster presentations in scientific meetings); products (e.g., software, CD-ROM videos, databases); and activities (reported scientific activities such as scientific positions or positions in conferences organization, participation in journal editorial boards, activities on human escurces education, and participation in international funding projects). Minimum and maximum values are assigned to each tage for national and international impact.
Claro	2011	Scientometrics	Researcher	Metric	The x-index	IF and author contribution	Aims to enable cross-disciplinary comparison and uses indicators of both quality and quartity, taking into account the number of publications a researcher has published, and then calculating a publication score for each. This considers number of authors on the paper and the journal's grear impact factor; it is also normalized by the journals in which the author tends to publish (rather than top-down classification of a field). Also uses a co-authorship share coefficient. Therefore, arms to determine relative contribution to a paper and normalize by the efforts, it is not based on individual article citations but that of the journal (JIF), which can have limitations.
			For peer r	eview onl	y - http://bmjope	en.bmj.com/site	e/about/guidelines.xhtmen

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Cordero- Villafafila	2015	Revista de Psiquiatría y Salud Mental (English Edition)	Both	Metric	RC Algorithim	IF	The first English-language publication of this metric, it quantitatively evaluates the personal impact factor of the sci production of isolated researchers. It also an individual form and group form (RGγG), and is able to assess personal impa individual publications, or a group of them. It also provide procedure to classifie the arch centers of different types base the impact (FRCγG) there is by their results amongst research the same field. One of the limitations of the RC algorithm is precisely, its dependence on said bibliographic databases, w have a strong pre-emined constant of studies published in English.
Crespo	2015	PLOS One	Other	Metric	Exchange Rate	Citation count	This is an average-based indicator that is used to explore differential citation and between disciplines by using it as a normalization factor. It is not suitable for assessing individu researchers but produce insight into comparison across disc
De Witte	2010	Scientometrics	Researcher	Metric	RES-score - Research Evaluation Score	Data Envelopmen t Analysis	Authors present a methodology to aggregate multidimension research output, using a ailored version of the non-paramet Envelopment Analysis model. This they claim is a more acc representation of a search performance.
Delgadillo	2016	Family & Consumer Sciences Research Journal	Both	Metric	HLA-index	h-index	This index, actually point and a book by Harzi (2011), normalizes to take into account career st discipline.
Dodson	2012	Biochemical and Biophysical Research Communications	Researcher	Metric	SP-index	IF	This metric is said a quantify the scientific production of researchers, representing the product of the annual citation r by the accumulated mpetric factors of the journals in which t papers are publisher, divided by the annual number of public papers.
Duffy	2008	Journal of Counseling Psychology	Both	Metric	IRPI - Integrated Research Productivity Index	Citation count	This metric statistically combines an individual's author-we publications (AWS) average times cited by other publication (MC), and years since first publication (Y) into a comprehens score, calculated as (AVS) x MC)/Y. It thereby accounts for differences in career length.
Ebadi	2016	Scientometrics	Researcher	Model	iSEER	Machine learning	An intelligent machine garning framework for scientific ev of researchers (iSEER) considers various "influencing facto different types" (e.g., funding, collaboration pattern, perforr such as quantity and impact of papers, efficiency). It can be a complementary tool to overcome limitations in peer-revie
			For peer r	eview onl	y - http://bmjop	en.bmj.com/site	e/about/guidelines.xhtm

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Ekpo 2016 Journal of Medical Imaging and Radiation Sciences Researcher Metric Metric TotalImpact Author continuition count and citation For each of the authors, the total number of publications in peer reviewed journals (2), tical number of citations per publication collaboration metrics, and illo-inde& are extracted (using SciVal). This metric assessed whether authors were leading the research or coauthor count and citation Franceschini 2012 Scientometrics Both Metric Information not available Citation counts and h-index A study specific metrics A study specific metrics Both Franceschini 2012 Scientometrics Both Metric The Success- Index Citation not available Citation counts and h-index A study specific metrics A study specific metrics The success- tine to avait for some the success- index A study specific metrics Scientometrics Researcher Metric Franceschini 2012 Scientometrics Researcher Metric The Success- Index Citation counts, NSP-index The Success- Index Citation counts, NSP-index This metric is based on Komulski's (2011) NSP (number of successful papers) if de Boutin the is stored with publications/patering Franceschini 2012 Scientometrics Researcher Metric The Success- Index						ВΛ	1J Open	-025320 on 30 M: opyright, includi
not availablecounts and h-indexpublications/patent fraining to publications/patents of one researcher (an indigator of tendency for co-authorship). It also u the minimum and mixing un years: the oldest publication/patent and the year relating to peir latest one. This provide an indicatio of the temporal extension of the publishing or patenting activity a researcher. They also use the most-cited is publication/patent researcher. They also use the most-cited is publication/patent of the temporal extension of the publishing or patenting activity a researcher. They also use the most-cited is publication/patent researcher. They also use the conv." in terms of impact/diffusion. The segmetrics are also scalable to teams thou where the h-spectrum is is-values to a group of researchers (including average and medium), and the h-group is the h-index the union of publications/patents associated with publications/patentsFranceschini2012ScientometricsResearcherMetricThe Success- IndexCitation counts, NSP-index by Komulski (2011)This metric is based on comulski's (2011) NSP (number of successful papers) idde with the exception that for each publications. While it is more complicated than the organized that the organized that the organized that the organized to differential propensity to cite and therefore suitable for comparisons between complicated than the organized to differential propensity to cite and therefore suitable for comparisons between	Ekpo	2016	Medical Imaging and Radiation	Researcher	Metric	TotalImpact	contribution, publication count and citation	For each of the authors, the total number of publications in peer reviewed journals (P), total number of citations (C), international collaboration metrics, number of citations per publication (CPP) index, and i10-index are extracted (using SciVal). This metric assessed whether authors were leading the research or coauthors by judging their post to in the list of authors for each article. Authors listed as finder for the list of authors for each article. Authors listed as finder for the list of authors. Each authors total impact was the state in-between as coauthors. Each authors total impact was the state in the list of by: TotalImpact=P×C×FSL.
Index counts, NSP-index successful papers) index with the exception that for each publication the comparison term is sometimes replaced by a more by Komulski (2011) of a representative complexity to cite, determined on the ba of a representative complexity to cite and therefore suitable for comparisons between				0		not available	counts and h-index	publications/patent and their citations and also quantifies avera number of co-authors relating to publications/patents of one researcher (an indicator of tendency for co-authorship). It also u the minimum and mixing um years: the oldest publication/patent and the year relating to peir latest one. This provide an indication of the temporal extension of the publishing or patenting activity a researcher. They also use the most-cited is publication/patent of researcher, representing the "jewel in the crown" in terms of impact/diffusion. This provides a group of researchers (including average and medium), and the h-group is the h-index the union of publications patents associated with publications/patents.
	Franceschini	2012	Scientometrics	Researcher	Metric		counts, NSP-index by Komulski	successful papers) index with the exception that for each publication the comparison term is sometimes replaced by a more appropriate indicator of propensity to cite, determined on the ba of a representative comparison of publications. While it is more complicated than the original, it is insensitive to differential propensity to cite and therefore suitable for comparisons between

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Frittelli	2016	Journal of the Association for Information Science and Technology	Researcher	Metric	SRM - Scientific Research Measures	h-index and calculus	Proposes a novel class of measures (SRM) based on calculus principles that rank scientist's research performance by taking into account the whyle fation curve of a researcher (their performance curve number of citations of each publication, in decreasing order of itations). The performance cures can be chosen flexibly (e.g. before the factor of a field They extend this ide performance by taking before the seniority, characteristics of a field on theories of risk-factor of the seniority classes researchers with the same citation for the seniority of the seniorit
Gao	2016	PLOS One	Both	Metric	PR-index - PageRank Index	Network analysis and h-index	This metric uses Page hk score calculation combined with h- index calculation to as ure author impact. It considers publicat and citation quantited also takes a publication's citation netwo into consideration. This means the index will rank majority author higher by applying age Rank based on the publication citation relationship (distinguishing higher quality citations from lower ones).
Han	2013	Institute of Strategic Studies Islamabad	Both	Metric	New Evaluation Index	Network analysis	The new evaluation and takes into account direct and indirect references, direct and indirect citations, and citation network.
Holliday	2010	International Journal of General Medicine	Article	Model	Modified Delphi technique of peer-review	Peer-review	This paper reports using the modified Delphi process to appraise and rank research applications, with experts rating each application's scientific merit, originality, the adequacy of the stud design to achieve the research goals, and whether the potential impact of the study voud warrant its funding. While its ease of administration, reproduce bility, and accessibility makes this a useful adjunct to the traditional processes of grant selection, it do not directly assess individual researcher's but their work.
Hutchins	2016	PLOS Biology	Both	Metric	iCite	Citation count	This is used for inderideal articles and normalizes their citation score by adding in so-citation metrics.
Ibrahim	2015	New Library World	Both	Metric	Hx	h-index and author contribution	This metric is a hybridization of two indicators based on the individual h-index (weighted by the average number of co-author for each paper) and h-index contemporary weighted by qualitative factors (conferences and journal in which a researcher participate or published). It accounds for the period of citations and number authors on a paper, is applicable at all levels and for any disciplin of research, takes conferences into consideration, and is thought reduce unscientific practices such as integration of authors who have not genuinely contributed.

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Ioannidis	2016	PLOS Biology	Researcher	Metric	Composite	Citation count, h- index and author contribution	A study-specific composite metric based: on total number of citations in, for example, 2013 (NC), total number of citations received in 2013 to papers for which the researcher is single at (NS), total number of citations received in 2013 to papers for which the researcher is single at (NS), total number of citations received in 2013 to papers for which the researcher is single at author (NSF), total number of citati received in 2013 to papers for which the researcher is single, f or last author (NSF) (NSF) (NSF), total number of citati received in 2013 to papers for which the researcher is single, f or last author (NSF) (NSF) (NSF), and the researcher is single, f or last author (NSF) (NSF) (NSF), giving eacle at the standardized (NC, H, Hm, NS, NSF) (NSFL), giving eacle at the highest raw value for the researcher is indicator. The six staff addiced indicators are then summed to
			07		0		generate the composite address C. Well-tested and validated usin factor analysis, which yielded two factors: bulk impact (NC ar author order and constant prship-adjusted impact (Hm, NS, NSF NSFL).
Iyendar	2009	Academic Medicine	Researcher	Model	RD - Research Density and Individual Impact Factor	IF	RD measures the ability to obtain grants at a point in time, while IFF reflects the quarty of research. The adopted methodology compares the impact factor of an investigator's articles with the of the top journals within their own field. Each investigator identified the top these journals in his or her field. The average impact factor of these these journals was used as the benchmar that investigator. Each faculty member was then asked to calculate his or her own individual impact factor (IIF) for two consecutions of these these benchmarks as target. This benchmark selected after reviewing results of comparisons of investigator. IIFs with their self-defined benchmarks at several multiples (575%, and 100%). We used 75% of the self-defined benchmark the target, because a signalikely for every paper to be published the best journal in the field, and yet 75% reflects the reasonable high standard of the resourch quality that MSSM strives for. The data were collated and the IIF of each faculty member was computed as the ratio of his or her impact factor to 75% of his her self-defined benchmark, expressed as a percentage.
Jeang	2008	Retrovirology	Researcher	Metric	Mentoring Index	h-index	Argues that good mentoing should be a significant considerat of one's contribution to beince. It focuses on using the h-index previous trainees in evaluating established researchers. It is the this index could encourage the development of long-lasting mentoring relationships.

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Krapivin	2009	Complex Sciences	Both	Metric	PaperRank and PR- hirsch	Network analysis and h-index	Based on PageRank, which has been very successful in ranking web pages, essentially considering the reputation of the web page referring to a given bage and the outgoing link density (i.e., page P linked by pages Lowhere L has few outgoing links are consider more important than pages P cited by pages L where L has man outgoing links). Page thank (PR) applies page rank to papers by considering papers to be pages and citations as links, and hence trying to consider not the page of the citing paper and the density of outgoing citations for the citing paper. The PR-Hirsch is a modification of the difference based on the same PageRank approach. PR and Page based on the same PageRank approach of the page based on the same PageRank approach. PR and Page based on the same PageRank approach. PR and Page based on the same PageRank approach of the page based on the same PageRank approach based on the page based on the same page based on the
Kreines	2016	Journal of Computer and Systems Sciences International	Article	Model	Information not available	Citation count and IF	of a citing paper. Proposes a model for assessing quality in the content of individuant articles using computational analysis with bibliometric and scientometric data aumber of citations and the journal's IF).
Lando	2014	PLOS One	Article	Metric	l-index	h-index	This index considers the most elite papers and rewards papers of high impact and based on the form of the citation distribution. If thought to outperform the h-index in terms of accuracy and sensitivity to the form of the citation distribution, while being strongly correlated with other important h-type indices. It rewar the more regular and religible researchers.
Liang	2015	IEEE International Conference on Smart City/SocialCom/ SustainCom	Both	Model	Temporal tracking model		The temporal research exolution model takes into account individual output, researcher profile and experiences Bibliographique
			For peer r	eview onl	y - http://bmjop	en.bmj.com/site	e/about/guidelines.xhtment

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Lippi	2017	Annals of Translational Medicine	Researcher	Metric	SIF-Scientist Impact Factor	IF	This metric is calculated as all citations of articles published in t two years following the publication year of the articles, divided the overall number of articles published in that year. For exampl the SIF for the year 2017 would be obtained by dividing all citations in the year 2017 would be obtained by dividing all citations in the year 2016 to articles published in the year 2014, divided by the we all number of articles published in the year 2014. The total for the published of recent citations is normalized according to the number of recently published articles, limiting t bias emerging from the publishing a large number of scarcely cited articles; and the out the scientist, so complementing an overall career indicator, such the h-index.
Markpin	2008	Scientometrics	Other	Metric	ACIF - Article-Count Impact Factor	IF	This is proposed as join al-level metric that is calculated as the total number of articles ated in the current year divided by the number of articles ablieved in 1st and 2nd year. Note that is base on the number of articles that were cited, rather than the times cited articles. However, it could be used for individual researchers.
Matsas	2012	Brazilian Journal of Physics	Both	Metric	NIF - Normalized Impact Factor	IF	Introduces a normalized impact factor that looks at the researched influence on their set entitic community by assessing the degree which they have been influenced by their community. Looks each of an author's publications, the number of co-authors, references the article and citations is has received. From the way it is calculated: "in a closed community of identical individuals (i.e., who publish, reference and are cited by each other at the same rate), all members have $MIF = 1$." Leaders in a field are then those with a NIF greater than ar equal to 1 i.e., they influence their per at least as much as grey are influenced by them.
Maunder	2007	La Revue Canadienne de Psychiatrie	Article	Metric	Citation Ratio	Citation count	This metric is designed by overcome systematic differences amongst niche fields by comparing the impact of a particular paj to the average impact of paper in its journal. A ratio above 1 indicates relatively greater success.
Mazloumian	2011	PLOS One	Article	Metric	Boost Factor	Citation count	This metric calculates when a particular research gains scientific authority, that is, they publish some groundbreaking work that the leads to an upswing in chations of their earlier papers. It is able model the trend of the "gich get richer", a cascade of citations an too improve the "signal go-noise" ratio in citation rates by detect sudden changes in citations.

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Milone	2016	American Journal of Orthopedics	Article	Metric	Information not available	Publication count	A study specific measurement simply calculated by taking the mean of first and lage authored publications.
Mooji	2014	Scientometrics	Both	Model	Information not available	Peer-review, altmetrics, citation count	This paper proposes a comprehensive and new framework for assessing research guality assessment which utilizes intrinsic (i.e., the internal quality of the publication) and extrinsic indicators (i.e., citation counts, well the dimension of the former and billing metric and altmetric data at the individual article and author levels for the latter. One limit includes that the assessment of extrinsic actors is still biased in terms of multi- author papers. This time work builds in a quality check on peer- review.
Moreira	2015	PLOS One	Researcher	Metric	μ	Information not available	Suggests accumulated characteristics from an author's aggregated publications following asymptotic number, and then use a lognormal model. Greates μ as a scale of expected citability of a researcher's publication it is able to be used at all career stages and indicates more of quality over quantity.
Morel	2009	PLOS Neglected Tropic Diseases	Researcher	Metric	Information not available	Network Analysis	Co-citation network generated using SNA of publications, to identify groups and ndigiduals with high collaboration rates.
Niederkroten thaler	2011	BMC Public Health	Article	Model	Information not available	Information not available	A tool designed to measure the societal impact of research publications. It consists of three quantitative dimensions: (1) the aim of a publication (2) the efforts of the authors to translate their research results, and, if translation was accomplished, (3) (a) the size of the area where translation was accomplished (regional, national or international) (b) its status (preliminary versus permanent) and (c) the target group of the translation (individuals, subgroup of population).
Nosek	2010	Personality and Social Psychology Bulletin	Researcher	Metric	Ics- Individual researcher career-stage impact	Citation count	Produces career-stage instric of scientific impact based on citation counts. Its development was based on extensive data collection to produce a regression of expected growth of impact over time. It, therefore, reflects the distance from one's expected impact at a given career stage.
Pagani	2015	Scientometrics	Article	Metric	Methodi Ordinatio	IF	Based on IF, number of itations and year of publication in a normalized, weighted nuthematical equation. It is a potential way to define scientific relevance.
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Pan	2014	Science Reports	Researcher	Metric	Author Impact Factor (AIF)		Defined as the AIF of an author A in year t is the average number of citations given by papers published in year t to papers publishe by A in a period of at years before year t. Uses a time window of years for calculation
Patel	2013	Journal of the Royal Society of Medicine	Researcher	Model	sRM - statistical Regression Model	Citation count	Used to estimate the number of high visibility (based on citation count) publications and the researcher.
Рере	2012	PLOS One	Researcher	Metric	TORI - Total Research Impact	Citation count	Includes non-self-characteris accrued by the researcher, number of authors on cited page and number of bibliographic references to generate the cumulative putput of a scholar by summing the impa of every external citetion accrued in his/her career. This removes biases associated with cration counts.
Petersen	2013	Journal of Informetrics	Researcher	Metric	Z	h-index	Z is aimed at correcting the h-index's penalty (which in some case neglects 75% of an author's body of work) by including the total number of citations for meir work in the metric.
Põder	2017	Trames-Journal of the Humanities and Social Sciences	Researcher	Metric	(Current or predicted) impact rate of researcher	Citation count	Based on the citations per year squared, this metric provides a means of assessing acceleration/impact and is based on time serie data. This is more sensitive to productivity overtime and can go down unlike the h-mode.
Prathap	2014	Scientometrics	Researcher	Metric	Z-index	h-index	Purporting to include quality, quantity and consistency, it accoun for the high-end of see the performance, while compensating fo the skewness of citation-publication distributions.
Radicchi	2008	Proceedings of the National Academy of Sciences of the United States of America	Article	Metric	Relative Indicator - cf	Citation count	The relative indicator is used to deal with the fact that different fields have different citation patterns and allows for comparisons the success of articles in different fields.
Ribas	2015	Proceedings of the 24th International Conference on World Wide Web	Both	Metric	P-score	Citation count	It associates a reputation with publication venues based on the publication patterns of reference groups, composed by researcher in a given area of know dege. Although the choice of reference groups can be made by asing available citation data, the P-score metric itself does not degend on citation data. It uses just publication records of refearchers and research groups; that is, the papers and the venues where they published in.

