■Annotation

Peer review

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The maintenance of quality and integrity in clinical and basic science research depends upon peer review. This process has stood the test of time and has evolved to meet increasing work loads, and ways of detecting fraud in the scientific community. However, in the 21st century, the emphasis on evidence-based medicine and good science has placed pressure on the ways in which the peer review system is used by most journals.

This paper reviews the peer review system and the problems it faces in the digital age, and proposes possible solutions.

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The publication of research findings is the essence of developing and improving scientific understanding. Peer review is the accepted method of pre-publication scrutiny in scientific journals. It seeks to ensure that clinicians have access to data that allow them to treat patients in the best way possible, practising evidence-based medicine, while endeavouring to avoid fraud and poor science. Several interested parties are involved in this process, each with their own requirements and expectations. Authors look to receive fair and impartial advice and the scientific community must be able to trust research findings. Ultimately the general public relies on the publication process to ensure that the best treatment is offered to them. Journals are under considerable pressure to ensure the integrity and accuracy of material they publish in order to maintain quality and the continued trust placed in them. Therefore, all aspects of the process by which scientific material is reviewed and published need to be continually assessed.

The rigour of the peer review process is by no means consistent across journals with some being very stringent and others more flexible. The process usually begins with the editor who screens submitted papers (Fig.1) using their own policy for accepting or rejecting a paper for formal review.[1] If it clears this stage, it is then passed on to relevant experts, many of whom will be on the journal's editorial board.

The reviewer is given a timeline and must look at the article in detail, identifying its strengths and weaknesses. Most reviewers learn how to review by practice rather than by instruction or training.[2] Promisingly, there is a shifting trend towards providing education in how to review, be this through dedicated papers[1-4] or by reviewers' training days, as implemented by *The Bone & Joint Journal* (*BJJ*). Journal clubs provide a useful forum for learning how to read a paper critically.

Often more than one referee will review a paper. The outcome is then communicated, with commentary and justification, to the author(s). If it is thought that the paper is of sufficient quality but requires adjustments, the author(s) have the opportunity to correct it or improve it and to re-submit. The referees may disagree on the merits of a paper, in which case the editor may either make the final decision or ask the opinion of a further reviewer.[5]

Although not claimed as perfect, the peer review process is considered the best system available to the scientific community.[6-8] In 2009 an international survey of 4000 research workers showed that 84% believed peer review to be necessary to control scientific information, although only 69% were satisfied with the system in its present form. A large majority (91%) believed that their last paper had been improved as a result of peer review.

Advantages of peer review

Peer review has clear advantages for everybody involved in the process. Authors receive specific advice from senior clinicians often leading to significant improvements in their paper. Being invited to review for a journal is considered to be an honour[9] and reviewers gain access to data before publication allowing them to keep up-to-date with advances in their field. The journals can judge interest in an article from the

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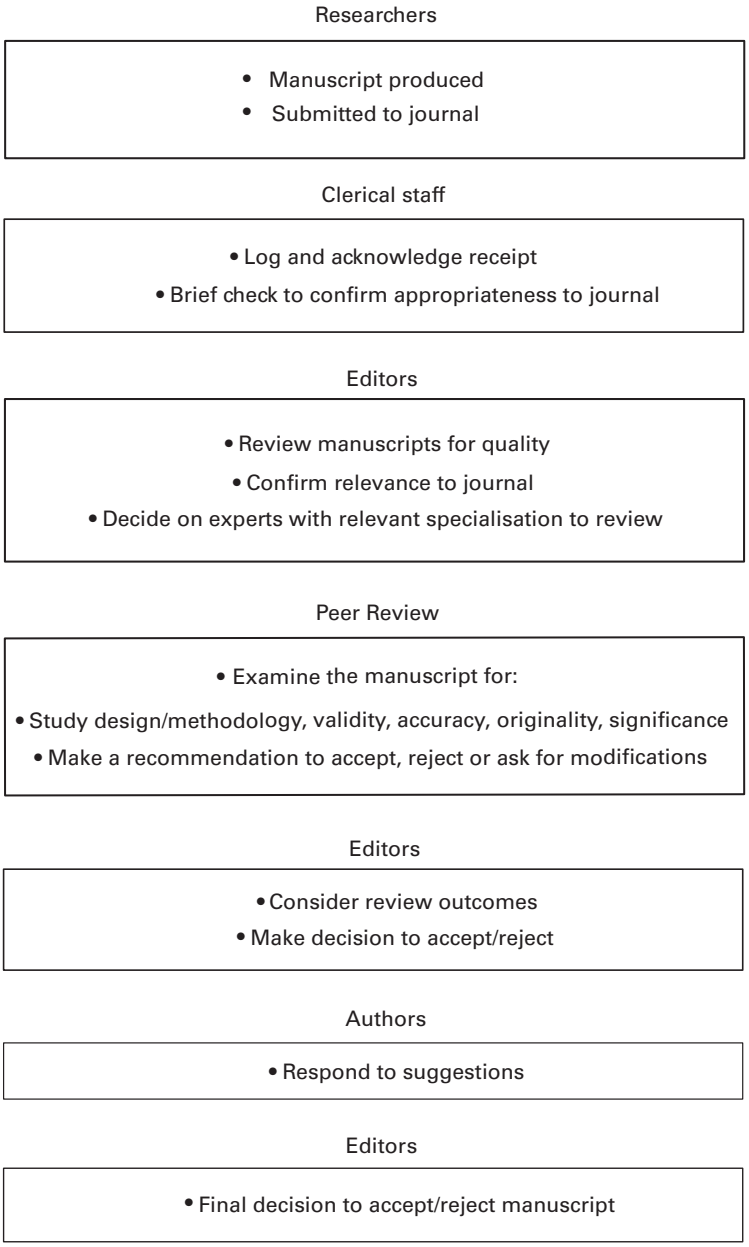

Fig. 1

The current peer review system (modified from Research Information Network[11])

reviewers' responses and thus improve their impact factor and circulation, while the detection of fraud and inaccuracies ensures the quality of the published work, protecting patients from the dissemination of false information.

