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Title:

Measuring academic research impact: Creating a citation profile using the conceptual framework for

implementation fidelity as a case study

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Abstract:

The "citation score" remains the most commonly used measure of academic impact, but is also viewed as practically and conceptually limited. The aim of this case study was to test the feasibility of creating a "citation profile" for a single, frequently-cited methods paper, the author's own publication on the conceptual framework for implementation fidelity. This was a proof-of-concept study that involved an analysis of the citations of a single publication. This analysis involved identifying all citing publications and recording, not only how many times the key paper was cited within each citing publication, but also within which sections of that publication (e.g. Background, Methods, Results etc.). Level of impact could be categorised as high, moderate or low. The key paper had been cited more than 400 times and had a high impact in 25% of publications based on citation frequency within publications, i.e. the key paper was cited three or more times; and a low impact in 58% of citing publications, i.e. the key paper was cited just once. There were 41 "high impact" publications based on location of the citations, of which 35 (85%) were also categorised as high impact by frequency. These results suggest that it is both possible and straightforward to categorise the level of impact of a key paper based on its "citation profile", i.e, the frequency with which the paper is cited within citing publications, thus adding depth and value to the citation metric.

Introduction

The academic research and policy agenda increasingly seeks to measure and use "impact" as a means of determining the value of different items of published research (Wilsdon et al. 2015; Chandler 2014). However, there is much debate about how best to define and quantify impact, and it is now also acknowledged that any assessment of impact must take into account influence beyond the limited bounds of academia, in areas such as public policy(Chandler 2014; Wilsdon et al. 2015; REF 2014).Within academia, it is generally accepted that the number of times a paper is cited, the so-called citation statistic, count or score, offers the most useful and easily-measured guide to its impact(Sarli et al. 2010; Bjork and Solomon 2015; Wilsdon et al. 2015). The underlying assumption is that the cited work has influenced the citing work in some way. Such citation analysis has been more easily conducted since the early 2000s when bibliographic databases such as Web of Science and Scopus started to make available citation statistics for individual publications(Wilsdon et al. 2015). In recent years there have been attempts to understand this metric more fully, by seeking to identify factors that might predict which publications have greatest impact using this metric(Sarli et al. 2010; Ravallion and Wagstaff 2011; Royle et al. 2013). However, this metric is also viewed as practically and conceptually limited due to issues such as self-citing or reciprocal citing by colleagues(Sarli et al. 2010) and the failure to distinguish between negative or positive citation: highly-cited literature might attract attention due to controversy or even error(Wilsdon et al. 2015; Lortie et al. 2013). Nevertheless, it remains an accepted, albeit limited, measure of academic impact. Such citation scores also do not tell us how a piece of research has actually been used in practice, only that it is known and cited. The aim of this case study was to address this latter issue: to test the feasibility of creating a "citation profile" for a single, frequently-cited paper by exploring and quantifying "academic impact" based on how the key paper was being used, rather than simply whether it was cited.

Methods

This was a proof-of-concept study that involved an analysis of the citations of a single publication, the so-called "key paper". The key paper was the author's own publication on the conceptual framework for implementation fidelity(Carroll et al. 2007). This publication was chosen because it is one of the most highly-accessed articles in the journal Implementation Science and has been frequently-cited (more than 400 citations in Google Scholar). This high "citation score" might be due in part to its being a methodological publication, which was cross-disciplinary in reach, and published in a multidisciplinary journal. It therefore represented a viable case-study

publication. A systematic search was conducted to identify all citations of this key paper. This involved interrogating the three most important multidisciplinary bibliographic databases reporting citation statistics: Web of Science, Scopus and Google Scholar(Wilsdon et al. 2015; Harzing and Van der Wal 2008). These databases were selected because their coverage included some so-called "grey literature"(Rothstein and Hopewell 2009), including book chapters and academic dissertations, as well as standard peer-reviewed journals. There was no search of specific conference abstract or dissertation databases. Altmetrics were also noted. The search was conducted on 3rd November 2015. All citations were imported into EndNote reference management software and duplicates were deleted. The author then retrieved the full text of each citation.