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Ricker	2009	Interciencia	Researcher	Model	Rule-based peer-review	Peer-review	Computer generated per review, which is positive as res get peer-review feedback. Can also measure evaluators se certain criteria of interest important journals of interest b field.	elect
Ruane	2009	Scientometrics	Both	Metric	h1-index	h-index	A measure of superdision quality, it gives the supervisor l calculated by the hand set of their PhD students.	al i
Sahoo	2017	Omega	Researcher	Model	Composite indicator	h-index, IF, citation counts	Calculated based on the elative weight of the six indicated journal tier, total citated s, author h-index, number of pap impact factor, and jaurnal h-index.	ers,
Saxena	2013	Journal of Pharmacology Pharmacotherape utics	Researcher	Metric	ORPI - Original Research Publication Index	Citation count	Indicates originality and visibility, by inclu number of original articles, citations, accounting for self- and the total number of pitable articles (i.e., including rev case reports). Also	ding citat view
Sibbald	2015	Journal of the Medical Library Association	Both	Model	Modified approach to citation analysis	Citation count	Includes grey literative in the citation analysis search pro- involves quantitative and qualitative methods of analysis better understanding of now a research paper was used. H this is more expensive and time consuming than tradition	to g Iow
Sittig	2015	MEDINFO 2015: eHealth- enabled Health	Researcher	Model	The Biomedical Informatics Researchers ranking website	Information not available	This new system was developed to overcome previous sc productivity ranking strategies. However, it is limited to b informatics.	
Sorenson	2011	Journal of Parkinson's Disease	Both	Metric	"Broad impact" citations	Citation count	Citations from those outside the field are used as a measu broader impact.	
Surla	2017	The Electronic Library	Researcher	Metric	Research Impact Factor	IF	Allows a measure of scientific influence of a researcher in relative scientific area.	1 the
Szymanski	2012	Information Sciences	Both	Metric	CENTs - sCientific currENcy Tokens and the I-index	Citation count and h- index	An accumulation of "cerris" based on the number of non-scitations. This is also the premise behind the i-index, whe papers a ranked according to CENTs rather than just all c	reby
			For peer r	eview onl	y - http://bmjopo	en.bmj.com/site	e de Enseignement v/about/guidelines.xhtment	

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Tan	2016	The Annals of Applied Statistics	Article	Model	Information not available	Citation count	Proposes to use two established models in the creation of a third. The proposed model provides a structural understanding of the field variation in cigation behavior and a measure of visibility for
Vieira	2011	Scientometrics	Researcher	Metric	hnf-index	h-index	individual articles a justed for citation probabilities within/betwee topics. a Considers the difference citation of each field and the number of authors be apply blication, and hence can be used to
Wagner	2012	Research Evaluation	Researcher	Metric	I3 - Integrated impact indicator	Citation count	measure researcher of formance. A framework for incertaing citations and non-parametric statistic of percentiles, which alge whighly cited papers to be weighted mo than less-cited ones and a statistic
Waltman	2013		Article	Metric	HCP – Highly cited publications index	Citation count	A simple model in whice the number of citations of a publication depends not only on the citation but al on other 'random' fictors. Does not account for productivity.
Wang	2013	Science	Article	Model	Mechanistic model for citation dynamics	Citation count	Authors demonstrate a pedictable course for citations of single articles over time, perperting, therefore, to create more reliable predictive index of individual impact.
Williamson	2008	Family Medicine	Researcher	Metric	Information not available	Too broad to classify	Quantifies activities within three domains: teaching, service and research and scholagy as tivity. A time intensive- process that is suitable for promotion within institutions, but not grant funding o more macro-scale assessments.
Wootton	2013	Health Research Policy and Systems	Researcher	Metric	R - Simple indicator of researcher output		Formula is $R=g+p+R$ and comprises grant income (g), publication (peer-reviewed and veighted by JIF; p) and numbers of PhD students supervised no credit for submission after the due date of submission; s).
Yaminfirooz	2015	The Electronic Library	Both	Metric	mh-index	h-index	Use to identify differences in the impact of authors with the same h-index, and differences between the outputs of influential researchers working in Ecertain field and the ones publishing only a few papers during a year, can track the impact of highly cited papers.
Yang	2013	Journal of Informetrics	Researcher	Metric	A-index - Axiomatic approach	Citation count and author contribution	Allows for evaluation opindividual researcher in the team context (i.e., co-authorship networks).

2					BM	J Open	-025320 on 30 opyright, inclu
							-025320 on 30 M opyright, includi
Zhang	2012	Scientometrics	Both	Model	Scientometric age pyramid	Information not available	Accounts for the different ages of academics, different fields, co authorship patterns and analysis of journals. The pyramid represents the number of publications on one side and number of citations on the other side.
Zhou	2012	New Journal of Physics	Both	Metric	AP Algorithm	Citation count	Considers the prestige of the scientists citing the article but assumes equal control of each author to the paper.
Zhu	2015	arXiv	Researcher	Metric	The hip index - Influence- primed h- index	h-index	The hip-index weight wations by how many times a reference mentioned, which is the ght to make it a better indicator of researcher performance
Zhuo	2008	Omega	Other	Metric	Z factor	IF	Uses both the number publications and the impact factors of journals in which the ywere published.
Zou	2016	Scientometrics	Researcher	Metric	S-ZP index	IF	Metric based on journal ampact factor of publications and autho order.
Zycxkowski	2010	Scientometrics	Both	Metric	C - Citation matrix	h-index	A scheme based on version of the citation based on previous scientific achievements and authors citing the paper.
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Reporting checklist for systematic review and meta-analysis.

 meta-analysis.

 Based on the PRISMA guidelines.

 Instructions to authors

 Complete this checklist by entering the page numbers from your manuscript where readers will finder the items listed below.

 Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" an provide a short explanation.

 Upload your completed checklist as an extra file when you submit to a journal.

 In your methods section, say that you used the PRISMA Group. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement

 Reporting Item

		Reporting Item		Page Numb	÷
	<u>#1</u>	Identify the report as a systematic review analysis, or both.	r, meta-	Title page	chnologies
Structured summary	<u>#2</u>	Provide a structured summary including, applicable: background; objectives; data study eligibility criteria, participants, and interventions; study appraisal and synthe	sources;	2-3	
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Page 69 of 72			BMJ Open	
1 2 3 4 5 6			methods; results; limitations; conclusions and implications of key findings; systematic review registration number	
7 8 9 10 11	Rationale	<u>#3</u>	Describe the rationale for the review in the context of what is already known.	4-5
12 13 14 15 16 17 18 19 20 21	Objectives	<u>#4</u>	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	5-7
22 23 24 25 26 27 28 29 30 31	Protocol and registration	<u>#5</u>	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address) and, if available, provide registration information including the registration number.	Review protocol exists but is unpublished
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60	Eligibility criteria	<u>#6</u>	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rational	5-7
	Information sources	<u>#7</u>	Describe all information sources in the search (e.g., databases with dates of coverage, contact with study authors to identify additional studies) and date last searched.	5-7
	Search	<u>#8</u> For	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated. peer review only - http://bmjopen.bmj.com/site/about/guidelines.xh	4-7, Appendix 1

		BMJ Open	
Study selection	<u>#9</u>	State the process for selecting studies (i.e., for screening, for determining eligibility, for inclusion in the systematic review, and, if applicable, for inclusion in the meta-analysis).	4-7
Data collection process	<u>#10</u>	Describe the method of data extraction from reports (e.g., piloted forms, independently by two reviewers) and any processes for obtaining and confirming data from investigators.	5-7 and Appendix
Data items	<u>#11</u>	List and define all variables for which data were sought (e.g., PICOS, funding sources), and any assumptions and simplifications made.	Page 6-7 and Appendix 2
Risk of bias in individual studies	<u>#12</u>	Describe methods used for assessing risk of bias in individual studies (including specification of whether this was done at the study or outcome level, or both), and how this information is to be used in any data synthesis.	5-7
Summary measures	<u>#13</u>	State the principal summary measures (e.g., risk ratio, difference in means).	The primary outco measure was methods to asses research achievement.

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5			•	
1 2 3 4			measures of consistency (e.g., I2) for each meta- analysis.	
5 6 7	Risk of bias	<u>#15</u>	Specify any assessment of risk of bias that may	5-6
, 8 9	across studies		affect the cumulative evidence (e.g., publication	
10 11 12			bias, selective reporting within studies).	
13 14	Additional	<u>#16</u>	Describe methods of additional analyses (e.g.,	8-12
15 16 17	analyses		sensitivity or subgroup analyses, meta-regression),	
17 18 19 20			if done, indicating which were pre-specified.	
21 22	Study selection	<u>#17</u>	Give numbers of studies screened, assessed for	7-8
23 24			eligibility, and included in the review, with reasons	
25 26			for exclusions at each stage, ideally with a flow	
27 28 29			diagram.	
30 31 32	Study	<u>#18</u>	For each study, present characteristics for which	8-12
32 33 34 35	characteristics		data were extracted (e.g., study size, PICOS,	
35 36			follow-up period) and provide the citation.	
37 38 39	Risk of bias	<u>#19</u>	Present data on risk of bias of each study and, if	6
40 41 42	within studies		available, any outcome-level assessment (see	
43 44 45			Item 12).	
46 47	Results of	<u>#20</u>	For all outcomes considered (benefits and harms),	7-11
48 49	individual		present, for each study: (a) simple summary data	
50 51 52	studies		for each intervention group and (b) effect	
53 54			estimates and confidence intervals, ideally with a	
55 56 57			forest plot.	
58 59 60		For	peer review only - http://bmjopen.bmj.com/site/about/guidelines.xk	ntml

			BMJ Open	Page 72	Open of 72
1 2	Synthesis of	<u>#21</u>	Present the main results of the review. If meta-	Not applicable to this	st published
3 4	results		analyses are done, include for each, confidence	review.	hed as
5 6 7 8			intervals and measures of consistency.		as 10.1136/bmjopen-2018-025320 on 30 March
8 9 10	Risk of bias	<u>#22</u>	Present results of any assessment of risk of bias	4-5 Protect	6/bmjop
11 12 13 14	across studies		across studies (see Item 15).	ed by c	en-2018
14 15	Additional	<u>#23</u>	Give results of additional analyses, if done (e.g.,	ہو Not applicable to thigh	-025320
16 17	analysis		sensitivity or subgroup analyses, meta-regression	review.) on 30
18 19 20			[see Item 16]).	4-5 Not applicable to thight, including for uses 13-17	March
21 22 23	Summary of	<u>#24</u>	Summarize the main findings, including the	13-17 Is a start s	2019. D
24 25	Evidence		strength of evidence for each main outcome;	related	Download
26 27			consider their relevance to key groups (e.g., health	to tex	aded f
28 29 30 31 32 33 34			care providers, users, and policy makers	(ABES)	rom htt
	Limitations	<u>#25</u>	Discuss limitations at study and outcome level	15-16 m ini,	o://bmjo
34 35			(e.g., risk of bias), and at review level (e.g.,	ng, Al	0
36 37			incomplete retrieval of identified research,	, trainin	nj.com
38 39 40			reporting bias).	15-16 mining, Al training, and similar technologies.	en.bmj.com/ on June 13,
41 42	Conclusions	<u>#26</u>	Provide a general interpretation of the results in	16-17 similar	
43 44 45			the context of other evidence, and implications for	echnol	025 at
46 47			future research.	ogies.	Agence
48 49 50	Funding	<u>#27</u>	Describe sources of funding or other support (e.g.,	18	Bibliog
51 52			supply of data) for the systematic review; role of		raphiq
53 54 55 56			funders for the systematic review.		2025 at Agence Bibliographique de l Enseignement
57 58 59 60		For	peer review only - http://bmjopen.bmj.com/site/about/guidelines.xh	ntml	eignement

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2 3	CC-BY. This checklist ca	in be completed online using <u>https://www.goodreports.org/</u> , a tool made by	lished
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The Comprehensive Researcher Achievement Model (CRAM):

a framework for measuring researcher achievement, impact and influence derived from a systematic literature review of metrics and models

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Primary Subject Heading :	Research methods
Secondary Subject Heading:	Health services research
Keywords:	Researcher assessment, Research metrics, h-index, Journal impact factor, Comprehensive Researcher Achievement Model (CRAM), Citat
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1	The Comprehensive Researcher Achievement Model (CRAM):
2	a framework for measuring researcher achievement, impact and influence derived from
3	a systematic literature review of metrics and models
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1 2		
- 3 4	34	ABSTRACT
5 6 7	35	Objectives Effective researcher assessment is key to decisions about funding allocations,
	36	promotion and tenure. We aimed to identify what is known about methods for assessing
8 9	37	researcher achievements, leading to a new composite assessment model.
10 11 12 13 14 15 16	38	Design We systematically reviewed the literature via the Preferred Reporting Items for
	39	Systematic Review and Meta-Analysis Protocols (PRISMA-P) framework.
	40	Data sources All Web of Science databases (including Core Collection, MEDLINE, and
	41	BIOSIS Citation Index) to the end of 2017.
17 18	42	Eligibility criteria (1) English language, (2) published in the last 10 years (2007-2017), (3)
19 20	43	full text was available, and (4) the article discussed an approach to the assessment of an
21	44	individual researcher's achievements.
22 23	45	Data extraction and synthesis Articles were allocated amongst four pairs of reviewers for
24 25	46	screening, with each pair was randomly assigned 5% of their allocation to review
26 27	47	concurrently against inclusion criteria, with inter-rater reliability assessed using Cohen's
27 28 29 30 31 32	48	Kappa (κ). The κ statistic showed agreement ranged from moderate to almost perfect
	49	(0.4848-0.9039). Following screening, selected articles underwent full text review and bias
	50	assessed.
33 34	51	Results Four hundred and seventy-eight articles were included in the final review.
35 36 37 38 39 40 41	52	Established approaches developed prior to our inclusion period (e.g., citations and outputs, h-
	53	index, journal impact factor), remained dominant in the literature and in practice. New
	54	bibliometric methods and models emerged in the last 10 years including: measures based on
	55	PageRank algorithms or "altmetric" data, methods to apply peer judgement, and techniques to
42	56	assign values to publication quantity and quality. Each assessment method tended to
43 44	57	prioritize certain aspects of achievement over others.
45 46	58	Conclusions All metrics and models focus on an element or elements, at the expense of
47 48	59	others. A new composite design, the Comprehensive Researcher Achievement Model
49	60	(CRAM) is presented which supersedes past anachronistic models. The CRAM is modifiable
50 51	61	to a range of applications.
52 53	62	Keywords: Researcher assessment; Research metrics; h-index; Journal impact factor;
54	63	citations; outputs; Comprehensive Researcher Achievement Model (CRAM)
55 56	64	
57 58	65	Article Summary
59 60	66	Strengths and limitations of this study

1 2		
2 3 4	67	• A large, diverse dataset of over 478 articles, containing many ideas for assessing
5	68	researcher performance, was analyzed
6 7	69	• Strengths of the review include executing a wide-ranging search strategy, and the
8 9	70	consequent high number of included articles for review; the results are limited by the
10 11	71	literature itself, e.g., new metrics were not mentioned in the articles, and therefore not
12	72	captured in the results
13 14	73	• A new model combining multiple factors to assess researcher performance is now
15 16	74	available
17 18	75	• Its strengths include combining quantitative and qualitative components in the one
19	76	model
20 21	77	• The CRAM model, despite being evidence-oriented, is a generic one and now needs
22 23	78	to be applied in the field
24 25		to be applied in the field
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79 INTRODUCTION

Judging researchers' achievements and academic impact continues to be an important means of allocating scarce research funds and assessing candidates for promotion or tenure. It has historically been carried out through some form of expert peer judgement, to assess the number and quality of outputs, and in more recent decades, citations to them. This approach requires judgements regarding the weight which should be assigned to the number of publications, their quality, where they were published, and their downstream influence or impact. There are significant questions about the extent to which human judgement based on these criteria is an effective mechanism for making these complex assessments in a consistent and unbiased way.(1-3) Criticisms of peer assessment, even when underpinned by relatively impartial productivity data, include the propensity for bias, inconsistency among reviewers, nepotism, group-think and subjectivity.(4-7)

To compensate for these limitations, approaches have been proposed that rely less on subjective judgement and more on objective indicators.(3, 8-10) Indicators of achievement focus on one or a combination of four aspects: quantity of researcher outputs (*productivity*); value of outputs (*quality*); outcomes of research outputs (*impact*); and relations between publications or authors and the wider world (influence).(11-15) Online publishing of journal articles has provided the opportunity to easily track citations and user interactions (e.g., number of article downloads) and thus has provided a new set of indices against which individual researchers, journals and articles can be compared and the relative worth of contributions assessed and valued.(14) These relatively new metrics have been collectively termed *bibliometrics*(16) when based on citations and numbers of publications, or *altmetrics*(17) when calculated by alternative online measures of impact such as number of downloads or social media mentions.(16)

The most established metrics for inferring researcher achievement are the h-index and the Journal Impact Factor (JIF). The JIF measures the average number of citations of an article in the journal over the previous year, and hence is a good indication of journal quality but is increasingly regarded as a primitive measure of quality for individual researchers.(18) The h-index, proposed by Hirsch in 2005,(19) attempts to portray a researcher's productivity and impact in one data point. The h-index is defined as the number (h) of articles published by a researcher that have received a citation count of at least h. Use of the h-index has become widespread, reflected in its inclusion in author profiles on online databases such as Google Scholar and Scopus.

