

intervention. Such children are likely to have learning and behavioural problems.

In India too, BCG is given as early as possible after birth or preferably along with the first dose of DPT (diphtheria–tetanus–pertussis) vaccine at 6 weeks. This allows health provider access to children either in the neonatal period or early infancy. A similar screening programme could therefore be instituted in India using the existing infrastructure.

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Medical literature and Chinese whispers

Greenberg SA. (Children's Hospital Informatics Program and Department of Neurology, Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts, USA.) How citation distortions create unfounded authority: Analysis of a citation network. *BMJ* 2009;**339**:b2680. [doi: 10.1136/bmj.b2680]

SUMMARY

Citation of previous work helps progressive building of new scientific concepts and is an important aspect of the scientific communication and publication process. In scientific publications, citations also serve as a persuasive tool for convincing readers. Thus, a study of citation patterns on a subject over time may help in understanding how scientific knowledge on that particular subject has evolved.

In this study, the author constructed a complete citation network of all English language papers published in journals indexed in PubMed on a specific subject and analysed the citation patterns. The subject selected for this purpose was whether beta-amyloid, a protein that accumulates in the brain in Alzheimer disease, is produced by and injures skeletal muscle of patients with inclusion body myositis.

A total of 242 published papers on the subject were identified and these had 645 citations to support or refute the hypothesis. A total of 220 553 citation paths supporting the hypothesis were identified. Ten most authoritative papers (papers most often used as citations), including 4 primary data papers, 5 model papers and 1 review paper, all supported the hypothesis. The analysis identified the existence of several forms of distortions in citation. These included: (i) a citation bias against papers that refuted or otherwise weakened the causative relationship of beta-amyloid with inclusion body myositis (with 94% of all citations being made to papers with original data supporting the

hypothesis and only 6% to papers providing evidence against it); (ii) citation amplification, i.e. repeated use of citations to review papers that contained no original data on the subject; and (iii) citation invention. The last of these included several phenomena, including (a) citation of content of a previous paper but claiming a different meaning or implication for it than that in the original paper (citation diversion), (b) referring to a hypothesis generated in a previous publication as a fact by merely citing that paper (citation transmutation), (c) providing non-peer-reviewed conference abstracts as citations making these appear as peer-reviewed (back door invention), (d) supporting a claim with a citation to paper(s) which do not contain data on that claim (dead-end citation), and (e) including the words 'experimental results' in the title of a paper that does not contain any methods or results for an experiment (title invention).

In addition, the author was able to obtain 9 of 27 grant proposals on the subject submitted to the US National Institutes of Health using the Freedom of Information Act. Eight of these proposals requesting for future research funding had citation problems similar to those identified in the published literature.

These findings indicate that distortions in the use of citations in a scientific field, over a period of time, may lead to a cascading effect and result in an unfounded authority of claims and possibly a misleading belief system in the subject. Analysis of citation network may help clarify the validity of other published scientific belief systems, and help identify the existence of similar distortion of scientific evidence.

COMMENT

Except for path-breaking discoveries or absolutely novel ideas, which occur but rarely, most biomedical research is a slow, cumulative process where several studies taken together as a complex maze provide sufficient evidence to support or refute a hypothesis. Thus, each study advances the field only a tiny bit, providing a take-off point for further studies. This phenomenon

was aptly described by Sir Isaac Newton in his now famous sentence: 'If I have seen further it is only by standing on the shoulders of giants.'¹

Because of the interrelated nature of scientific literature and the dependence of scientific progress on prior knowledge, citations are an essential part of the scholarly communication process including manuscripts, grant applications, technical reports, consensus statements, etc. It is hard to think of a paper today without any citations. Citations in an original research paper serve to place the data and hypothesis work reported therein in the context of existing knowledge, whether supportive of or contrary to these. In case of review articles, citations to available information, again both supportive and critical, are woven together as a set of arguments in an attempt to provide the reader a complete overview of the subject. Thus, a review article can be looked upon as a fabric woven out of several threads, each representing a citation to a previous work, of many shades.

The presence of citations in a document provides reassurance to its readers that original scientific data to support the arguments made in it exist. In addition, it provides them access to a verifiable source to cross-check these facts or obtain further information. That the citation process is important to the advancement of science is attested to by the common perception among scientists that a highly cited paper is more important to scientific endeavour than a less-cited paper.

That the citation process is imperfect is well known.²⁻⁴ Several types of problems have been reported. First, the details provided in citations are often incomplete and inaccurate. This makes it difficult and, at times, impossible for readers to reach the primary source to verify the information cited, thereby defeating the very purpose of citation. However, these inaccuracies are often not malicious or even intentional, but are caused by lack of attention on the authors' part. Journal editors and publishers are trying to address this by verifying each citation for accuracy before publication.