Impact was explored by recording the frequency with which the key paper was cited within a citing publication. This was an extension of the basic "Number of times cited" metric, and represented a simple statistic, which in most cases was verified by utilising the search function to scrutinise electronic text for all instances of the citation (only 13 full-text articles were acquired in hard-copy, electronic versions were available for the remainder). Despite being conducted by a single researcher, this feature reduced the chance of errors in these data. The assumption was that the greater the number of times the key paper was cited within the citing publication, the greater its "impact". A scoping process conducted on the 50 most recent publications citing the key paper identified a citation frequency within the publications ranging from 1 to 13. For the purposes of this study, impact was categorised by simple frequency, so that a single citation of the key paper within the citing publication was considered to represent low impact (likely to be just a reference "in passing" to the key paper(Field et al. 2014)); two citations represented moderate impact; and three or more citations represented high impact (see Table 1). The result would be a "citation profile" for the key paper, which indicated the number of publications on which it had had a "high impact" and what percentage this represented as a proportion of all citing publications.

An assessment was also made to determine whether this metric was "contextually robust"(Wilsdon et al. 2015) by taking into account the location of key paper citations within the citing publications. The assumption was that citation in the Methods section is qualitatively different from citation in the Background section: the former suggests real potential influence on the design and conduct of another study, the latter suggests simple referencing "in passing". In the same way, the citation of the key paper across more than one section within a publication also suggests potentially greater impact than citation within a single section, such as the Background or Discussion. For this reason, a simple grading scheme based on citation location was developed. The impact of

the key paper was defined as "high" if it was cited within the Methods section and one or more other sections of citing publication; "moderate", if it was cited in two or more sections (excluding a Methods section); and "low" if it was cited in only one section. See Table 1. The aim was to explore whether the findings for frequency were robust when considering this additional, contextual variable.

<insert Table 1 here>

Different types of publication are structured in different ways: published primary research, technical reports and systematic reviews have a standard structure (e.g. Background, Methods, Results, Discussion, Conclusion), while study protocols do not have Results or Conclusion sections, and editorials, non-systematic literature reviews (narrative reviews) and book chapters often do not have explicit Methods sections. Assigning a location to citations in these last-named publications was sometimes difficult. Consequently, the key paper might not achieve a "high impact" in these particular publication types based on location of the citation(s). Publication type was therefore recorded. This not only enabled an assessment of whether impact differed between publication types, but also enabled further detail to be added to the key paper's "citation profile". The publication types were based on a modified version of the National Library of Medicine thesaurus (2016) (see Table 2).

<insert Table 2 here>

When full-text versions of all citing publications had been acquired, the author recorded the following data: date; publication type; the number of times the key paper was cited within the citing publication, by section (Background, Methods, Results, Discussion, Conclusion); non-English language; and whether there was self-citation. These data were recorded in Excel (the dataset is available as a supplementary file). The collected data were then tabulated and summarised. These data permitted an assessment of impact, i.e. whether simple frequency of the citations within citing publications offered a measureable metric of academic impact, and whether categories of impact (high, moderate and low) based on this metric remained robust when also taking

into account the location of the citation(s) within a citing paper. The aim was to present a "citation profile" for the key paper. The study also considered how the citation profile changed over time and by type of citing publication.

Results

The key paper had been cited more than 400 times by 3rd November 2015. Following deduplication of results from across the three databases, efforts were made to acquire the full text of all 416 unique publications. Twelve publications were unavailable to the author and 11 publications listed the key paper in their references but did not actually cite the paper within their text; these publications were therefore excluded from this study. The final total of unique publications citing the key paper one or more times within their text was 393. For details of the search process and its results, see the flowchart in the **Figure**. There was only 2/393 instances of self-citation (Carroll et al. 2010; Booth 2008) and one of citation by an author's colleague (Leaviss and Uttley 2015).

<Insert Figure here>

Publication type

The break-down of these citing publications by publication type is reported in Table 3. The citing publications mostly appeared in peer-reviewed journals (68%) rather than non-peer-reviewed literature (32%). The most frequent type of publication citing the key paper was primary research (41%), followed by narrative reviews (18%) and academic dissertations (14%).

<insert Table 3 here>

With the exception of a "blip" in 2011, the nature of the citation profile is as might be expected for standard peer-reviewed journal articles: the number of citing publications rises incrementally each year, with the greatest

increases in primary research four or five years after the publication of the key paper (see Table 4). This perhaps reflects a typical time-lag between a publication and its demonstrable impact on the published research of others (Hopewell et al. 2007).