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Also influenced by the advent of online databases, there has been a proliferation of other assessment models and metrics,(16) many of which purport to improve upon existing approaches. (20, 21) These include methods that assess the impact of articles measured by: downloads or online views received; practice change related to specific research; take-up by the scientific community; or mentions in social media.

Against the backdrop of growth in metrics and models for assessing researchers' achievements, there is a lack of guidance on the relative strengths and limitations of these different approaches. Understanding them is of fundamental importance to funding bodies that drive the future of research, tenure and promotion committees, and more broadly for providing insights into how we recognize and value the work of science and scientists, particularly those researching in medicine and healthcare. This review aimed to identify approaches to assessing researchers' achievements published in the academic literature over the last 10 years, considering their relative strengths and limitations and drawing on this to propose a new composite assessment model.

30 127 **METHOD**

128 Search Strategy

All Web of Science databases (eight in total, including Web of Science Core Collection, MEDLINE, and BIOSIS Citation Index) were searched using terms related to researcher achievement (researcher excellence, track record, researcher funding, researcher perform*, relative to opportunity, researcher potential, research* career pathway, academic career pathway, funding system, funding body, researcher impact, scientific* productivity, academic productivity, top researcher, researcher ranking, grant application, researcher output, *h*index, i*index, impact factor, individual researcher*) and approaches to its assessment (model, framework, assess*, evaluat*, *metric*, measur*, criteri*, citation*, unconscious bias, rank*) with "*" used as an unlimited truncation to capture variation in search terms, as seen in Appendix 1. These two searches were combined (using "and") and results were downloaded into EndNote, the reference management software.

140 Study Selection

After removing duplicate references in EndNote,(22) articles were allocated amongst pairs of
reviewers (MB-JCL, CP-CB, KL-JH, KC-LAE) for screening against inclusion criteria.
Following established procedures,(23, 24) each pair was randomly assigned 5% of their

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allocation to review concurrently against inclusion criteria, with inter-rater reliability assessed using Cohen's Kappa (κ). The κ statistic was calculated for pairs of researchers, with agreement ranging from moderate to almost perfect (0.4848-0.9039).(25) Following the abstract and title screen, selected articles underwent full text review. Reasons for exclusion were recorded.

13 149 Inclusion Criteria

The following inclusion criteria were operationalized: (1) English language, (2) published in the last 10 years (2007-2017), (3) full text for the article was available, and (4) the article discussed an approach to the assessment of an individual researcher's achievements (at the researcher or singular output-level). The research followed the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) framework.(26) Empirical and non-empirical articles were included, because many articles proposing new approaches to assessment, or discussing the limitations of existing ones, are not level one evidence or research-based. Both quantitative and qualitative studies were included.

158 **Data Extraction**

Data from the included articles were extracted, including: the country of article origin, the characteristics of the models or metrics discussed, the perspective the article presented on the metric or model (positive, negative, indeterminable) including any potential benefits or limitations of the assessment model (and if these were perceived or based on some form of evidence). A customised data extraction sheet was developed in Microsoft Excel, trialed among members of the research team and subsequently refined. This information was synthesized for each model and metric identified through narrative techniques. The publication details and classification of each paper are contained in **Appendix 2**.

167 Appraisal of the Literature

Due to the prevalence of non-empirical articles in this field (e.g., editorial contributions, commentaries), it was determined that a risk of bias tool such as the Quality Assessment Tool could not be applied.(27) Rather, assessors were trained in multiple meetings (October 24, October 30, November 13, 2017) to critically assess the quality of articles. Given the topic of the review (focusing on the publication process), the type of models and metrics identified (i.e., more metrics that use publication metrics) may influence the cumulative evidence and

- 174 subsequently create a risk of bias. In addition, three researchers (JH, EM, CB) reviewed every
- 175 included article, to extract documented conflicts of interests of authors.
- 176 Patient and public involvement

177 Patients and the public were not involved in this systematic review.

12 178 **RESULTS**

 179 The final dataset consisted of 478 academic articles. The data screening process is presented180 in Figure 1.

181 Figure 1. Data screening and extraction process for academic articles 182 <Insert Figure 1>

Of the 478 included papers (see Appendix 2 for a summary), 295 (61.7%) had an empirical component, which ranged from interventional studies that assessed researcher achievement as an outcome measure (e.g., a study measuring the outcomes of a training program),(28) as a predictor(29-31) (e.g., a study that demonstrated the association between number of citations early in one's career and later career productivity), or reported a descriptive analysis of a new metric. (32, 33) One hundred and sixty-six (34.7%) papers were not empirical, including editorial or opinion contributions that discussed the assessment of research achievement, or proposed models for assessing researcher achievement. Seventeen papers (3.6%) were reviews that considered one or more elements of assessing researcher achievements. The quality of these contributions ranged in terms of the risk of bias in the viewpoint expressed. Only for 19 papers (4.0%) did the authors declare a potential conflict of interest.

Across the study period, 78 articles (16.3%) involved authors purporting to propose new models or metrics. Most articles described or cited pre-existing metrics and largely discussed their perceived strengths and limitations. Figure 2 shows the proportion of positive or negative discussions of five of the most common approaches to assessing an individual's research achievement (altmetrics, peer-review, h-index, simple counts, and JIF). The approach with most support was altmetrics (51.0% of articles mentioning altmetrics). The JIF was discussed with mostly negative sentiments in relevant articles (69.4%).

Figure 2. Percentages of positive and negative discussion regarding selected commonly
 used metrics for assessing individual researchers (n=478 articles)

59 205 <Insert Figure 2>

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Legend: Positive discussion refers to articles that discuss the metric in a favorable light or focus on the strengthsof the metric; negative discussion refers to articles that focus on the limitations or shortcomings of the metric.

208 Citation-Based Metrics

Publication and Citation Counts

One hundred and fifty-three papers (32.0%) discussed the use of publication and citation counts for purposes of assessing researcher achievement, with papers describing them as a simple "traditional but somewhat crude measure",(34) as well as the building blocks for other metrics.(35) A researcher's number of publications, commonly termed an n-index,(36) was suggested by some to indicate researcher productivity, (14) rather than quality, impact or influence of these papers.(37) On the other hand, the literature suggested that numbers of citations indicated the academic impact of an individual publication or researcher's body of work, calculated as an author's cumulative or mean citations per article.(38) Some studies found support for the validity of citation counts and publications in that they were correlated with other indications of a researcher's achievement, such as awards and grant funding, (39, 40) and predictive of long term success in a field.(41) For example, one paper argued that having larger numbers of publications and being highly cited early in one's career predicted later high quality research.(42)

A number of limitations of using citation or publication counts was observed. For example, Minasny et al. (2013) highlighted discrepancies between publications and citations counts in different databases because of their differential structures and inputs.(43) Other authors(38, 44, 45) noted that citation patterns vary by discipline, which they suggested can make them inappropriate for comparing researchers from different fields. Average citations per publication were reported as highly sensitive to change or could be skewed if, for example, a researcher has one heavily-cited article. (46, 47) A further disadvantage is the lag-effect of citations. (48, 49) and that in most models citations and publications count equally for all co-authors, despite potential differential contributions.(50) Some also guestioned the extent to which citations actually indicated quality or impact, noting that a paper may influence clinical practice more than academic thinking.(51) Indeed, a paper may be highly cited because it is useful (e.g., a review), controversial, or even by chance, making citations a limited indication of quality or impact.(40, 50, 52) In addition to limitations, numerous authors made the point that focusing on citation and publication counts can have unintended, negative consequences for the assessment of researcher achievement, potentially leading to gaming and manipulation, including self-citations and gratuitous authorship.(53, 54)

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Singular Output-Level Approaches

Forty-one papers (8.6%) discussed models and metrics at the singular output or article-level that could be used to infer researcher achievement. The components of achievement they reported assessing were typically quality or impact. (55, 56) For example, some papers reported attempts to examine the quality of a single article by assessing its content.(57, 58) Among the metrics identified in the literature, the immediacy index (II) focused on impact by measuring the average number of cites an article received in the year it was published.⁽⁵⁹⁾ Similarly, Finch suggested adapting the Source Normalized Impact per Publication (SNIP; a metric used for journal-level calculations across different fields of research) to the article-level.(21)

Many of the article-level metrics identified could also be upscaled to produce researcher-level indications of academic impact. For example, the sCientific currENcy Tokens (CENTs), proposed by Szymanski et al. (2012), involved giving a "cent" for each new non-self-citation a publication received; CENTs are then used as the basis for the researcher-level i-index, which follows a similar approach as the h-index, but removes self-citations.⁽⁶⁰⁾ The TAPSIF (Temporally-Averaged Paper-Specific Impact Factor) calculates an article's average number of citations per year combined with bonus cites for the publishing journal's prestige, and can be aggregated to measure the overall relevance of a researcher (Temporally Averaged Author-Specific Impact Factor; TAASIF).(61)

Journal impact factor

The JIF, commonly recognized as a journal-level measure of quality,(59, 62-64) was discussed in 211 (44.1%) of the papers reviewed in relation to assessing singular outputs or individual researchers. A number of papers described the JIF being used informally to assess an individual's research achievement at the singular output-level, and formally in countries such as France and China.(65) It implies article quality because it is typically a more competitive process to publish in journals with high impact factors.(66) Indeed, the JIF was found to be the best predictor of a paper's propensity to receive citations.(67)

The JIF has a range of limitations when used to indicate journal quality.(68) including that it is disproportionally affected by highly cited, outlier articles, (41, 69) and is susceptible to "gaming" by editors.(17, 70) Other criticisms focused on using the JIF to assess individual articles or the researchers who author them.(71) Some critics claimed that using the JIF to measure an individual's achievement encourages researchers to publish in higher-impact but

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less-appropriate journals for their field—which ultimately means their article may not be read by relevant researchers.(72, 73) Furthermore, the popularity of a journal was argued to be a poor indication of the quality of any one article, with the citation distributions for calculating JIF found to be heavily skewed (i.e., a small subset of papers receive the bulk of the citations while some may receive none).(18) Ultimately, many commentators argued that the JIF is an inappropriate metric to assess individual researchers because it is an aggregate metric of a journal's publication, and expresses nothing about any individual paper.(21, 49, 50, 74) However, Bornmann et al. (2017) suggested one case in which it would be appropriate to use JIF for assessing individual researchers: in relation to their recently published papers that had not had the opportunity to accumulate citations.(75) Researcher-Level Approaches h-index

The h-index was among the most commonly discussed metrics in the literature (254 [53.1%] of the papers reviewed); in many of these papers, it was described by authors as more sophisticated than citation and publication counts, but still straightforward, logical and intuitive.(76-78) Authors noted its combination of productivity (h publications) and impact indicators (h citations) as being more reliable(79, 80) and stable than average citations per publications(41) because it is not skewed by the influence of one popular article.(81) One study found that the h-index correlated with other metrics more difficult to obtain.(78) It also showed convergent validity with peer-reviewed assessments(82) and was found to be a good predictor of future achievement.(41)

However because of the lag-effect with citations and publications, the h-index increases with a researcher's years of activity in the field, and cannot decrease, even if productivity later declines.(83) Hence, numerous authors suggested it was inappropriate for comparing researchers at different career stages,(84) or those early in their career.(70) The h-index was also noted as being susceptible to many of the critiques leveled against citation counts, including potential for gaming, and inability to reflect differential contributions by co-authors.(85) Because disciplines differ in citation patterns(86) some studies noted variations in author h-indices between different methodologies(87) and within medical subspecialties.(88) Some therefore argued that the h-index should not be used as the sole measure of a researcher's achievement.(88)

h-index variants

1 2				
3	303	A number of modified versions of the h-index were identified; these purported to draw on its		
4 5	304	basic strengths of balancing productivity with impact while redressing perceived limitations.		
6 7	305	For example, the g-index measures global citation performance,(89) and was defined		
8 9	306	similarly to the h-index but with more weight given to highly cited articles by assuming the		
9 10 11	307	top g articles have received at least g ² citations.(90) Azer and Azer (2016) argued it was a		
12	308	more useful measure of researcher productivity.(91) Another variant of the h-index identified,		
13 14	309	the m-quotient, was suggested to minimize the potential to favor senior academics by		
15 16	310	accounting for the time passed since a researcher has begun publishing papers.(92, 93) Other		
17	311	h-index variations reported in the articles reviewed attempted to account for author		
18 19	312	contributions, such as the h-maj index, which includes only articles in which the researcher		
20 21	313	played a core role (based on author order); and the weighted h-index, which assigns credit		
22 23	314	points according to author order.(89, 94)		
24	215	Description Lange of which Citation Barred Matrice		
25 26 27 28 29 30 31 32 33 34 35 36 27	315	Recurring Issues with Citation-Based Metrics		
	316	The literature review results suggested that no one citation-based metric was ideal for all		
	317	purposes. All of the common metrics examined focused on one aspect of an individual's		
	318	achievement, and thus failed to account for other aspects of achievement. The limitations		
	319	with some of the frequently used citation-based metrics are listed in Box 1 .		
	320			
	321	Box 1. Common limitations in the use of citation-based metrics		
37 38		1. Challenges with reconciling differences in citation patterns across varying fields of		
39 40		study		
41		 Time-dependency issues stemming from differences in career length of researchers Prioritizing impact over merit, or quality over quantity, or vice versa 		
42 43		4. The lag-effect of citations		
44		5. Gaming and the ability of self-citation to distort metrics		
45 46		6. Failure to account for author order		
47		7. Contributions from authors to a publication are viewed as equal when they may not		
48 49		be		
50		8. Perpetuate "publish or perish" culture		
51 52	222	9. Potential to stifle innovation in favor of what is popular		
53 54	322			
55 56	323	Non-Citation Based Approaches		
57 58	324	altmetrics		
59 60				

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In contradistinction with the metrics discussed above, fifty-four papers (11.3%) discussed altmetrics (or "alternative metrics"), which included a wide range of techniques to measure non-traditional, non-citation based usage of articles, that is, influence.(17) Altmetric measures included the number of online article views, (95) bookmarks, (96) downloads, (41) PageRank algorithms(97) and attention by mainstream news.(65) in books(98) and social media, for example, in blogs, commentaries, online topic reviews or tweets. (99, 100) These metrics typically measure the "web visibility" of an output.(101) A notable example is the social networking site for researchers and scientists, ResearchGate, which uses an algorithm to score researchers based on the use of their outputs, including citations, reads, and recommendations.(102)

A strength of altmetrics lies in providing a measure of influence promptly after publication.(70, 103, 104) Moreover, altmetrics allows tracking of the downloads of multiple sources (e.g., students, the general public, clinicians, as well as academics) and multiple types of format (e.g., reports and policy documents),(105) which are useful in gauging a broader indication of impact or influence, compared to more traditional metrics that solely or largely measure acknowledgement by experts in the field through citations.(17)

Disadvantages noted in the articles reviewed included that altmetrics calculations have been established by commercial enterprises such as Altmetrics LLC (London, UK) and other competitors, (106) and there may be fees levied for their use. The application of these metrics has also not been standardized. (98) Furthermore, it has been argued that, because altmetrics are cumulative and typically at the article-level, they provide more an indication of influence or even popularity,(107) instead of quality or productivity.(108) Hence, one study suggested no correlation between attention on Twitter and expert analysis of an article's originality, significance or rigour.(109) Another showed that Tweets predict citations.(110) Overall, further work needs to assess the value of altmetric scores in terms of their association with other traditional indicators of achievement.(111) Notwithstanding this, there were increasing calls to consider altmetrics alongside more conventional metrics in assessing researchers and their work.(112)

Past Funding

A past record of being funded by national agencies was identified as a common measurement of individual academic achievement (particularly productivity, quality and impact) in a number of papers, and has been argued to be a reliable method that is consistent across

medical research.(113-115) For example, the NIH's (National Institute of Health's) RePORT
(Research Portfolio Online Reporting Tools) system encourages public accountability for
funding by providing online access to reports, data and NIH-funded research projects.(113,
116)

9 361 10 362

363 New Metrics and Models Identified

The review also identified and assessed new metrics and models that were proposed during the review period, many of which had not gained widespread acceptance or use. While there was considerable heterogeneity and varying degrees of complexity among the 78 new approaches identified, there were also many areas of overlap in their methods and purposes. For example, some papers reported on metrics that used a PageRank algorithm, (117, 118) a form of network analysis based on structural characteristics of publications (e.g., co-authorship or citation patterns).(14) Metrics based on PageRank purported to measure both the direct and indirect impact of a publication or researcher. Other approaches considered the relative contributions of authors to a paper in calculating productivity.(119) Numerous metrics and models that built upon existing approaches were also reported.(120) For example, some developed composite metrics that included a publication's JIF alongside an author contribution measure(121) or other existing metrics.(122) However, each of these approaches reported limitations, in addition to their strengths or improvements upon other methods. For example, in focusing on productivity, a metric necessarily often neglected impact.(123) Appendix 3 provides a summary of these new or re-fashioned metrics and models, with details of their basis and purpose.