Another issue is that of authors often citing their own papers in preference to those of others. This may be related to a tendency to pat one's own back, a greater familiarity with their own work than that of others, a perceived need to increase the value of one's work by citing it more often, and at times due to unhealthy competition with other research groups. This poses some problems, but still does not distort the scientific literature as much.

A more important problem, in comparison, is the use of scientifically inaccurate citations. Thus, a primary source may not say what the citing document claims it as conveying. A related problem is that of selective citation, i.e. authors of a document selectively referring to a segment of published knowledge that supports their viewpoint, either completely ignoring or downplaying the other parts that contradict it. Such citations distort the scientific record.

A few safeguards exist to prevent such misuse of citations, though these are not always as effective as one would wish. First, journals expect that their peer reviewers, being experts in the subject that the manuscript relates to, would be familiar with the literature on the subject and hence detect any major misquotations or selective citations. However, the peer-review process is by itself subjective. Whereas some reviewers look at the list of citations carefully and may even locate and read some that they are unfamiliar with, others believe that their duty stops at looking at the authors' data *per se*. Also, better reviewers may get more review requests, leading to a less hands-on policy. Second, it is expected that readers who refer to citations and find these to be

wrongly cited would write back in the journal's correspondence section. However, this too is more an exception than the norm, even though trace back of citations has become easier with electronic versions of journals carrying hypertext links to cited papers. A third measure is increasing stress on 'structured reviews' and 'meta-analyses', which use a pre-defined strategy for searching and identifying articles, and collecting data for inclusion in review articles.

If we already know that such problems exist, what does this paper add to merit this comment? The author of the paper, interestingly, looked at the extent and impact of miscitations not in individual articles, but in the entire body of literature on a particular subject. This is somewhat akin to looking at the effect of a new pathogen not on an individual but on an entire population, providing the proverbial 'big picture'. This study is novel since no such attempt has previously been made.

The author used methods based on the 'graph theory', which uses mathematical structures to model pair-wise relations between objects (here: citation and the citing paper) from a certain collection.⁵ These techniques are extensively used in social science research to study social interactions and community dynamics. In medicine, these have been used to better understand epidemic patterns of infectious diseases and in predicting the effect of various intervention measures in controlling their spread.^{6,7} In applications somewhat related to the one used in the current paper, these techniques have also been used to study patterns of co-authorship and scientific collaboration,⁸ and of the spread of computer viruses through networks.⁹

The study found that a large network of scientific literature existed on the chosen subject, namely beta-amyloid production was responsible for skeletal muscle injury in inclusion body myositis. However, this entire edifice consisting of 242 papers was based on support from only 4 papers with actual experimental data, a disproportionately small number. All the papers were from the same laboratory. Though other papers, including some from the same research group, contradicting the association were available, these were hardly ever cited in subsequent literature even by their own authors. In contrast, citations for papers supporting a relationship of beta-amyloid with inclusion body myositis were used to amplify the association by making the evidence appear stronger than it actually was. Thus, the entire belief system about the relationship of beta-amyloid with inclusion body myositis appeared to be based more on questionable evidence than on real facts.

If this study is true, it is a telling blow on the state of current medical literature. Its findings suggest that medical literature has a momentum of its own. Once a few papers supporting a hypothesis are published, these encourage a publication spree in the field, which rough rides its way, disregarding any evidence to the contrary. This is possibly because such publications serve everyone: the authors get their publications in print, the future researchers get research funding and, possibly, even the journals get to fill their pages. The reviewers who are supposed to detect these errors are either too busy or too inhibited to question. Alternatively, since they too work in the same field, they may have their own axe to grind by keeping the particular research field alive.

Based on the authors' data, it would appear that current medical knowledge is somewhat analogous to the final message in 'Chinese Whispers',¹⁰ a game in which players stand in a line and convey a whispered message successively between them. Errors accumulate unintentionally during repeated re-telling of the message, and the final version differs significantly, and often

amusingly, from the initial message. In fact, things may be even worse for medical literature, since some players in the game (such as the pharmaceutical industry) may be interested in driving the distortion in the message in a particular direction. Money is known to play a role in a similar process on the internet, where some websites try to increase their importance, by buying hyperlinks which are comparable to citations in published journals, to increase their 'PageRanks'.¹¹

This study has its limitations. The author looked at literature on only one topic; it is possible that this particular field is peculiar. He searched for only English language articles on PubMed and may have missed out some papers. Also, though robust computer programs are available for analysis based on the graph theory, some components of the analysis use subjective decisions. This being a single-author study, the author was the only arbiter for many decisions, and this may have introduced an interpretation bias; however, to his credit, he has provided information on all such decisions (published as web-only supplementary material—121 pages!).

However, despite these shortcomings, the findings warn us that a potential minefield exists and further work is needed. By showing that the graph theory and network analysis can be used to study the development of evidence on a scientific topic, the author has opened a new way for similar studies in other branches of medicine. He has also developed an orderly nomenclature to classify various types of distortions in citation, and this should be useful for future studies. It would be interesting to watch for more results.

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