<insert Table 4 here>

Grey literature publications, by contrast, and despite representing a smaller percentage of citing publications, achieved peaks by four or five years with comparable numbers to peer-reviewed publications, e.g. in 2011 and 2012, the numbers of citing book chapters (6 and 9, respectively) and academic dissertations (7 and 7), were similar to those for primary research (3 and 14) and narrative reviews (7 and 9). However, citations by peer-reviewed journal articles continued to increase, while grey literature citations declined or plateaued at a certain level. This might reflect the nature of research: non-peer-reviewed work is published faster, but is also more limited in distribution than peer-reviewed work (Rothstein and Hopewell 2009; Last 1995).

Impact based on frequency of citation of the key paper within citing papers

The majority of publications cited the key paper only once (58%), suggesting low impact (see Table 5). However, 25% (98/393) cited it three or more times suggesting that the key paper was having a high reported impact on those studies. The citation frequency within these studies, which might be considered to demonstrate high impact of the key paper, ranged from three to as many as 14 in peer-reviewed studies (Hasson et al. 2012) and 17 in academic dissertations (with their longer word count) (Rice 2011). Primary research studies published in peer-reviewed journals were the principal publication type across all levels of impact.

<insert Table 5 here>

It is also apparent that the key paper had its greatest academic impact on primary research studies and academic dissertations: as the citation frequency increases within publications, so the proportion of primary research increases also (from 31% of the publications with only a single citation of the key paper, to 45% of the

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publications with three or more such citations). Academic dissertations demonstrate a similar trend (increasing from 11% to 16%). Based on citation frequency of the key paper within a publication, all levels of impact increase over time (with the exception of 2015, but the data are incomplete for this year) and, in any given year, the key paper only had a low impact on the majority of the citing publications, ranging between 53% (49/93 in 2015) and 65% (8/12 in 2009) of all citing publications in a given year. Full details are reported in Table 6.

< insert Table 6 here>

Impact based on location of citations of the key paper within citing papers

Based on the location of citations, the academic impact of the key paper was categorised as low in 79% (310/393) of the citing publications; moderate in 11% (42/393); and high only in 10% (41/393) (see Table 7). This compares with 58%, 17% and 25% for low, moderate and high impact, respectively, based on frequency of citation alone (see Table 4). The metric based on frequency of within-publication citations suggested a higher impact for the key paper than that suggested by the location of those citations.

<insert Table 7 here>

The data on the principal publication types were largely similar for the location of citations as for the frequency of citations (see Table 4), with the exception of the high impact publications, which had a much higher percentage of primary research (63%), and also included study protocols.

Frequencies and location of citations of the key paper within citing publications

There was a large degree of consistency between the data on the frequency of citations within citing papers and the data on the location of these citations, especially publications categorised as "low impact". There were 310 "low impact" publications based on location of the citations, of which 230 (74%) were also categorised as low impact based on frequency (cited only once in the publication) (see Table 8). No publication categorised as low impact based on frequency was categorised as moderate or high impact by location. There were 41 "high

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impact" publications based on location of the citations, of which 35 (85%) were also categorised as high impact based on frequency (cited three or more times in the publication). These results suggest there is a relationship between the frequency of citations of the key paper and their location within the citing paper.

<insert Table 8 here>

The location-based data therefore confirms that the frequency with which the key paper is cited within a publication is a good indicator of "low" or "high" impact: it represents a "contextually robust" metric (Wilsdon et al. 2015). If "high impact" was re-defined as two or more citations of the key paper within two or more sections within a publication, rather than just three or more citations in two or more sections, which must include the Methods, then there would be even higher consistency between the metrics in terms of "high impact". There were 83 "high impact" publications based on location of the citations, of which 83 (100%) would also be categorised as high impact based on a frequency of two or more.