DISCUSSION

This systematic review identified a large number of diverse metrics and models for assessing an individual's research achievement that have been developed in the last 10 years (2007-2017), as evidenced in Appendix 3. At the same time, other approaches that pre-dated our study time period of 2007-2017 were also discussed frequently in the literature reviewed, including the h-index and JIF. All metrics and models proposed had their relative strengths, based on the components of achievement they focused on, and their sophistication or transparency.

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The review also identified and assessed new metrics and over the past few decades. Peer-review has been increasingly criticized for reliance on subjectivity and propensity for bias, (7) and there have been arguments that the use of specific metrics may be a more objective and fair approach for assessing individual research achievement. However, this review has highlighted that even seemingly objective measures have a range of shortcomings. For example, there are inadequacies in comparing researchers at different career stages, and across disciplines with different citation patterns.(86) Furthermore, the use of citation-based metrics can lead to gaming and potential ethical misconduct by contributing to a "publish or perish" culture in which researchers are under pressure to maintain or improve their publication records. (124, 125) New methods and adjustments to existing metrics have been proposed to explicitly address some of these limitations; for example, normalizing metrics with "exchange rates" to remove discipline-specific variation in citation patterns, thereby making metric scores more comparable for researchers working in disparate fields.(126, 127) Normalization techniques have also been used to assess researchers' metrics with greater recognition of their relative opportunity and career longevity.(128)

Other criticisms of traditional approaches center less on how they calculated achievement, and more on what they understood or assumed about its constituent elements. In this review, the measurement of impact or knowledge gain was often exclusively tied to citations.(129) Some articles proposed novel approaches to using citations as a measure of impact, such as giving greater weight to citations from papers that were themselves highly cited(130) or that come from outside the field in which the paper was published.(131) However, even other potential means of considering scientific contributions and achievement, such as mentoring, were still ultimately tied to citations because mentoring was measured by the publication output of mentees.(132)

A focus only on citations was widely thought to disadvantage certain types of researchers. For example, researchers who aim to publish with a focus on influencing practice may target more specialized or regional journals that do not have high JIFs, where their papers will be read by the appropriate audience and findings implemented, but they may not be well-cited.(51) In this regard, categorizing the type of journal in which an article has been published in terms of its focus (e.g., industry, clinical, regional/national) may go some way toward recognizing those publications that have a clear knowledge translation intention, and therefore prioritize real-world impact over academic impact. (124) There were only a few other approaches identified that captured broader conceptualizations of knowledge gain, such as practical impact or wealth generation for the economy, and these too were often simplistic,

such as including patents and their citations(133) or altmetric data.(98) While altmetrics hold potential in this regard, their use has not been standardized,(98) and they come with their own limitations, with suggestions that they reflect popularity more so than real world impact.(107) Other methodologies have been proposed for assessing knowledge translation and real-world impact, but these can often be labor intensive.(134) For example, Sutherland et al. (2011)(135) suggested that assessing individual research outputs in light of specific policy objectives, through peer-review based scoring, may be a strategy, but this is typically not feasible in situations such as grant funding allocation, where there are time-constraints and large applicant pools to assess. In terms of how one can make sense of the validity of many of these emerging approaches for assessing an individual's research achievements, metrics should demonstrate their legitimacy empirically, as well as having a theoretical basis for their use and clearly differentiating what aspects of quality, achievement or impact they purport to examine.(55, 67) If the recent, well-publicized (136-138) San Francisco Declaration on Research Assessment (DORA)(139) is anything to go by, internationally there is a move away from the assessment of individual researchers using the JIF and the journal in which the research has been published. Figure 3. The Comprehensive Researcher Achievement Model (CRAM) <Insert Figure 3> There is momentum, instead, for assessment of researcher achievements on the basis of a wider mix of measures, hence our proposed Comprehensive Researcher Achievement Model (CRAM) (Figure 3). On the left-hand side of this model is the researcher to be assessed, and key characteristics that influence the assessment. Among these factors, some (i.e., field or discipline, co-authorship, career longevity) can be controlled for depending on the metric, while other components, such as gaming or the research topic (i.e., whether it is "trendy" or innovative) are less amenable to control or even prediction. Online databases, which track citations and downloads and measure other forms of impact, hold much potential and will likely be increasingly used in the future to assess both individual researchers and

- their outputs. Hence, assessment components (past funding, articles, citations, patents,
- downloads, and some media traction) included in our model are those primarily accessible online.
- **Strengths and Limitations**

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The findings of this review suggest assessment components should be used with care, and with recognition of how they can be influenced by other factors, and what aspects of achievement they reflect (i.e., productivity, quality, impact, influence). No metric or model singularly captures all aspects of achievement, and hence use of a range, such as the examples in our model, is advisable. CRAM recognizes that the configuration and weighting of assessment methods will depend on the assessors and their purpose, the resources available for the assessment process, and access to assessment components. Our results must be interpreted in light of our focus on academic literature. The limits of our focus on peer-reviewed literature were evident in the fact some new metrics were not mentioned in articles, and therefore not captured in our results. While we defined impact broadly at the outset, overwhelmingly the literature we reviewed focused on academic, citation-based impact. Furthermore, although we assessed bias in the ways documented, the study design limited our ability to apply a standardized quality assessment tool. A strength of our focus was that we set no inclusion criteria with regard to scientific discipline, because novel and useful approaches to assessing research achievement can come from diverse fields. Many of the articles we reviewed were broadly in the area of health and medical research, and our discussion is concerned with the implications for health and medical research, as this is where our interests lie.

³⁶ ₃₇ 476 **CONCLUSION**

There is no ideal model or metric by which to assess individual researcher achievement. We have proposed a generic model, designed to minimize risk of the use of any one or a smaller number of metrics, but it is not proposed as an ultimate solution. The mix of assessment components and metrics will depend on the purpose. Greater transparency in approaches used to assess achievement including their evidence-base is required.(37) Any model used to assess achievement for purposes such as promotion or funding allocation should include some quantitative components, based on robust data, and be able to be rapidly updated, presented with confidence intervals, and normalized.(37) The assessment process should be difficult to manipulate, and explicit about the components of achievement being measured. As such, no current metric suitably fulfills all these criteria. The best strategy to assess an individual's research achievement is likely to involve the use of multiple approaches(140) in order to dilute the influence and potential disadvantages of any one metric, while providing

more rounded picture of a researcher's achievement; (85, 141) this is what the CRAM aims to contribute.

All-in-all, achievement in terms of impact and knowledge gain is broader than the number of articles published or their citation rates, and yet most metrics have no means of factoring in these broader issues. Altmetrics hold promise in complementing citation-based metrics and assessing more diverse notions of impact, but usage of this type of tool requires further standardization.(98) Finally, despite the limitations of peer-review, the role of expert judgement should not be discounted.(41) Metrics are perhaps best applied as a complement or check on the peer-review process, rather than the sole means of assessment of an individual's research achievements.(142)

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514	All data has been made available as Appendices.
515	
516	Author Contributions
517	JB conceptualized and drafted the manuscript, revised it critically for important intellectual
518	content, and led the study. JH, KC and JCL made substantial contributions to the design,
519	analysis and revision of the work and critically reviewed the manuscript for important
520	intellectual content. CP, CB, MB, RC-W, FR, PS, AH, LAE, KL, EA, RS and EM carried out
521	the initial investigation, sourced and analyzed the data and revised the manuscript for
522	important intellectual content. PH and JIW critically commented on the manuscript,
523	contributed to the revision and editing of the final manuscript and reviewed the work for
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525	agree to be accountable for all aspects of the work.

2			
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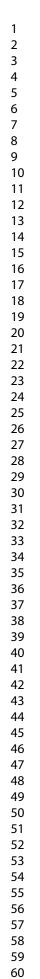
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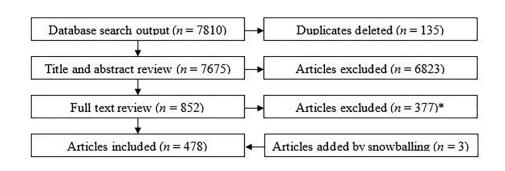
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4	873	130.	Zhou Y-B, Lu L, Li M. Quantifying the influence of scientists and their publications:
5	874		distinguishing between prestige and popularity. <i>New J Phys.</i> 2012;14: doi:
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43	908	172.	Inform Rev. 2010;34(2):339-48. doi:10.1108/14684521011037034
44	909		ngor ni nev. 2010,5 ((2).55) 10. doi:10.1100/1100/0521011057051
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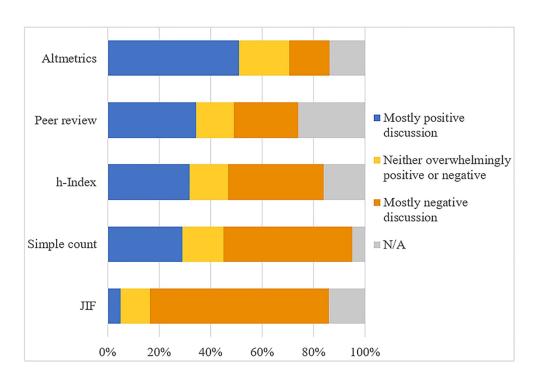


*Reasons for exclusion are noted below

Reason for exclusion at the full text level	Number of articles excluded
Not in English language	47
Full text not available	62
Does not discuss assessment of an individual researcher	268
Total	377

Data screening and extraction process for academic articles

279x188mm (300 x 300 DPI)



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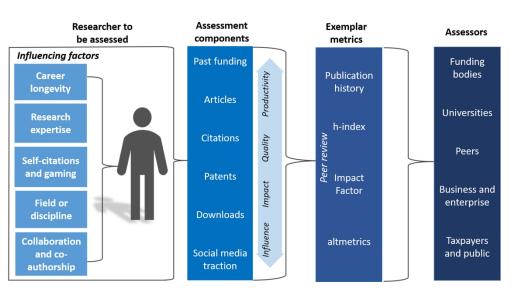
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Percentages of positive and negative discussion regarding selected commonly used metrics for assessing individual researchers (n=478 articles)

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The Comprehensive Researcher Achievement Model (CRAM)

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Appendix 1: Full Search Strategy		30 March 2 cluding for	
Name of database	Web of Science Core Collection, BIOSIS Citation In	nd 🙀 , 🕅	edline
Platform	Web of Science [Clarivate Analytics]		
Database coverage	2007-2017		
Date exported to Reference Management Software (EndNote)	19 th October 2017	Superior Superior Superior	
Search strategy	Model OR framework OR assess* OR evaluat*OR *metric*OR measur* OR criteri*OR citation*OR unconscious bias OR rank*	led from http: feur (ABES) b text and dat	Results: 13,282,151
	AND researcher excellence OR track record OR researcher funding OR researcher perform* OR relative to opp OR researcher potential OR research* career pathwa academic career pathway OR funding system OR fu body OR researcher impact OR scientific* productiv academic productivity OR top researcher OR resear ranking OR grant application OR researcher output h*index OR i*index OR impact factor OR individua researcher	r minitopen.bezi.com/ protiky.ang.bezi.com/ ndgi.ang.bezi.com/ vity.ang.bezi.com/ chity.ang.bezi.com/ chity.ang.bezi.com/	Results: 11,616
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Appendix 2:	Summar	y table of included articles and the metrics or mode	ls they disc		on 30 March 2019					
First author	Year	Publication Details Journal name	Format^	Metric or Peer- review	· Mgodel A r - D Simple Simple Causes	h- index	JIF	Other	earch Achie Alt- metrics	New
Abramo	2016	Scientometrics	ED		aded fr erieur to tex			Y		_
Agarwal	2016	Asian Journal of Andrology	ED		r (AB Yanc	Y	Y	Y	Y	
Ahmad	2013	Anesthesia and Analgesia	EM		d data					
Aixela	2015	Perspectives: Studies in Translatology	ED	Y	://bmj ta min	Y	Y	Y		
Akl	2012	Canadian Medical Association Journal	EM	Y	ning,					
Albion	2012	Australian Educational Researcher	EM		, Al tra	Y	Y	Y		
Alguliyev	2016	Journal of Scientometric Research	EM		nj.com rainin		Y	Y		
Allen	2010	ScienceAsia	ED		n∕ on ıg, an	Y	Y			
Anderson	2008	Scientometrics	ED		nd sin	Y				Y
Anderson	2017	Applied Economics	EM	Y	e 13, milar	Y	Y			
Anfossi	2015	International Journal of Dermatology	EM	0	2025 tech		Y			
Antunes	2015	Revista do Colegio Brasileiro de Cirurgioes	EM	Y	i at Ag Inolog	Y				
Aoun	2013	World Neurosurgery	RE	Y	gies.	Y	Y			
Aragon	2013	Nature Scientific Reports	EM							Y
Armado	2017	Transinformação	EM		Bibliogr	Y		Y		
Assimakis	2010	Scientometrics	EM		raphi					Y
Azer	2016	Education Forum			ique	Y	Y	Y		
Babineau	2014	The Western Journal of Emergency Medicine - For peer review only - http://bmjopen.bmj.c	EM		de	Y				

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1 2 3 4	Baccini	2014	Scientometrics	EM		30 March cluding fc	Y	Y	Y	
5	Badar	2016	Aslib Journal of Information Management	EM	Y	2019 or use		Y		
6 7	Bai	2016	PLOS One	EM		Yre	Y	Y	Y	Y
8 9	Bala	2013	Journal of Clinical Epidemiology	EM		Sup Sup lated		Y		
10	Balaban	2013	Journal of General Physiology	ED	Y	aded berieu I to te				
11 12	Balandin	2009	Augmentative and Alternative Communication	ED		ur (A	Y	Y		
13 14	Barczynski	2009	Journal of Human Kinetics	ED		from http: ur (ABES) ext and date		Y	Y	
15	Bastian	2017	Journal of Bone and Joint Surgery-American Volume	EM		ata mi	Y			
16 17	Baum	2011	SAGE	EM	Y	njope iining		Y		
18 19	Beck	2017	Research Evaluation	EM	Y					
20	Beirlant	2010	Scandinavian Journal of Statistics	EM		n.bmj.con Al trainin	Y			
21 22	Belikov	2015	f1000 Research	EM		ing, a	Y			Y
23 24	Bellini	2012	The Lancet	ED		n June Yang si	Y	Y		
25	Belter	2015	Journal of The Medical Library Association	ED	Y	he 13, similar	Y			
26 27	Benchimol-Barbosa	2011	Arquivos Brasileiros de Cardiologia	ED		, 2025 Ir tech		Y		
28 29	Benway	2009	Urology	ED	Y		Y			
30	Bertuzzi	2013	Molecular Biology of the Cell	ED		5 at Agenc		Y		
31 32	Bharathi	2013	PLOS One	ED		ë	Y			
33 34	Bini	2008	Electronic Transactions on Numerical Analysis	EM		Bibliog				Y
35	Birks	2014	Health Services Research & Policy	EM	Y	grap	Y			
36 37	Biswal	2013	PLOS One	ED		hique	Y		Y	
38 39	Bloch	2016	Research Evaluation	EM		e de l			Y	
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Bloching	2013	South African Journal of Science	EM	Y	ng fo	March				Y
Bollen	2016	Scientometrics	ED	Y	orus	2019				Y
Bolli	2014	Circulation Research	ED		s re	Do				
Bornmann	2009	EMBO Reports	ED		Sup	Y Y	Y			
Bornmann	2015	Journal of Informetrics	EM	Y	Superieu lated to te	Y Y	Y			
Bornmann	2016	EMBO Reports	ED		Y ar ⊇	Ϋ́	Y			
Bornmann	2014	Scientometrics	EM		Hd dai	Y				
Bornmann	2008	Research Evaluation	EM	Y	نف ^ر <u>ع</u>	Y	Y	Y		
Bornmann	2017	Journal of Informetrics	EM		ning	Y	Y	Y		
Bornmann	2017	Journal of Korean Medical Science	ED			5	Y	Y		
Bould	2011	British Journal of Anaesthesia	EM			Y				
Bradshaw	2016	PLOS One	EM		<u>م</u>	Y	Y	Y		
Brown	2011	American Journal of Occupational Therapy	ED		nd si	Y	Y	Y		
Buela-Casal	2012	Scientometrics	EM				Y			
Buela-Casal	2010	Revista de Psicodidáctica	ED		Yech	у 0 25	Y	Y	Y	
Butler	2017	Clinical Spine Surgery	ED		nolo				Y	
Cabazas Clavijo	2013	Medicina Intensiva (English edition)	RE		gies	Y	Y			
Cagan	2013	Disease Models & Mechanisms	ED			P Ri	Y			
Callaway	2016	Nature	ED			Riblion	Y			
Calver	2013	Grumpy Scientists	ED		Y	Y Y	Y	Y		
Calver	2015	Australian Universities Review	ED		1			Y		
Caminiti	2015	BMC Health Services Research	RE							Y
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1 2 3 4	Cantin	2015	International Journal of Morphology	EM		30 March Icluding fc	Y				
5	Carpenter	2014	Academic Emergency Medicine	ED		2019 or use	Y	Y	Y	Y	
6 7	Carpenter	2014	Information Service and Use	ED		9. Dov es re		Y		Y	
8 9	Castelnuovo	2010	Clinical Practice & Epidemiology in Mental Health	RE		wnloa Supe lated t	Y	Y		Y	Y
10	Castillo	2010	American Journal of Neuroradiology	ED		aded perieu 1 to te	Y		Y		
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13 14	Choi	2014	Journal of Radiation Oncology	EM	Y	nd da	Y		Y		Y
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16 17	Chopra	2016	Aesthetic Surgery Journal	EM		njope iining	Y				
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25	Ciriminna	2013	Chemistry Central Journal	ED	1,	ingila	Y	Y	Y		
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35	Costas	2011	Scientometrics	EM		Y aph			Y		
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Crotty		European Heart Journal	ED		<i>(</i> ^ -	py V				
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Cynical Geographers Collective	2011	Antipode	ED		d to text and data i	variant fr	Y			
Czarnecki	2013	Bulletin of the Polish Academy of Sciences	EM		and	B Y				
da Silva	2017	Scientometrics	ED		s) data	*	Y	Y	Y	
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de Granda-Orive	2014	Archivos de Bronconeumología	ED			6		Y		
De Gregori	2016	Journal of Pain Research	EM		ig, ar	on on			Y	
De la Flor-Martínez M	2017	Medicina Oral Patologia Oral Y Cirugia Bucal	EM	Y		Y				
De Marchi	2016	Scientometrics	EM	1	nilar	n 13 3	Y			
De Witte	2010	Scientometrics	EM	Y	tech	2025				Y
Delgadillo	2016	Family & Consumer Sciences research journal	RE		nolo	a¥ Y A				Y
DeLuca	2013	Academic Emergency Medicine	EM	Y	gies.	Y Y				
Devos	2011	Clinics and Research in Hepatology and Gastroenterology	ED		(Bin Y				
Diamandis	2017	BMC Medicine	ED			bliogr	Y			
DiBartola	2017	Journal of Veterinary Internal Medicine	ED		2	Y	Y	Y		
Diem	2013	Research in Higher Education	EM		2	D D	Y			
Ding	2011	Information Processing and Management	EM		Y	P Y	Y	Y	Y	

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Diniz-Filho	2016	Journal of Informetrics	EM	Y	Yes		Y			
Dinsmore	2014	PLOS Biology	ED		Downli Su relate				Y	
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Eysenbach	2011	Journal of Medical Internet Research	EM		Y hig	Y	Y		Y	
Fabry	2017	GMS Journal for Medical Education	ED	Y	lue d		Y		Y	
		For peer review only - http://bmjopen.br	nj.com/site/ab	out/guidel	e l Enseigneme ines.xhtmle	1				

Fang	2016	eLIFE	EM	Y	on 30 March including fo	-				
Fazel	2017	Evidence-based Mental Health	EM	Y	or use			Y	Y	
Fedderke	2015	Research Policy	EM		Yrel					
Feethman	2015	Veterinary Record	ED		yvnloa Supe elated		Y			
Ferrer-Sapena	2016	Research Evaluation	ED		berieu 4 to te		Y	Y	Y	Y
Filler	2014	Academic Medicine	EM		ur (A	, ,		Y		
Finch	2010	Bioessays	ED		rr (ABES) ar (ABES) ext and dat	Y	Y	Y		
Flaatten	2016	Acta Anaesthesiologica Scandinavica	ED		ata m		Y			
Franceschet	2010	Journal of Informetrics	EM		njope nining		Y	Y		
Franceschini	2012	Scientometrics	EM		eh.bm g, Al tr			Y		Y
Franceschini	2012	Scientometrics	EM		nj.com trainin		Y	Y		Y
Franceschini	2012	Scientometrics	EM		ya or	Y		Y		
Frittelli	2016	Journal of the Association for Information Science and Technology	EM	Λ.	n June 1 and simil	Y	Y			Y
Frixione	2016	PLOS One	EM	Y	з, ar			·	Y	
Fujita	2017	IEEE 41st Annual Computer Software and Applications Conference (COMPSAC)	EM	Y	25 at A chn <u>o</u> lo					
Gambadauro	2007	European Journal of Obstetrics & Gynecology and Reproductive Biology	ED		vgies.	-	Y			
Gao	2016	PLOS One	ED		Biblio	Y				Y
Garcia-Perez	2015	Scientometrics	EM		Y grap			Y		
Garcia-Perez	2009	Spanish Journal of Psychology	EM		Y hiqu	Y				
Garner	2017	Journal of Neurointerventional Surgery	RE		Y de	Y				
		For peer review only - http://bmjopen.bmj	j.com/site/al	oout/guideli	I Enseignement	-				

 $\begin{array}{c} 11\\ 12\\ 13\\ 14\\ 15\\ 16\\ 17\\ 18\\ 19\\ 20\\ 21\\ 22\\ 23\\ 24\\ 25\\ 26\\ 27\\ 28\\ 29\\ 30\\ 31\\ 32\\ 33\\ 34\\ 5\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ \end{array}$

Page 39	of 72		BMJ Ope	en		-025320 on opyright, in					
1 2 3 4	Gasparyan	2017	Journal of Korean Medical Science	ED		-025320 on 30 March opyright, including fo		Y	Y	Y	
5	Gast	2014	Plastic and Reconstructive Surgery	EM		2019. ^{or} Yse	Y				
6 7	Gast	2014	Plastic & Reconstructive Surgery	EM		9, Do es re	Y		Y		
8 9	Gaughan	2008	Research Evaluation	EM). Downloa Supe es related			Y		
10	Gefen	2011	Journal of Biomechanics	LE	Y	adec berie	Y				
11 12	Giminez-Toledo	2016	Scientometrics	EM		ur (A ext a			Y		
13 14	Glänzel	2014	Transinformação	ED		baded from http: perieur (ABES) I to text and dat	Y		Y		
15	Good	2015	Research Evaluation	ED		ata mi			Y		
16 17	Gorraiz	2010	LIBER Quarterly	ED		njope Ying		Y		Y	
18 19	Gracza	2008	Library Collections Acquisitions & Technical Services	ED			Y	Y			
20	Grisso	2017	Journal of Women's Health	EM	Y	Al training,					
21 22	Grzybowski	2017	Clinics in Dermatology	ED		ing, a		Y			
23 24	Gumpenberger	2016	Scientometrics.	ED	Y	n June and si	Y	Y		Y	
25	Haddad	2014	The Bone and Joint Journal	ED	1/	ne 13, simila		Y			
26 27	Haddow	2015	Research Evaluation	EM		, 2025 Ir tech					
28 29	Haeffner-Cavaillon	2009	Archivum Immunologiae et Therapiae Experimentalis	ED	Y		Y	Y	Y		
30	Halbach	2011	Annals of Anatomy	EM		i at Agend nologies	Y		Y		
31 32	Hall	2015	Tourism Management	ED		, e		Y			
33	Halvorson	2016	Implications for Training in the Health Professions	EM		Bibliog	Y				
34 35	Hamidreza	2013	Acta Informatica Medica	EM		grap	Y				
36 37	Hammarfelt	2017	Research Evaluation	EM	Y	hique	Y	Y			
38	Han	2013	ISSI	EM	Y	e de l		Y			Y
 39 40 41 42 43 44 45 46 			For peer review only - http://bmjopen.bn	nj.com/site/ab	out/guideli	l Enseignement					

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Han	2010	Journal of Animal and Veterinary Advances	EM		cluding	30	Y			
Haslam	2009	Research Evaluation	EM		for use		Y			
Haslam	2010	European Journal of Social Psychology	EM		10	P Y	Y	Y	Y	
Healy	2011	Breast Cancer Research and Treatment	EM		Sup					
Heinzl	2012	AIP Conference Proceedings	ED		erie to to	Y	Y	Y		
Henrekson	2011	The Manchester School	EM			Υ	Y	Y		
Herteliu	2017	Publications	EM		ur (ABES)	Y				
Hew	2017	Telematics and Informatics	EM		Yai. Yai.		Y			
Hicks	2015	Nature	ED		ining	Y	Y			
Hicks	2015	Nature	ED		Alt	Y	Y			
Hoffman	2014	47th Hawaii International Conference on System Sciences	0		raini	Y	Y		Y	
Holliday	2010	International Journal of General Medicine	EM	Y	ng, ai	2	Y			Y
Houser	2017	Leukos	ED		nd si	Y	Y			
Hughes	2015	International Journal of Radiation Oncology Biology Physics NB Conference supplement	EM	V	e I.3, zo mila <u>r</u> te	ש א ע				
Hunt	2011	Acta Neuropsychiatrica	ED		echno	y Y Y	Y			
Hutchins	2016	PLOS Biology	EM		ologie	+				Y
Hyman	2014	Molecular Biology of the Cell	ED		s.					
Ibrahim	2015	New Library World	EM	Y	Y D	Rin Y				Y
Ioannidis	2016	PLOS Biology	EM		Y G	Y				Y
Ion	2017	Chirurgia	RE		buide	Y	Y	Y		
Iyendar	2009	Academic Medicine	EM		ā		Y			Y

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1 2 3	Jackson	2015	Medical Journal of Australia	ED	Y	1 30 March ncluding fo					
4 5	Jackson	2011	PLOS One	EM		or use			Y		
6 7	Jacob	2007	Scientometrics	EM		<u>9</u> . Dov		Y			
8	Jacso	2010	Online Information Review	EM		synloa Sup elated		Y	Y		
9 10	Jacso	2008	Online Information Review	ED		d to t	Y				
11 12 13	Jalil	2013	IEEE International Conference on Teaching, Assessment a Learning for Engineering (TALE)	nd EM		aded from http perieur (ABES) I to text and da		Y			
14 15	Jamjoom	2015	Neurosciences	EM		ita · 🟅	Y				
16	Jamjoom	2016	World Neurosurgery	EM		minin	Y				
17 18	Jan	2016	Journal of Scientometric Research	EM		ng, A	Y		Y		
19 20	Javey	2012	American Chemical Society	ED			Y	Y			
21	Jeang	2008	Retrovirology	ED		mj.com/ (training,	Y				Y
22 23	Jokic	2009	Biochemia Medica	ED		on Ju And	Y	Y			
24 25	Joshi	2014	The Journal of Contemporary Dental Practice	ED	1.	une 13, I similar	Y		Y		
26	Joynson	2015	f1000 Research	EM		13, 20 ilar te					
27 28	Kaatz	2015	Academic Medicine	EM	Y	2025 at techno					
29 30	Kaatz	2016	Academic Medicine	EM	Y	log					
31	Kali	2015	Indian Journal of Pharmacology	ED		ence Y.				Y	
32 33	Kalra	2013	Journal of Neurosurgery-Pediatrics	EM		Bibli	Y		Y		
34 35	Kaltman	2014	Circulation Research	EM		Y gra					
36	Kapoor	2013	The Annals of Medical and Health Sciences Research	ED		iphiq		Y			
37 38	Kellner	2008	Anais Da Academia Brasileira De Ciencias	EM		ue d	Y				
 39 40 41 42 43 44 45 46 			For peer review only - http://bmjopen.k	omj.com/site/ab	out/guidel	e I Enseignement					

Knudson2015Kosmulski2012Krapivin2009Kreiman2011Kreines2016Kshettry2013Kulasagareh2010Kulczycki2017Kumar2009Kuo2017Lando2014Lariviere2016Lariviere2016Lariviere2016Lariviere2011	World Neurology Quest Research Evaluation Complex Sciences Frontiers in Computational Neuroscience Journal of Computer and Systems Sciences International World Neurosurgery European Archives of Oto-Rhino-Laryngology Journal of Informetrics Iete Technical Review Computers in Human Behavior PLOS One	EM ED ED ED EM ED ED ED ED ED	Y	-025320 on 30 March 2019. Downloaded from http://bmjopen.bm Superieur (ABES) . opyright, including for uses related to text and data mining Al t	Y Y Y Y	Y Y Y Y	Y	Y Y	Y Y
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Kreines2016Kshettry2013Kulasagareh2010Kulczycki2017Kumar2009Kuo2017Lando2014Lariviere2010Lariviere2016Lariviere2011	Journal of Computer and Systems Sciences International World Neurosurgery European Archives of Oto-Rhino-Laryngology Journal of Informetrics Iete Technical Review Computers in Human Behavior	EM ED EM ED ED EM	Y	a mining, Al t	Y Y		Y	Y	Y
Kshettry2013Kulasagareh2010Kulczycki2017Kumar2009Kuo2017Lando2014Lariviere2010Lariviere2016Lariviere2011	World Neurosurgery European Archives of Oto-Rhino-Laryngology Journal of Informetrics Iete Technical Review Computers in Human Behavior	ED EM ED ED EM		a mining, Al t	Y Y	 Y	Y		Y
Kulasagareh2010Kulczycki2017Kumar2009Kuo2017Lando2014Lariviere2010Lariviere2016Lariviere2011	European Archives of Oto-Rhino-Laryngology Journal of Informetrics Iete Technical Review Computers in Human Behavior	EM ED ED EM		a mining, Al t	Y Y	 Y	Y		
Kulczycki2017Kumar2009Kuo2017Lando2014Lariviere2010Lariviere2016Lariviere2011	Journal of Informetrics Iete Technical Review Computers in Human Behavior	ED ED EM		a mining, Al t	Y Y	Y			
Kumar2009Kuo2017Lando2014Lariviere2010Lariviere2016Lariviere2011	Iete Technical Review Computers in Human Behavior	ED EM		ining, Al t	Y	Y			
Kuo2017Lando2014Lariviere2010Lariviere2016Lariviere2011	Computers in Human Behavior	EM		YA t)	Y			
Lando2014Lariviere2010Lariviere2016Lariviere2011					x				
Lariviere 2010 Lariviere 2016 Lariviere 2011	PLOS One			aini , co	2			Y	
Lariviere2010Lariviere2016Lariviere2011	I LOS OIR	EM		raining, a	Y				Y
Lariviere 2011	Journal of the American Society for Information Science and Technology	EM	1.	and simi		Y			
	PLOS One	EM	V	بن آم ر					
	Journal of Informetrics	EM		techno	2 7 7		Y		
Lauer 2015	The New England Journal of Medicine	ED	Y	alogies.	*				
Law 2013	Asia Pacific Journal of Tourism Research	EM	Y	Y. Y.	2	Y			
Lee 2009	Journal of neurosurgery	EM		Вірі	Y				
Leff 2009	International Journal of COPD	ED		logra	`	Y			
Leydesdorff 2016	Scientometrics	ED			5	Y	Y		
Li 2015	Science	EM	Y	ue de	5				

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Li		2016	In: Nah FFH, Tan CH, eds. Hci in Business, Government, and Organizations: Ecommerce and Innovation, Pt I. Vol 97512016:61-71.	EM	Y	n 30 March 2019. ncluding for use					
			IEEE International Conference on Smart			<u>.</u>					
Liar	ng	2015	City/SocialCom/SustainCom	EM		Downloaded Superie related to t					Y
Liac	0	2011	Decision Support Systems	EM		d to		Y			
Linc	dner	2015	PLOS One	EM	Y	Yxt of fro					
Line	dner	2016	American Journal of Evaluation	EM	Y	ied from http ieur (ABES) b text and de					
Lipp	pi	2009	Clinical Chemistry and Laboratory Medicine	ED		b) · lata m	Y	Y			
Lipp	pi	2013	Clinica Chimica Acta	EM		mining,	Y	Y			
Lipp	pi	2017	Annals of Translational Medicine	EM		ng, Al	Y	Y			Y
Liss	soni	2011	Industrial and Corporate Change	EM		l train		Y			
Litti	man	2017	Medical Education Online	EM		ning,	Y	Y			
Liu		2011	Management Information Systems	EM		ynd Ynd			Y	Y	
Lop	Dez	2015	Journal of Surgical Education	EM	Y	une 13 simila	Y				
Lop	Dez	2015	Journal of Hand Surgery America	EM	0	T T	Y				
Lort	tie	2013	Scientometrics	EM	0	2025 at Liechno		Y			
Lov	vegrove	2008	BioScience	EM	Y	t Ager blogie	Y		Y		
Loz	zano	2017	Current Science	ED		Y ^{es} Ce	Y		Y		
Mac	cMasters	2017	Academic Psychiatry	EM		Y Biblio	Y				
Mag	ggio	2017	Academic Medicine	EM		gra	Y			Y	
Mal	li	2017	Science & Public Policy	EM		phiq					
Mar	rkel	2017	Journal of Pediatric Surgery	EM		Y de	Y		Y		
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Markpin	2008	Scientometrics	EM		-025320 on 30 March opyright, including fo		Y			Y
Marsh	2008	American Psychologist	EM	Y	or use					
Marshall	2017	Otolaryngology—Head and Neck Surgery	EM		9. Do		Y			
Marzolla	2016	Journal of Informetrics	EM	Y	Sup Sup	Y		Y		
Mas-Bleder	2013	Scientometrics	EM		Yo te	•		Y		
Matsas	2012	Brazilian Journal of Physics	EM		r (Al	·				Y
Maunder	2007	La Revue Canadienne de Psychiatrie	EM		I from http: ur (ABES) ext and dat		Y	Y		Y
Maximin	2014	RadioGraphics	ED	Y	Yaa . Mon		Y		Y	
Mazloumian	2011	PLOS One	EM		njope					Y
Mazmanian	2014	Evaluation & the Health Professions	RE		g, Al t			Y		
McAlister	2011	American Heart Association Journals	ED		Yaini		Y			
McGovern	2013	Academic Medicine	EM	Y	ing or Ya or			Y		
Medo	2016	Physical Review	EM		n Jun and si	· Y		Y		
Meho	2008	Journal of the American Society for Information Science and Technology	EM	V_	e 13, milar	Y				
Mester	2016	Interdisciplinary Description of Complex Systems	ED		2025 a		Y			
Metcalf	2010	Radiologic Technology	EM		ıt Age ologie					
Milone	2016	American Journal of Orthopedics	EM	Y	ence les.	Y				Y
Minasny	2013	PeerJ	EM		Y Bibli	Y				
Mingers	2015	European Journal of Operational Research	ED		Y gra	Y		Y		
Mingers	2009	Journal of the Operational Research Society	EM		Y hiqu	Y				
Mingers	2017	Scientometrics	EM		Y e de					