Other variables

Two additional metrics indicative of academic impact might be the citation of a key paper in publications in languages other than English, the principal language of scholarly publication (Van Leeuwen et al. 2001), and cross-disciplinary citation. Twenty-seven of the 393 publications (7%) citing the key paper were in languages other than English: Spanish (n=8); Dutch (n=6); French (n=4); Swedish and German (n=3 each) and Czech, Flemish and Portuguese (one each). The principal publication type for these non-English language publications were academic dissertations (n=10), followed by narrative reviews (n=6) and primary research (n=5). Cross-disciplinary citation is perhaps less relevant to this case study, given that the key paper is not discipline-specific, and this is reflected in the range of journals publishing primary research in this sample: the disciplines covered include programme evaluation (e.g. Implementation Science, Evaluation and Program Planning); medicine (e.g. British Medical Journal, Journal of Clinical Epidemiology); health services research (e.g. Health Policy and Planning, Milbank Quarterly, Trials); psychology (Applied Psychology, Contemporary School Psychology); and education (e.g. Children and Youth Services Review, Topics in Early Childhood Education); etc.. Altmetrics related to a key paper might also be useful (Wilsdon et al. 2015), but in this case the key paper only "amassed"

six tweets in terms of Altmetrics, which is low. This arguably reflects the paper's publication almost 10 years ago. However, the key paper also had almost 300 readers on the social reference-sharing site, Mendeley, and there is a possible relationship between trends on this site and future citations (Fairclough and Thelwall 2015).

Discussion

This small study aimed to provide some insight into the story behind the basic "citation score", the number of times a key paper is cited. It focused on the author's own frequently-cited methods paper to test the hypothesis that the frequency with which the key paper is cited within the citing publications, the "citation profile", might offer an easily measurable, unambiguous metric of academic impact, providing greater depth and context than the simple "citation score". It demonstrated that this generally held true for the categories of "high" and "low" impact, regardless of where the citations appeared in the citing publication and regardless of publication type. This is the first citation analysis of its kind to be published and the data suggests that frequency of citation within a publication is a potentially useful and viable measure of academic impact.

Of the 41 publications that were categorised as "high impact" based on location, 35 (85%) were also categorised as high impact based on frequency. This suggests that a within-publication citation frequency of three or more will identify the vast majority of publications in which there is clear impact on the conduct and design of another study. Of those publications with three or more citations of the key paper, approximately one third (32/98) were "moderate impact" based on location of the citations (citations in at least two sections, other than the Methods), and one third (31/98) were "low impact" (citations only in a single section (see Table 8). The location of the citations might not indicate quite the same level of impact as when the citations appear in the Methods as well as other sections, but they do still indicate high impact; the impact might simply be different. Three or more citations of the key paper appearing in the Background and/or the Discussion, for example, indicates much more than an influence "in passing"; rather they might indicate some real influence on the justification of a study or on the interpretation of its results. This consideration of the location of citations therefore supports the hypothesis that frequency of citation offers an easily measureable, potentially useful metric for gauging academic impact.

The a priori categorisation of "moderate impact" based on the citation of the key paper two times in the citing publication, or within at least two sections, was less robust than the categories of "high" and "low" impact: only a small percentage of publications (17%) cited the key paper twice compared with those which cited it once (58%) or three or more times (25%), and more than 75% of publications (32/42) that cited the key paper in two or more sections (not including the Methods) actually cited it three or more times, which is indicative of "high impact" based on simple frequency of citation. This suggests that a binary "citation profile" based simply on low impact (single citation or citation in a single section) and high impact (more than one citation across more than one section), might offer a more useful metric. By not specifying the need for citations to appear in a Methods section for "high impact" to have been achieved, this allows for a key paper to be important in another publication's rationale, and the interpretations of its results, as well as its actual study design and conduct. According to this binary "citation profile", the implementation fidelity key paper would be judged to have had a high impact on 21% of citing publications (83/393) and a low impact on 79% of citing publications (310/393). A still simpler, binary metric might be single citation vs two or more citations of the key paper within a publication: this would have generated a citation profile for the key paper of high impact on 41% of citing publications (163/393) and low impact on 59% of citing publications (230/393). However, this might exaggerate the number of publications that represent "high impact" for a key paper. Consequently, perhaps the most easy-to-measure "profile", reflecting the most robust data, as discussed above, is the figure of three or more citations within a publication. These data indicate that the key paper in this study had a high impact on 98/393 (25%) of citing publications.