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Mirnezami	2016	Science and Public Policy	EM		-025320 on 30 March opyright, including fo			Y		
Misteli	2013	The Journal of Cell Biology	ED		or use		Y			
Moed	2015	Journal of the Association for Information Science and Technology	RE		9. Downloade Superie es related to				Y	
Moed	2009	Archivum Immunologiae et Therapia Experimentalis	ED		uper ed to	Y	Y	Y		
Mooij	2014	Scientometrics	EM		ed from ht ieur (ABES b text and c			Y		Y
Moppett	2011	British Journal of Anaesthesia	EM	Y		Y		Y	Y	
Moreira	2015	PLOS One	EM		b) ·	Y	Y		Y	Y
Morel	2009	PLOS Neglected Tropic Diseases	EM		minir	Y				Y
Moustafa	2016	Accountability in Research-Policies and Quality Assurance	ED		ing, A					
Murphy	2011	Irish Journal of Medical Science	EM				Y			
Murphy	2017	Nature	ED		mj.com/ (training,			Y		
Mutz	2015	Journal of the Association for Information Science and Technology	EM	Y	on June 13, , and similar					
Mutz	2012	Zeitschrift fur Psychologie	EM	Y	e 13, mila					
Nah	2009	Journal of The American Society for Information Science and Technology	EM	C	2025 at r technol		Y	Y		
Napolitano	2016	Critical Care Medicine	ED		t Ager ologie			Y		
Nature Editorial Office	2013	Nature Letters	ED		Y Bib		Y			
Nature Editorial Office	2017	Nature	ED		liograp		Y			
Neufeld	2011	Research Evaluation	EM	Y	hique	Y				
Neylon	2009	PLOS Biology	ED		Y de		Y			
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Nicol	2007	Medical Journal of Australia	EM	Y	-023320 on 30 march opyright, including fo		Y			
Nicolini	2008	Scientometrics	EM		or use		Y	Y		
Niederkrotenthaler	2011	BMC Public Health	EM		s re	}				Y
Nielsen	2017	Studies in Higher Education	EM		Superieu lated to te	<u>,</u>	Y	Y		
Nigam	2012	Indian Journal of Dermatology, Venerology and Leprology	ED		to te	Y				
Nightingale	2013	Nurse Education in Practice	EM		Ytt and	Y	Y		Y	
Nosek	2010	Personality and Social Psychology Bulletin	EM		BES)	Y				Y
Nykl	2015	Journal of Informetrics	EM	Y	ta m	Y	Y			
O'Brien	2012	Oikos	ED		ining					
O'Connor	2010	European Journal of Cancer Care	ED		Alt		Y	Y		
Okhovati	2016	Global Journal of Health Science	EM	Y	Ynir	Y	Y	Y		
Oliveira	2013	Revista Paulista de Pediatria	EM		no Ya o		Y	Y		
Oliveira	2011	Arquivos Brasileiros de Cardiologia	EM		nd si	Y	Y			
Oliveira	2013	Scientometrics	EM		Yila ,	Y	Y	Y		
Opthof	2009	Netherlands Heart Journal	EM		r tech	Y Y	Y			
Orduna-Malea	2015	El Profesional de la Información	ED	Y	n ar n		Y		Y	Y
Osterloh	2015	Evaluation Review	EM	Y) gies		Y			
Ouimet	2011	Scientometrics	EM		- c			Y		
Pagani	2015	Scientometrics	RE		Y III	<u>,</u>	Y			Y
Pagel	2011	British Journal of Anaesthesia	EM		gi apri	Y				
Pagel	2011	Anaesthesia	EM		Indre			Y		
Pagel	2015	Original Investigations in Education	EM		Y C	-		Y		

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1 2 3 4	Paik	2014	Surgical Education	EM		30 March cluding fc	Y				
5	Pan	2014	Science Reports	EM		2019 or use	Y	Y			Y
6 7	Pandit	2011	Anaesthesia	ED		Yre Yre	Y		Y		
8 9	Patel	2013	Journal of the Royal Society of Medicine	EM	Y	Wnlo Sup Yec	Y	Y	Y		Y
10	Patel	2011	Journal of the Royal Society of Medicine	RE		Yo te	Y	Y	Y		
11 12	Patrow	2011	Journal of Postgraduate Medicine	ED		ur (A	Y				
13 14	Pepe	2012	PLOS One	EM		aded from http: perieur (ABES) I to text and dat	Y				Y
15	Pereyra-Rojas	2017	Frontiers in Psychology	EM	Y	p://bm) . ata mi	Y		Y		
16 17	Perlin	2017	Journal of Informetrics	EM		njope vinjng		Y			
18	Persson	2014	Acta Physiologica	ED		<mark>eh.bm</mark> g _i Al tr				Y	
19 20	Peters	2017	Journal of Infometrics	ED		nj.co traini		Y			
21 22	Petersen	2013	Journal of Informetrics	EM		rj.com/ or					Y
23	Petersen	2010	Physical Review	EM		n Jun and si					
24 25	Pinnock	2012	Nurse Education Today	ED	1,	ne 13, Yinjila		Y			
26 27	Põder	2017	Trames-Journal of the Humanities and Social Sciences	EM	0	8, 2025 ur tech	Y				Y
28	Prabhu	2017	World Neurosurgery	ED		5 at	Y	Y	Y	Y	
29 30	Prathap	2016	Scientometrics	EM		Agen ogjes		Y			
31 32	Prathap	2012	Scientometrics	EM		C	Y	Y	Y		
33	Prathap	2014	Scientometrics	EM		Biblio	Y				Y
34 35	Prathap	2017	Current Science	ED		Y ap	Y	Y			Y
36 37	Pringle	2008	Learned Publishing	ED		Y qu	Y	Y	Y		
38	Pshetizky	2009	Journal of the American Board of Family Medicine	EM		Y Q		Y			
39 40 41 42 43 44 45			For peer review only - http://bmjopen	ı.bmj.com/site/ab	pout/guidelir	Enseignement					
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Pugh Jr	2013	Journal of General Physiology	ED			rch		Y			
Pulina	2007	Italian Journal of Animal Science	EM		ruse	2019	Y	Y	Y		
Pyke	2015	BioScience	ED		is rel	. Do					Y
Qi	2016	Scientometrics	EM		Yed	/nlo					
Quigley	2012	Journal of Cancer Education	EM		to te	wnloaded Superieu	Y				
Rad	2012	Academic Radiology	EM		Xt a	r (A	Y				
Radicchi	2008	Proceedings of the National Academy of Sciences of the United States of America	EM		d data Yata	http:// ES) .	Y		Y		Y
Radicchi	2012	Journal of Informetrics	EM		Ynin	omjo			Y		
Raj	2016	Academic Medicine	EM		 ¥g. A	ĕ	Y		Y		
Ramasesha	2011	Current Science	ED		Ytra	bmj.c	Y	Y	Y		
Rana	2013	Journal of Cancer Education	EM		Yraining,	bm/	Y				
Ravenscroft	2017	PLOS One	EM		, and	ر no	Y	Y	Y	Y	
Rey-Rocha	2015	Scientometrics	EM	1.	Ysimi	June					
Rezek	2011	Academic Radiology	EM		lar te	13, 20					
Ribas	2015	Proceedings of the 24th International Conference on World Wide Web	0	Y	schnglo	2025 at A	Y				Y
Ribas	2015	arXiv	ED		gies	genc					Y
Ricker	2009	Interciencia	ED	Y		ce Bib		Y			Y
Rieder	2010	Langenbeck's Archives of Surgery	ED			bliogr	Y		Y		
Robinson	2011	Journal of School Psychology	ED			Iraphi		Y			
Rodriguez-Navarro	2011	PLOS One	EM			ique					Y
Ronai	2012	Pigment Cell and Melanoma research	ED	Y	Y	de I E					
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1 2					n 30 M: ncludii					
3 4	Rons	2009	Research Evaluation	EM	March Iding fo					
5	Rosati	2016	Journal of Cardiac Surgery	EM	2019 r use	Y				
6 7	Ruane	2009	Scientometrics	EM	. Do	Y				Y
8 9	Saad	2010	Scientometrics	EM	Wnloa Supe lated	Y				
10	Safdar	2015	Society for Academic Emergency Medicine (SAEM)	EM Y						
11 12	Sahel	2011	Science Translational Medicine	ED	from Y and Y and	Y	Y			
13 14	Sahoo	2017	Omega	EM		Y	Y			Y
15	Saleem	2011	Internal Archives of Medicine	ED		Y	Y			
16 17	Sangam	2008	Current Science	ED	://bmjope :a mining	Y	Y			
18 19	Santangelo	2017	Molecular Biology of the Cell	ED			Y	Y		
20	Saraykar	2017	Academic Psychiatry	EM	bmj.com/ (Al training,	Y				
21 22	Sarli	2016	Missouri Medicine	ED	ing, a		Y	Y	Y	
23 24	Satyanarayana	2008	Indian Journal of Medical Research	ED	n June and sir	Y	Y			
25	Saxena	2013	Journal of Pharmacology Pharmacotherapeutics	EM	imila	Y	Y	Y		Y
26 27	Sebire	2008	Ultrasound in Obstetrics and Gynaecology	ED	, 202t	Y		Y	Y	
28 29	Selek	2014	Scientometrics	EM	5 at , hpol	Y		Y		
30	Seo	2017	Management Decision	EM	5 at Agend		Y			
31 32	Shanta	2013	Journal of Medical Physics	ED	γö	Y	Y			
33 34	Shibayama	2015	Research Policy	EM	Y Dio		Y			
35	Sibbald	2015	Journal of the Medical Library Association	ED	grap					Y
36 37	Simons	2008	Science	ED	hique		Y			
38	Sittig	2015	MEDINFO 2015: eHealth-enabled Health	EM	Y C	Y				Y
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Slim	2017	Anaesthesia, Critical Care & Pain Medicine	ED			y for		Y		Y	
Slyder	2011	Scientometrics	EM			2019. r <u>Y</u> use					
Smeyers	2011	Journal of Philosophy of Education	ED			S rela	'	Y			
Smith	2008	Bone & Joint Journal	ED			/nloa Sup ated	ļ.	Y			
Soares de Araujo	2011	Revista Brasileira de Medicina do Esporte	EM			aded erieu to te	Y	Y	Y		
Sobhy	2016	Embo Reports	ED			r (A)	1	Y			
Sobkowicz	2015	Journal of Artificial Societies and Social Simulation	EM	Y		wnloaded from http: Superieur (ABES) . lated to text and data					
Solarino	2012	Annals of Geophysics	RE			Yani	Y	Y			Y
Sood	2015	Eplasty	EM			ining					
Sorenson	2011	Journal of Parkinson's Disease	EM			Y <u>></u>	Y				Y
Spaan	2009	Medical & Biological Engineering & Computing	ED			mj.con trainin	Y	Y			
Spearman	2010	Journal of Neurosurgery	EM			ing, a					
Spreckelsen	2011	BMC Medical Informatics and Decision Making	EM	•		n Jun and si	· Y	Y	Y		
Staller	2017	Qualitative Social Work	ED	1		ingilar	37			Y	
Stallings	2013	Proceedings of the National Academy of Sciences of the United States of America	EM	" (7	r techno	Y				Y
Street	2009	Health Research Policy and System	EM	Y		t Age alogie	•				
Stroebe	2010	American Psychologist	ED			Y. ence	<u> </u>		Y		
Stroobants	2013	Nature	ED			Bibli					
Sturmer	2013	Revista Brasileira De Fisioterapia	EM			Y gra	Y				
Suiter	2015	The Journal of Academic Librarianship	EM			phiq	Y	Y	Y	Y	
Suminski	2012	The Journal of the American Osteopathic Association	EM			Y e		Y	Y		
Suminski		*									

Page 51	of 72			BMJ Open		-025320 on 30 March opyright, including fo					
1 2 3	Surla	2017	The Electronic Library	ED		on 30 March , including fc		Y			Y
4	Susarla	2017	Plastic and Reconstructive surgery	EM		fory	Y	I			
5 6			Journal of Dental Education		Y	2019. ryses	T Y				
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16 17	Swanson	2016	Annals of Plastic Surgery	EM		njope	Y				
18	Szklo	2008	Epidemiology	ED				Y			
19 20	Szymanski	2012	Information Sciences	EM		Al trainin	Y	Y	Y		Y
21 22	Taborsky	2007	International Journal of Behavioural Biology	ED	Y	Ģ, Z					
23	Tan	2016	The Annals of Applied Statistics	EM		and si	Y	Y		Y	Y
24 25	Tandon	2015	National Academy Science Letters-India	ED		une 13, simila		Y			
26 27	Taylor	2015	Poultry Science	ED		3, 2025 ar tech	Y	Y		Y	
28	Teixeira	2013	PLOS One	EM		25 at A chnolo	Y				
29 30	Tenreiro Machado	2017	Entropy	EM	Y	Ageno			Y		
31 32	Thelwall	2017	Aslib Journal of Information Management	EM		6				Y	
33	Therattil	2016	Annals of Plastic Surgery	EM		Biblio	Y				
34 35	Thomaz	2011	Arquivos Brasileiros De Cardiologia	ED		ograp	Y	Y	Y		
36	Thorngate	2014	Advances in Social Simulation	EM	Y	ohique					
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Torrisi	2014	Scientometrics	EM	Y	or us	2019	Y	Y	Y		
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Trueger	2015	Annals of Emergency Medicine	ED		lated to te	oluv	Y	Y		Y	
Tschudy	2016	Journal of Pediatrics	EM		to te	aded	Y		Y		
Tse	2008	Nature	ED		xt an	from	Y	Y			Y
Tuitt	2011	Canadian Journal of Gastroenterology	EM		ext and dat	http	Y	Y	Y		
Usmani	2011	Sudanese Journal of Paediatrics	ED		a. mi	//bn	Y	Y			
Valsangkar	2016	Surgery	EM		ning.	jope	Y		Y		
van Arensbergen	2012	Higher Education Policy	EM	Y	A	n.bm					
van den Besselaar	2009	Research Evaluation	EM	Y	training,	j.cor					
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van Noorden	2010	Nature	ED		tech	2025	Y	Y	Y	Y	
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Wagner	2012	Research Evaluation	ED							Y
Waisbren	2008	Journal of Women's Health	EM		d to text	<u> </u>				
Walijee	2015	Plastic and Reconstructive Surgery	ED		text and c	-			Y	
Walker	2010	BMC Medical Education	EM				Y	Y		
Wallace	2012	PLOS One	EM	Y	- mainin Yinin					
Walters	2011	Journal of the American Society for Information Science and Technology	EM	Y	ġ,		Y			
Waltman	2013	In: Gorraiz J, Schiebel E, Gumpenberger C, Horlesberger M, Moed H, eds. 14th International Society of Scientometrics and Informetrics Conference	EM		Al training _Y an	Y				Y
Waltman	2013	Journal of Informetrics	EM		June Ysim					
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Ward	2012	Anaesthesia	ED	Ċ	techr	2 2 2 1				
Watson	2015	Journal of Pediatric Surgery	EM			v				
Welk	2014	Research Quarterly for Exercise and Sport	ED		nologies.		Y			
Wieczorek	2016	Financial Environment and Business Development	ED		Y B	Y	Y			
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First author	Year	Journal name	Level	Metric or Model	Name	Basis	It accounts for the teoperated distribution of citations.
Anderson	2008	Scientometrics	Researcher	Metric	Tapered h- index	h-index	=
Aragon	2013	Nature Scientific Reports	Both	Metric	Scientist impact (Φ)	Author contribution s and citation counts	Instead of the total $\mathbf{a}_{\mathbf{p}}$ for of citations, the proposed measure Φ (Scientist Impact) $\mathbf{a}_{\mathbf{p}}$ is a discerning the genuine number of people (specifically lead author) the paper (or first author) has had an impact upon by renewing self-citation. In other words, Φ aims at measuring the paper is reach.
Assimakis	2010	Scientometrics	Researcher	Metric	The Golden Productivity Index	Author contribution and publication count	A rank dependent index that measures the productivity of an individual researcher by evaluating the number of papers as well as the rank of co-auther ship. It emphasizes the first author's contribution.
Bai	2016	PLOS One	Researcher	Metric	COIRank algorithm	Network analysis	Quantifies scientific impact by reproducing the accumulated COI relationship in the generative community. COIRank focuses on improving PageRant though setting a weight for PageRank algorithm and promotes the performance in identifying influential articles. It therefore accounts for self-citation and citation by others at the same institution.
Belikov	2015	f1000 Research	Researcher	Metric	L-index	h-index and author contribution	Accounts for co-author contribution by designating citations to each individual author according to their order on a paper. It also considers the age oppublications, favoring newer ones. However, if a scientist has made a significant scientific breakthrough and ceases publications, his or her bindex will remain high regardless. It ranges from 0.0-9.9.
Bini	2008	Electronic Transactions on Numerical Analysis	Both	Metric	Information not available	Citation count	Proposes to integrate models for evaluating papers, authors, and journals based on citations, co-authorship and publications. After the one-class model for manking scientific publications, they introduced the two-class model which ranks papers and authors, and the three-class model for ranking papers, authors, and journals.
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Bloching	2013	South African Journal of Science	Article	Metric	TAPSIF- temporally averaged paper-specific impact factor	Citation count and IF	Calculated from a press average number of citations per year (including the publication year) combined with bonus cites for the publishing journal' pressige—which is taken as the journal impact factor from the publication year. Annual TAPSIF values of all the papers by an authomic and be combined to measure the overall scientific relevance to the problem of the pr
Bollen	2016	Scientometrics	Researcher	Model	Equal Allocation Model	Peer-review	A novel model in which heach researcher is allocated funding and is required to donate appropriate funding to other researchers- hence uses crowd will be model for the funding to the searchers.
Caminiti	2015	BMC Health Services Research	Researcher	Metric	Information not available	Citation count	This work in progressing gests a mixture of 12 easily retrievable indicators (bibliometric and citation parameters, as well as "hidden" activities such as teaching, mentoring etc). The weighting system was constructed considering the hypothesized effort for all indicators. The chore in iddicators and attributed scores still remain to be validated. Modifier from Wooton, Health Res Policy Syst. 2013;11:2; Smith, Br Med J. 2001;323(7312):528–8.; and Mezrich J Am Coll Radiol. 2007;4(7):471–8.
Castelnuovo	2010	Clinical Practice & Epidemiology in Mental Health	Researcher	Metric	Single Researcher Impact Factor	IF	This metric takes into a count publications (journal articles, books, oral and poster presentations in scientific meetings); products (e.g., software, CD-ROM videos, databases); and activities (reported scientific activities such as scientific positions or positions in conferences organization, participation in journal editorial boards, activities on human escurces education, and participation in international funding projects). Minimum and maximum values are assigned to each tage for national and international impact.
Claro	2011	Scientometrics	Researcher	Metric	The x-index	IF and author contribution	Aims to enable cross-disciplinary comparison and uses indicators of both quality and quartity, taking into account the number of publications a researcher has published, and then calculating a publication score for each. This considers number of authors on the paper and the journal's grear impact factor; it is also normalized by the journals in which the author tends to publish (rather than top-down classification of a field). Also uses a co-authorship share coefficient. Therefore, arms to determine relative contribution to a paper and normalize by the efforts, it is not based on individual article citations but that of the journal (JIF), which can have limitations.
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Cordero- Villafafila	2015	Revista de Psiquiatría y Salud Mental (English Edition)	Both	Metric	RC Algorithim	IF	The first English-language publication of this metric, it quantitatively evaluates the personal impact factor of the sci production of isolated researchers. It also an individual form and group form (RGγG), and is able to assess personal impa individual publications, or a group of them. It also provide procedure to classifie the arch centers of different types base the impact (FRCγG) there is by their results amongst research the same field. One of the limitations of the RC algorithm is precisely, its dependence on said bibliographic databases, w have a strong pre-emined constant of studies published in English.
Crespo	2015	PLOS One	Other	Metric	Exchange Rate	Citation count	This is an average-based indicator that is used to explore differential citation and between disciplines by using it as a normalization factor. It is not suitable for assessing individu researchers but produce insight into comparison across disc
De Witte	2010	Scientometrics	Researcher	Metric	RES-score - Research Evaluation Score	Data Envelopmen t Analysis	Authors present a methodology to aggregate multidimension research output, using a ailored version of the non-paramet Envelopment Analysis model. This they claim is a more acc representation of a search performance.
Delgadillo	2016	Family & Consumer Sciences Research Journal	Both	Metric	HLA-index	h-index	This index, actually point and a book by Harzi (2011), normalizes to take into account career st discipline.
Dodson	2012	Biochemical and Biophysical Research Communications	Researcher	Metric	SP-index	IF	This metric is said a quantify the scientific production of researchers, representing the product of the annual citation r by the accumulated mpetric factors of the journals in which t papers are publisher, divided by the annual number of public papers.
Duffy	2008	Journal of Counseling Psychology	Both	Metric	IRPI - Integrated Research Productivity Index	Citation count	This metric statistically combines an individual's author-we publications (AWS) average times cited by other publication (MC), and years since first publication (Y) into a comprehens score, calculated as (AVS) x MC)/Y. It thereby accounts for differences in career length.
Ebadi	2016	Scientometrics	Researcher	Model	iSEER	Machine learning	An intelligent machine garning framework for scientific ev of researchers (iSEER) considers various "influencing facto different types" (e.g., funding, collaboration pattern, perforr such as quantity and impact of papers, efficiency). It can be a complementary tool to overcome limitations in peer-revie
			For peer r	eview onl	y - http://bmjop	en.bmj.com/site	e/about/guidelines.xhtm

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Ekpo 2016 Journal of Medical Imaging and Radiation Sciences Researcher Metric Metric TotalImpact Author continuition count and citation For each of the authors, the total number of publications in peer reviewed journals (2), tical number of citations per publication collaboration metrics, and illo-inde& are extracted (using SciVal). This metric assessed whether authors were leading the research or coauthor count and citation Franceschini 2012 Scientometrics Both Metric Information not available Citation counts and h-index A study specific metrics A study specific metrics Both Franceschini 2012 Scientometrics Both Metric The Success- Index Citation not available Citation counts and h-index A study specific metrics A study specific metrics The success- tine scarcher, representing the "powel in the crown" in terms of impact/diffusion. The segmetrics are also scalable to teams thou where the h-spectrm in ind-values to a group of researchers (including average and decium), and the h-group is the h-index the union of publications/patent are searcher, representing the "jewel in the crown" in terms of impact/diffusion. The segmetrics are also scalable to teams thou where the h-spectrm in ind-values to a group of researchers (including average and decium), and the h-group is the h-index the union of publications/patent are secarcher, representing the "jewel in the crown" in terms of impact/diffusion. The spectrem is ind-values to a group of researchers (including average and decium), and the h-group is the h-index the union of publications.						ВΛ	1J Open	-025320 on 30 M: opyright, includi
not availablecounts and h-indexpublications/patent fraining to publications/patents of one researcher (an indigator of tendency for co-authorship). It also u the minimum and mixing un years: the oldest publication/patent and the year relating to peir latest one. This provide an indicatio of the temporal extension of the publishing or patenting activity a researcher. They also use the most-cited is publication/patent researcher. They also use the most-cited is publication/patent of the temporal extension of the publishing or patenting activity a researcher. They also use the most-cited is publication/patent researcher. They also use the conv." in terms of impact/diffusion. The segmetrics are also scalable to teams thou where the h-spectrum is is-values to a group of researchers (including average and medium), and the h-group is the h-index the union of publications/patents associated with publications/patentsFranceschini2012ScientometricsResearcherMetricThe Success- IndexCitation counts, NSP-index by Komulski (2011)This metric is based on Komulski's (2011) NSP (number of successful papers) idde with the exception that for each publications. While it is more complicated than the organized that the organized that the organized that the organized to differential propensity to cite and therefore suitable for comparisons between complicated than the organized to differential propensity to cite and therefore suitable for comparisons between	Ekpo	2016	Medical Imaging and Radiation	Researcher	Metric	TotalImpact	contribution, publication count and citation	For each of the authors, the total number of publications in peer reviewed journals (P), total number of citations (C), international collaboration metrics, number of citations per publication (CPP) index, and i10-index are extracted (using SciVal). This metric assessed whether authors were leading the research or coauthors by judging their post to in the list of authors for each article. Authors listed as finder for the list of authors for each article. Authors listed as finder for the list of authors. Each authors total impact was the state in-between as coauthors. Each authors total impact was the state in the list of by: TotalImpact=P×C×FSL.
Index counts, NSP-index successful papers) index with the exception that for each publication the comparison term is sometimes replaced by a more by Komulski (2011) of a representative complexity to cite, determined on the ba of a representative complexity to cite and therefore suitable for comparisons between				O _f		not available	counts and h-index	publications/patent and their citations and also quantifies avera number of co-authors relating to publications/patents of one researcher (an indicator of tendency for co-authorship). It also u the minimum and mixing um years: the oldest publication/patent and the year relating to peir latest one. This provide an indication of the temporal extension of the publishing or patenting activity a researcher. They also use the most-cited is publication/patent of researcher, representing the "jewel in the crown" in terms of impact/diffusion. This provides a group of researchers (including average and medium), and the h-group is the h-index the union of publications patents associated with publications/patents.
	Franceschini	2012	Scientometrics	Researcher	Metric		counts, NSP-index by Komulski	successful papers) index with the exception that for each publication the comparison term is sometimes replaced by a more appropriate indicator of propensity to cite, determined on the ba of a representative comparison of publications. While it is more complicated than the original, it is insensitive to differential propensity to cite and therefore suitable for comparisons between

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Frittelli	2016	Journal of the Association for Information Science and Technology	Researcher	Metric	SRM - Scientific Research Measures	h-index and calculus	Proposes a novel class of measures (SRM) based on calculus principles that rank scientist's research performance by taking into account the whyle fation curve of a researcher (their performance curve number of citations of each publication, in decreasing order of itations). The performance cures can be chosen flexibly (e.g. before the factor of a field They extend this ide performance by taking before the seniority, characteristics of a field on theories of risk-factor of the seniority classes researchers with the same citation for the seniority of the seniorit
Gao	2016	PLOS One	Both	Metric	PR-index - PageRank Index	Network analysis and h-index	This metric uses Page hk score calculation combined with h- index calculation to as ure author impact. It considers publicat and citation quantited also takes a publication's citation netwo into consideration. This means the index will rank majority author higher by applying age Rank based on the publication citation relationship (distinguishing higher quality citations from lower ones).
Han	2013	Institute of Strategic Studies Islamabad	Both	Metric	New Evaluation Index	Network analysis	The new evaluation and takes into account direct and indirect references, direct and indirect citations, and citation network.
Holliday	2010	International Journal of General Medicine	Article	Model	Modified Delphi technique of peer-review	Peer-review	This paper reports using the modified Delphi process to appraise and rank research applications, with experts rating each application's scientific merit, originality, the adequacy of the stud design to achieve the research goals, and whether the potential impact of the study would warrant its funding. While its ease of administration, reproduce bility, and accessibility makes this a useful adjunct to the traditional processes of grant selection, it do not directly assess individual researcher's but their work.
Hutchins	2016	PLOS Biology	Both	Metric	iCite	Citation count	This is used for inderideal articles and normalizes their citation score by adding in so-citation metrics.
Ibrahim	2015	New Library World	Both	Metric	Hx	h-index and author contribution	This metric is a hybridization of two indicators based on the individual h-index (weighted by the average number of co-author for each paper) and h-index contemporary weighted by qualitative factors (conferences and journal in which a researcher participate or published). It accounds for the period of citations and number authors on a paper, is applicable at all levels and for any disciplin of research, takes conferences into consideration, and is thought reduce unscientific practices such as integration of authors who have not genuinely contributed.

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Ioannidis	2016	PLOS Biology	Researcher	Metric	Composite	Citation count, h- index and author contribution	A study-specific composite metric based: on total number of citations in, for example, 2013 (NC), total number of citations received in 2013 to papers for which the researcher is single at (NS), total number of citations received in 2013 to papers for which the researcher is single at (NS), total number of citations received in 2013 to papers for which the researcher is single at author (NSF), total number of citati received in 2013 to papers for which the researcher is single, f or last author (NSF) (NSF) (NSF), total number of citati received in 2013 to papers for which the researcher is single, f or last author (NSF) (NSF) (NSF), and the researcher is single, f or last author (NSF) (NSF) (NSF), giving eacle at the standardized (NC, H, Hm, NS, NSF) (NSFL), giving eacle at the highest raw value for the researcher is indicator. The six staff addiced indicators are then summed to
			07		0		generate the composite address C. Well-tested and validated usin factor analysis, which yielded two factors: bulk impact (NC ar author order and computer order and computer order and computer order and computer order of the second se
Iyendar	2009	Academic Medicine	Researcher	Model	RD - Research Density and Individual Impact Factor	IF	RD measures the ability to obtain grants at a point in time, while IFF reflects the quarty of research. The adopted methodology compares the impact factor of an investigator's articles with the of the top journals within their own field. Each investigator identified the top these journals in his or her field. The average impact factor of these these journals was used as the benchmar that investigator. Each faculty member was then asked to calculate his or her own individual impact factor (IIF) for two consecutions of these these benchmarks as target. This benchmark selected after reviewing results of comparisons of investigator. IIFs with their self-defined benchmarks at several multiples (575%, and 100%). We used 75% of the self-defined benchmark the target, because a signalikely for every paper to be published the best journal in the field, and yet 75% reflects the reasonable high standard of the resourch quality that MSSM strives for. The data were collated and the IIF of each faculty member was computed as the ratio of his or her impact factor to 75% of his her self-defined benchmark, expressed as a percentage.
Jeang	2008	Retrovirology	Researcher	Metric	Mentoring Index	h-index	Argues that good mentoing should be a significant considerat of one's contribution to beince. It focuses on using the h-index previous trainees in evaluating established researchers. It is the this index could encourage the development of long-lasting mentoring relationships.

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Krapivin	2009	Complex Sciences	Both	Metric	PaperRank and PR- hirsch	Network analysis and h-index	Based on PageRank, which has been very successful in ranking web pages, essentially considering the reputation of the web page referring to a given bage and the outgoing link density (i.e., page P linked by pages Lowhere L has few outgoing links are consider more important than pages P cited by pages L where L has man outgoing links). Page thank (PR) applies page rank to papers by considering papers to be pages and citations as links, and hence trying to consider not the page of the citing paper and the density of outgoing citations for the citing paper. The PR-Hirsch is a modification of the difference based on the same PageRank approach. PR and Page based on the same PageRank approach of based based on the same PageRank approach of based based on the same PageRank approach. PR and Page based on the same PageRank approach of based based on the same PageRank approach based based on the same PageRank
Kreines	2016	Journal of Computer and Systems Sciences International	Article	Model	Information not available	Citation count and IF	of a citing paper. Proposes a model for assessing quality in the content of individuant articles using computational analysis with bibliometric and scientometric data aumber of citations and the journal's IF).
Lando	2014	PLOS One	Article	Metric	l-index	h-index	This index considers the most elite papers and rewards papers of high impact and based on the form of the citation distribution. If thought to outperform the h-index in terms of accuracy and sensitivity to the form of the citation distribution, while being strongly correlated with other important h-type indices. It rewar the more regular and religible researchers.
Liang	2015	IEEE International Conference on Smart City/SocialCom/ SustainCom	Both	Model	Temporal tracking model		The temporal research exolution model takes into account individual output, researcher profile and experiences Bibliographique
			For peer r	eview onl	y - http://bmjop	en.bmj.com/site	e/about/guidelines.xhtment

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Lippi	2017	Annals of Translational Medicine	Researcher	Metric	SIF-Scientist Impact Factor	IF	This metric is calculated as all citations of articles published in t two years following the publication year of the articles, divided the overall number of articles published in that year. For exampl the SIF for the year 2017 would be obtained by dividing all citations in the year 2017 would be obtained by dividing all citations in the year 2016 to articles published in the year 2014, divided by the we all number of articles published in the year 2014. The total for the published of recent citations is normalized according to the number of recently published articles, limiting t bias emerging from the publishing a large number of scarcely cited articles; and the out the scientist, so complementing an overall career indicator, such the h-index.
Markpin	2008	Scientometrics	Other	Metric	ACIF - Article-Count Impact Factor	IF	This is proposed as join al-level metric that is calculated as the total number of articles ated in the current year divided by the number of articles ablieved in 1st and 2nd year. Note that is base on the number of articles that were cited, rather than the times cited articles. However, it could be used for individual researchers.
of P	Brazilian Journal of Physics	Both	Metric	NIF - Normalized Impact Factor	IF	Introduces a normalized impact factor that looks at the researched influence on their set entitic community by assessing the degree which they have been influenced by their community. Looks each of an author's publications, the number of co-authors, references the article and citations is has received. From the way it is calculated: "in a closed community of identical individuals (i.e., who publish, reference and are cited by each other at the same rate), all members have $MIF = 1$." Leaders in a field are then those with a NIF greater than ar equal to 1 i.e., they influence their per at least as much as grey are influenced by them.	
Maunder	2007	La Revue Canadienne de Psychiatrie	Article	Metric	Citation Ratio	Citation count	This metric is designed by overcome systematic differences amongst niche fields by comparing the impact of a particular paj to the average impact of paper in its journal. A ratio above 1 indicates relatively greater success.
Mazloumian	2011	PLOS One	Article	Metric	Boost Factor	Citation count	This metric calculates when a particular research gains scientific authority, that is, they publish some groundbreaking work that the leads to an upswing in chations of their earlier papers. It is able model the trend of the "gich get richer", a cascade of citations an too improve the "signal go-noise" ratio in citation rates by detect sudden changes in citations.