The approach taken by this study addresses published requirements for responsible metrics, according to which metrics should be "robust": they should be based on the best possible data in terms of accuracy and scope, and give "breadth and depth to the otherwise narrow indicator of citation counts"(Wilsdon et al. 2015). A metric based on within-publication citation frequency is unambiguous and thus capable of accuracy, as well as being potentially more "contextually robust" than a simple metric reporting how many publications have cited a particular key paper. The assessment of where the citations appeared in the citing publications provided further contextual information and confirmed the viability of within-publication citation frequency as a metric. The reported method is reproducible and transparent (Supplementary data sheet provided) and data can be verified and updated. The study has also sought to address the issue of "diversity"(Wilsdon et al. 2015), by not only

accounting for variation by location of the citation within a publication, but also by publication type, to understand how a piece of research might be used differently in different types of publication. The result is a proposed metric of academic impact: the "citation profile". It is not a measure of research quality, nor does it seek to measure other forms of impact or to address issues such as negative findings producing relatively lower citation scores (Lortie et al. 2013). The study merely seeks to contribute to the debate about how citation metrics might be used to give a more "contextually robust" picture of a paper's academic impact.

Limitations

It is a single small case study and a single researcher conducted the searching, screening and extraction. However, the simplicity of the metric, the counting and location of a key paper's citations, minimises the risk of interpretation or error (the chance of missing one or more citations and their location in a publication). However, it is a case study of a single key paper, which had cross-disciplinary appeal – so has the potential to be cited in more than one discipline – and was also published in an Article Processing Charge (APC) open access journal; these types of journals are increasingly having the same impact as subscription journals and are certainly more visible (Bjork and Solomon 2015). There are therefore questions concerning the generalisability of the findings relating to this particular case study paper. Future research should look at three different publication types on a single topic: a methods paper, a primary research paper and a secondary research paper (e.g. systematic review), to test whether the "citation profiles" of methods papers are consistent, and to determine whether different types of publication possibly have different citation profiles. As with other bibliometrics, publications in different disciplines are also likely to have different citation profiles.

Conclusion

These results suggest that it is both possible and straightforward to categorise the academic impact of research by simply counting the number of citations achieved by a key paper within its citing publications, thus adding depth and value to the basic metric of "citation score" or the number of publications to cite a paper. It represents a simple, easy-to-understand break-down of the academic impact of a published piece of research.

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Figure: Search results


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│   Google Scholar = 423  │
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│   Web of Science =177   │
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│     Scopus = 218        │
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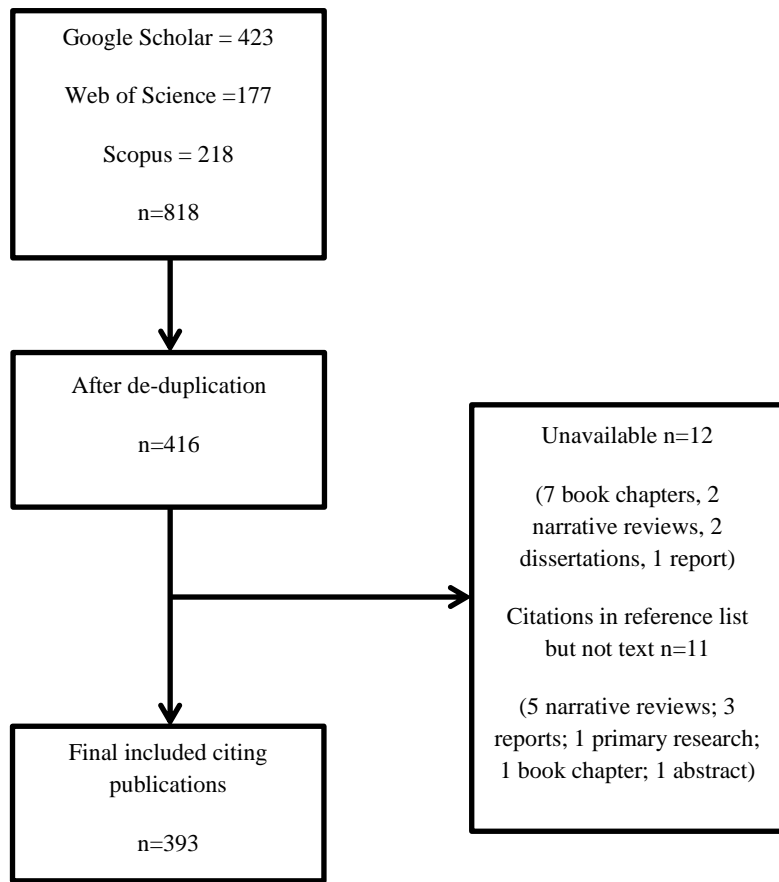
Table 1: Research impact based on frequency and location of key paper citations with citing publications:

Impact	Frequency of citation within citing publication	Citation location with citing publication
High	3 or more	Methods and other sections
Moderate	2	Two or more sections (excluding Methods)
Low	1	A single section

Table 2: Publication types

Publication type	Definition
Journal article: primary research	Original research following standard reporting structures, e.g. Background, Methods, Results, Discussion and Conclusion
Journal article: systematic review/meta-analysis	Works consisting of studies using an established method of combining the results of independent studies (usually drawn from the published literature) and synthesizing summaries and conclusions using published systematic review methods. It should be differentiated from narrative reviews of literature.
Journal article: literature / narrative review	An article published after examination of published material on a subject. It may be comprehensive to various degrees and the time range of material scrutinized may be broad or narrow, but generally is a review of the current literature.
Study protocol	A document detailing the design of a study
Editorial or letter	Work consisting of a statement of the opinions, beliefs, or policy of the editor or publisher of a journal, or other academic author
Technical report	Work consisting of a formal report giving details of the investigation and results of a … scientific problem … issued by a government agency or other official body (academic or non-academic)
Academic dissertation	Works consisting of formal presentations made usually to fulfil requirements for an academic degree
Book / Book chapter	A main division of a book, typically with a number or title

Table 3: Publication types

Publication type (peer-reviewed)	Number	Publication type (grey literature)	Number
Primary research	161	Editorial / Letter	10
Systematic review/meta-analysis	30	Technical report	18
Literature / narrative review	71	Academic dissertation	54
Study protocol	15	Book chapter	34

Table 4: By publication type: standard peer-reviewed journal article publication types

Year	2008	2009	2010	2011	2012	2013	2014	2015*	Total
Primary research	2	4	10	3	14	36	43	49	161
Systematic review	0	1	1	1	3	2	8	14	30
Narrative review	1	5	2	7	9	11	21	15	71
Protocols	1	0	2	0	0	4	8	0	15
Book chapters	0	0	1	6	9	5	7	6	34
Dissertations	1	1	4	7	7	15	10	9	54
Reports	2	0	2	4	3	4	3	0	18
Editorials	0	1	1	2	2	3	1	0	10
Total	7	11	22	28	45	77	100	93	393

*Note: Data are incomplete for 2015

Table 5: Impact by publication type based on frequency of citation of key paper within citing publication

Level of impact	Frequency of citations	Number (% of total*)	Principal publication types n (%)		
Low	1	230 (59%)	Primary research 71 (31)	Narrative review 32 (14)	Dissertations 26 (11)
Moderate	2	65 (17%)	Primary research 28 (43)	Narrative review 13 (20)	Dissertations 9 (14)
High	≥3	98 (25%)	Primary research 44 (45)	Dissertations 19 (19)	Narrative review 16 (16)
Total		393 (100%)*			

*Rounding to the nearest whole number

Table 6: Impact over time based on frequency of citation of key paper within publications

Level of impact	Number of citations	2008	2009	2010	2011	2012	2013	2014	2015*	Total
Low	1	6	8	15	18	28	44	62	49	230
Moderate	2	1	3	4	2	8	15	18	14	65
High	≥3	0	1	4	10	11	21	21	30	98
Totals		7	12	23	30	47	80	101	93	393

*Note: Data are incomplete for 2015

Table 7: Impact by location of citation(s) of citation of key paper within citing publications

Level of impact	Location of citations	Number (% of total)	Principal publication types n (%)		
Low	One section only	310 (79%)	Primary research 119 (38)	Narrative review 59 (19)	Dissertations 41 (10)
Moderate	Two or more sections (not Methods)	42 (11%)	Primary research 16 (38)	Narrative reviews 11 (26)	Dissertations / Systematic reviews 6 (14)
High	Methods + other sections	41 (10%)	Primary research 26 (63)	Dissertations 7 (17)	Study protocols 3 (7)
	Total	393 (100%)			

Table 8: Impact by frequency and location of citation(s) of the key paper within citing publications

Totals (n)	Level of impact by frequency	Level of impact by location Number (% as a proportion of total*)		
		Low	Moderate	High
230	Low	230 (74%)	0 (0%)	0 (0%)
65	Moderate	49 (16%)	10 (24%)	6 (15%)
98	High	31 (10%)	32 (76%)	35 (85%)
393		310 (100%)	42 (100%)	41 (100%)

*Rounding to the nearest whole number