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Milone	2016	American Journal of Orthopedics	Article	Metric	Information not available	Publication count	A study specific measurement simply calculated by taking the mean of first and lage authored publications.
Mooji	2014	Scientometrics	Both	Model	Information not available	Peer-review, altmetrics, citation count	This paper proposes a comprehensive and new framework for assessing research guality assessment which utilizes intrinsic (i.e., the internal quality of the publication) and extrinsic indicators (i.e., citation counts, well the dimension of the former and billing metric and altmetric data at the individual article and author levels for the latter. One limit includes that the assessment of extrinsic actors is still biased in terms of multi- author papers. This time work builds in a quality check on peer- review.
Moreira	2015	PLOS One	Researcher	Metric	μ	Information not available	Suggests accumulated chartions from an author's aggregated publications followin asymptotic number, and then use a lognormal model. Greates μ as a scale of expected citability of a researcher's publication it is able to be used at all career stages and indicates more of quality over quantity.
Morel	2009	PLOS Neglected Tropic Diseases	Researcher	Metric	Information not available	Network Analysis	Co-citation network generated using SNA of publications, to identify groups and ndigiduals with high collaboration rates.
Niederkroten thaler	2011	BMC Public Health	Article	Model	Information not available	Information not available	A tool designed to measure the societal impact of research publications. It consists of three quantitative dimensions: (1) the aim of a publication (2) the efforts of the authors to translate their research results, and, if translation was accomplished, (3) (a) the size of the area where translation was accomplished (regional, national or international (b) its status (preliminary versus permanent) and (c) the target group of the translation (individuals, subgroup of population).
Nosek	2010	Personality and Social Psychology Bulletin	Researcher	Metric	Ics- Individual researcher career-stage impact	Citation count	Produces career-stage instric of scientific impact based on citation counts. Its development was based on extensive data collection to produce a regression of expected growth of impact over time. It, therefore, reflects the distance from one's expected impact at a given career stage.
Pagani	2015	Scientometrics	Article	Metric	Methodi Ordinatio	IF	Based on IF, number of itations and year of publication in a normalized, weighted nuthematical equation. It is a potential way to define scientific relevance.
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Pan	2014	Science Reports	Researcher	Metric	Author Impact Factor (AIF)		Defined as the AIF of an author A in year t is the average number of citations given by papers published in year t to papers publishe by A in a period of at years before year t. Uses a time window of years for calculation
Patel	2013	Journal of the Royal Society of Medicine	Researcher	Model	sRM - statistical Regression Model	Citation count	Used to estimate the number of high visibility (based on citation count) publications and the researcher.
Рере	2012	PLOS One	Researcher	Metric	TORI - Total Research Impact	Citation count	Includes non-self-characteris accrued by the researcher, number of authors on cited page and number of bibliographic references to generate the cumulative putput of a scholar by summing the impa of every external citetion accrued in his/her career. This removes biases associated with cration counts.
Petersen	2013	Journal of Informetrics	Researcher	Metric	Z	h-index	Z is aimed at correcting the h-index's penalty (which in some case neglects 75% of an author's body of work) by including the total number of citations for meir work in the metric.
Põder	2017	Trames-Journal of the Humanities and Social Sciences	Researcher	Metric	(Current or predicted) impact rate of researcher	Citation count	Based on the citations per year squared, this metric provides a means of assessing acceleration/impact and is based on time serie data. This is more sensitive to productivity overtime and can go down unlike the h-mode.
Prathap	2014	Scientometrics	Researcher	Metric	Z-index	h-index	Purporting to include quality, quantity and consistency, it accoun for the high-end of see the performance, while compensating fo the skewness of citation-publication distributions.
Radicchi	2008	Proceedings of the National Academy of Sciences of the United States of America	Article	Metric	Relative Indicator - cf	Citation count	The relative indicator is used to deal with the fact that different fields have different citation patterns and allows for comparisons the success of articles in different fields.
Ribas	2015	Proceedings of the 24th International Conference on World Wide Web	Both	Metric	P-score	Citation count	It associates a reputation with publication venues based on the publication patterns of reference groups, composed by researcher in a given area of know dege. Although the choice of reference groups can be made by asing available citation data, the P-score metric itself does not degend on citation data. It uses just publication records of refearchers and research groups; that is, the papers and the venues where they published in.

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							-025320 on 30 M opyright, includi	
Ricker	2009	Interciencia	Researcher	Model	Rule-based peer-review	Peer-review	Computer generated per review, which is positive as res get peer-review feedback. Can also measure evaluators se certain criteria of interest important journals of interest b field.	elect
Ruane	2009	Scientometrics	Both	Metric	h1-index	h-index	A measure of superdision quality, it gives the supervisor l calculated by the hand set of their PhD students.	al i
Sahoo	2017	Omega	Researcher	Model	Composite indicator	h-index, IF, citation counts	Calculated based on the elative weight of the six indicated journal tier, total cited bases, author h-index, number of pap impact factor, and jaurnal h-index.	ers,
Saxena	2013	Journal of Pharmacology Pharmacotherape utics	Researcher	Metric	ORPI - Original Research Publication Index	Citation count	Indicates originality and visibility, by inclu number of original articles, citations, accounting for self- and the total number of pitable articles (i.e., including rev case reports). Also	ding citat view
Sibbald	2015	Journal of the Medical Library Association	Both	Model	Modified approach to citation analysis	Citation count	Includes grey literative in the citation analysis search pro- involves quantitative and qualitative methods of analysis better understanding of now a research paper was used. H this is more expensive and time consuming than tradition	to g Iow
Sittig	2015	MEDINFO 2015: eHealth- enabled Health	Researcher	Model	The Biomedical Informatics Researchers ranking website	Information not available	This new system was developed to overcome previous sc productivity ranking strategies. However, it is limited to b informatics.	
Sorenson	2011	Journal of Parkinson's Disease	Both	Metric	"Broad impact" citations	Citation count	Citations from those outside the field are used as a measu broader impact.	
Surla	2017	The Electronic Library	Researcher	Metric	Research Impact Factor	IF	Allows a measure of scientific influence of a researcher in relative scientific area.	1 the
Szymanski	2012	Information Sciences	Both	Metric	CENTs - sCientific currENcy Tokens and the I-index	Citation count and h- index	An accumulation of "cerris" based on the number of non-scitations. This is also the premise behind the i-index, whe papers a ranked according to CENTs rather than just all c	reby
			For peer r	eview onl	y - http://bmjopo	en.bmj.com/site	e de Enseignement :/about/guidelines.xhtment	

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Tan	2016	The Annals of Applied Statistics	Article	Model	Information not available	Citation count	Proposes to use two established models in the creation of a third. The proposed model provides a structural understanding of the field variation in cigation behavior and a measure of visibility for
Vieira	2011	Scientometrics	Researcher	Metric	hnf-index	h-index	individual articles a justed for citation probabilities within/betwee topics. a Considers the difference citation of each field and the number of authors b b b cation, and hence can be used to
Wagner	2012	Research Evaluation	Researcher	Metric	I3 - Integrated impact indicator	Citation count	measure researcher beformance. A framework for incertaing citations and non-parametric statistic of percentiles, which algo whighly cited papers to be weighted mo than less-cited ones and a statistic
Waltman	2013		Article	Metric	HCP – Highly cited publications index	Citation count	A simple model in whice the number of citations of a publication depends not only on the scientific impact of the publication but al on other 'random' gictor. Does not account for productivity.
Wang	2013	Science	Article	Model	Mechanistic model for citation dynamics	Citation count	Authors demonstrate a predictable course for citations of single articles over time, providing, therefore, to create more reliable predictive index of individual impact.
Williamson	2008	Family Medicine	Researcher	Metric	Information not available	Too broad to classify	Quantifies activities within three domains: teaching, service and research and scholagy as tivity. A time intensive- process that is suitable for promotion within institutions, but not grant funding o more macro-scale assessments.
Wootton	2013	Health Research Policy and Systems	Researcher	Metric	R - Simple indicator of researcher output		Formula is $R=g+p+R$ and comprises grant income (g), publication (peer-reviewed and veighted by JIF; p) and numbers of PhD students supervised no credit for submission after the due date of submission; s).
Yaminfirooz	2015	The Electronic Library	Both	Metric	mh-index	h-index	Use to identify differences in the impact of authors with the same h-index, and differences between the outputs of influential researchers working in Ecertain field and the ones publishing only a few papers during a year, can track the impact of highly cited papers.
Yang	2013	Journal of Informetrics	Researcher	Metric	A-index - Axiomatic approach	Citation count and author contribution	Allows for evaluation opindividual researcher in the team context (i.e., co-authorship networks).

2					BM	J Open	-025320 on 30 opyright, inclu
							-025320 on 30 M opyright, includi
Zhang	2012	Scientometrics	Both	Model	Scientometric age pyramid	Information not available	Accounts for the different ages of academics, different fields, co authorship patterns and analysis of journals. The pyramid represents the number of publications on one side and number of citations on the other side.
Zhou	2012	New Journal of Physics	Both	Metric	AP Algorithm	Citation count	Considers the prestige of the scientists citing the article but assumes equal control of each author to the paper.
Zhu	2015	arXiv	Researcher	Metric	The hip index - Influence- primed h- index	h-index	The hip-index weight wations by how many times a reference mentioned, which is the ght to make it a better indicator of researcher performance
Zhuo	2008	Omega	Other	Metric	Z factor	IF	Uses both the number publications and the impact factors of journals in which the ywere published.
Zou	2016	Scientometrics	Researcher	Metric	S-ZP index	IF	Metric based on journal ampact factor of publications and autho order.
Zycxkowski	2010	Scientometrics	Both	Metric	C - Citation matrix	h-index	A scheme based on version of the citation based on previous scientific achievements and authors citing the paper.
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						erie	mj.com/ on June 13, 2025 at Agence training, and similar technologies.
							nj.com/ on June 13, 2025 at Agence Bibliographique de I training, and similar technologies.

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Reporting checklist for systematic review and meta-analysis.

 meta-analysis.

 Based on the PRISMA guidelines.

 Instructions to authors

 Complete this checklist by entering the page numbers from your manuscript where readers will finder the items listed below.

 Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" an provide a short explanation.

 Upload your completed checklist as an extra file when you submit to a journal.

 In your methods section, say that you used the PRISMA Group. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement

 Reporting Item

		Reporting Item		Page Numb	÷
	<u>#1</u>	Identify the report as a systematic review analysis, or both.	r, meta-	Title page	chnologies
Structured summary	<u>#2</u>	Provide a structured summary including, applicable: background; objectives; data study eligibility criteria, participants, and interventions; study appraisal and synthe	sources;	2-3	
	For	peer review only - http://bmjopen.bmj.com/site/abou	t/guidelines.xl	ntml	

Page 69 of 72			BMJ Open	
1 2 3 4 5 6			methods; results; limitations; conclusions and implications of key findings; systematic review registration number	
7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 9 30 31 22 23 24 25 26 27 28 9 30 31 32 33 45 36 37 38 9 40 41 42 44 45 46 47 48 9 50 51	Rationale	<u>#3</u>	Describe the rationale for the review in the context of what is already known.	4-5
	Objectives	<u>#4</u>	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	5-7
	Protocol and registration	<u>#5</u>	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address) and, if available, provide registration information including the registration number.	Review protocol exists but is unpublished
	Eligibility criteria	<u>#6</u>	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rational	5-7
	Information sources	<u>#7</u>	Describe all information sources in the search (e.g., databases with dates of coverage, contact with study authors to identify additional studies) and date last searched.	5-7
52 53 54 55 56 57 58 59 60	Search	<u>#8</u> For	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated. peer review only - http://bmjopen.bmj.com/site/about/guidelines.xh	4-7, Appendix 1

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Study selection	<u>#9</u>	State the process for selecting studies (i.e., for	4-7 blishe
		screening, for determining eligibility, for inclusion in	ů as
		the systematic review, and, if applicable, for	0.113
		inclusion in the meta-analysis).	6/bmjop Protec
Data collection	<u>#10</u>	Describe the method of data extraction from	4-7 5-7 and Appendix 2 5-7 and Spendix 2
process		reports (e.g., piloted forms, independently by two	8-025; copyri
		reviewers) and any processes for obtaining and	320 on ght, in
		confirming data from investigators.	5-7 and Appendix 2 Protected by copyright, including for uses related to te Page 6-7 and Appendix 2
Data items	<u>#11</u>	List and define all variables for which data were	Page 6-7 and use 19
		sought (e.g., PICOS, funding sources), and any	Appendix 2
		assumptions and simplifications made.	nloaded fr Superieur ated to tex
Risk of bias in	<u>#12</u>	Describe methods used for assessing risk of bias	5-7 from htt
individual		in individual studies (including specification of	ata mi
studies		whether this was done at the study or outcome	/bmjopen mining, /
		level, or both), and how this information is to be	bmj.c
		used in any data synthesis.	ing, Al training, and sine and
Summary	<u>#13</u>	State the principal summary measures (e.g., risk	The primary outcom
measures		ratio, difference in means).	measure was
			methods to assess g
			research
			achievement.
Planned	<u>#14</u>	Describe the methods of handling data and	6-7 c
methods of		combining results of studies, if done, including	ie I En
analyis			seigne
	For	peer review only - http://bmjopen.bmj.com/site/about/guidelines.xh	ntml nent

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5			•			
1 2 3 4 5			measures of consistency (e.g., I2) for each meta- analysis.			
5 6 7	Risk of bias	<u>#15</u>	Specify any assessment of risk of bias that may	5-6		
8 9 10 11 12	across studies		affect the cumulative evidence (e.g., publication			
			bias, selective reporting within studies).			
13 14	Additional	<u>#16</u>	Describe methods of additional analyses (e.g.,	8-12		
15 16 17	analyses		sensitivity or subgroup analyses, meta-regression),			
17 18 19 20			if done, indicating which were pre-specified.			
21 22	Study selection	<u>#17</u>	Give numbers of studies screened, assessed for	7-8		
23 24			eligibility, and included in the review, with reasons			
25 26 27 28 29			for exclusions at each stage, ideally with a flow			
			diagram.			
30 31 32	Study	<u>#18</u>	For each study, present characteristics for which	8-12		
33 34	characteristics		data were extracted (e.g., study size, PICOS,			
35 36			follow-up period) and provide the citation.			
37 38 39	Risk of bias	<u>#19</u>	Present data on risk of bias of each study and, if	6		
40 41 42	within studies		available, any outcome-level assessment (see			
43 44 45			Item 12).			
46 47	Results of	<u>#20</u>	For all outcomes considered (benefits and harms),	7-11		
48 49	individual		present, for each study: (a) simple summary data			
50 51	studies		for each intervention group and (b) effect			
52 53 54			estimates and confidence intervals, ideally with a			
55 56 57			forest plot.			
58 59 60		For	peer review only - http://bmjopen.bmj.com/site/about/guidelines.xh	ıtml		

			BMJ Open	Page 72	open of 72
1 2	Synthesis of	<u>#21</u>	Present the main results of the review. If meta-	Not applicable to this	st published
3 4	results		analyses are done, include for each, confidence	review.	hed as
5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23			intervals and measures of consistency.		as 10.1136/bmjopen-2018-025320 on 30 March
	Risk of bias	<u>#22</u>	Present results of any assessment of risk of bias	4-5 Protect	6/bmjop
	across studies		across studies (see Item 15).	ed by c	en-2018
	Additional	<u>#23</u>	Give results of additional analyses, if done (e.g.,	ہو Not applicable to thigh	-025320
	analysis		sensitivity or subgroup analyses, meta-regression	review.) on 30
			[see Item 16]).	4-5 Not applicable to thight, including for uses 13-17	March
	Summary of	<u>#24</u>	Summarize the main findings, including the	13-17 Is a start s	2019. D
24 25	Evidence		strength of evidence for each main outcome;	related	Download
26 27			consider their relevance to key groups (e.g., health	to tex	aded f
28 29 30			care providers, users, and policy makers	(ABES)	rom http
30 31 32 33	Limitations	<u>#25</u>	Discuss limitations at study and outcome level	15-16 m ini,	o://bmjo
34 35			(e.g., risk of bias), and at review level (e.g.,	ng, Al	70
36 37			incomplete retrieval of identified research,	, trainin	nj.com
38 39 40			reporting bias).	15-16 mining, Al training, and similar technologies.	en.bmj.com/ on June 13,
41 42	Conclusions	<u>#26</u>	Provide a general interpretation of the results in	16-17 similar	
43 44 45			the context of other evidence, and implications for	echnol	025 at
46 47			future research.	ogies.	Agence
48 49 50	Funding	<u>#27</u>	Describe sources of funding or other support (e.g.,	18	Bibliog
51 52			supply of data) for the systematic review; role of		raphiq
53 54 55 56			funders for the systematic review.		2025 at Agence Bibliographique de l Enseignement
57 58 59 60		For	peer review only - http://bmjopen.bmj.com/site/about/guidelines.xh	ntml	eignement

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