Limitations of peer review

It is estimated that more than 1.3 million papers are published in peer reviewed journals each year.[10] This massive growth in activity increases the reviewers' workload and threatens the efficiency of the peer review process itself. It is a time consuming process, and the interval between submission and acceptance can be many months. The *BJJ* takes between six and eight weeks to reach a decision for most submitted papers. It is the responsibility of journals to ensure that the process is undertaken as quickly and efficiently as possible in order to allow the early dissemination of clinically relevant information.

Reviewing with an imposed deadline is hard work. It can take several hours over a number of days to consider a paper properly, looking at the appropriate literature, formulating relevant comments and coming to a conclusion.[5] Reviewers can expect no reward for the time spent, other than personal satisfaction. It has been estimated that publishing costs would increase by 45%[11] if reviewing were remunerated.

Errors can, however, be made during the reviewing process, which can result in influential papers being rejected or

Table I. The pros and cons of single and double-blinded, and open peer review.

	Double blind: ***Reviewer and author are unaware of each others identity***	**Single blind:** ***Reviewer aware of Author identity only***	**Open:** ***Reviewer and author aware of each others identity***	
			Identities only	**Fully open**
Pros	No personal conflicts No awareness of potential conflicts in ideas Juniors can be honest reviewers	Author unaware of capacity of reviewer Juniors can be honest reviewers	Biases open to public scrutiny No hidden agenda Transparent processes	Unlimited reviewer base Fully transparent process Rapid publication
Cons	No accountability No transparency Ideological bias unaccounted for No awareness of conflicts of interest Author can be identified from context/references	Reviewer may have animosity towards author. Cronyism Likelihood of abuse of power by reviewer (reviewer bias) Author unaware of reviewers background	Juniors less willing to review seniors Harder to recruit reviewers May inhibit criticism	Large number of reviews/comments Difficulty finding relevant comments Good articles/comments may be lost among others

inaccurate and fraudulent data being accepted. Examples abound of good papers having been rejected, including, for instance, that of the initial submission by Hans Krebs describing the cycle that bears his name, or the clinical trial demonstrating that lumpectomy and radiation are as effective as radical mastectomy for treating small breast cancers.[12]

The publication of false findings is very damaging.[13] A research worker was recently imprisoned for falsifying data in clinical trials.[14] It can, however, be difficult for reviewers to identify fraud. Various additions to the process have been recommended in an effort to eliminate fraud, such as the development of a formal 'risk assessment' form using a template devised by the editors. This would involve asking questions directly related to the possibility that the work may be deceptive or wrong for all papers selected for publication, thereby highlighting high risk research that would need further scrutiny. Other suggested additions include the publication of all primary data, a concerted effort to act with other high-profile journals in order to establish common standards and a clarification of responsibility to the authors.

Journals have responded to the quantity of papers which are submitted by increasing the number of reviewers available to them.[15,16] Most publish an annual acknowledgement of their reviewers, though these are seldom available online and it is difficult to find the number of reviewers currently on a journal's reviewing board. The selection of a reviewer is relevant to authors as it will have a direct effect on the outcome for their work. However, there is no transparent way in which reviewers are selected. For example, a paper published in the *American Journal of Roentgenology* showed that there was a preponderance for reviewers whose last names began with a letter early in the alphabet as a consequence to editors receiving lists of appropriate reviewers in alphabetical order,[17] they subsequently modified their practices to account for this.

The problem with large pools of reviewers within a journal was highlighted by a study in 1982 in which 12 papers that had been published previously, were resubmitted to the journals that published them. Only three were noted to be previously published material after submission, the rest were given thorough review and were rejected on the grounds of methodological failures rather than plagiarism.[18] Cloud based software that can automatically scan large databases of manuscripts, such as CrossCheck (CrossRef, Oxford, United Kingdom),[19] have helped to reduce the incidence of direct, word-for-word plagiarism. The determined fraudster, however, will always find a way to fool computer systems.

Also complicating the reviewer's task is the increasing sub-specialisation of all medical fields. A reviewer looking at a paper may have the appropriate knowledge to address most issues discussed in that paper, but science and medicine are multidisciplinary and the reviewer may not be equipped to discuss all of the aspects of a paper.

Reviewer bias

Brand[3] reported that the hardest task a reviewer faces is to attempt to be free of all biases. It is especially problematic in the face of original research whose findings challenge current practice. A classic example is the rejection of Galileo's theories in the early seventeenth century as they clashed with contemporary beliefs. It may be hard for reviewers to accept papers that threaten their knowledge, prejudices or beliefs.

Blinding

Two types of blinding may be used: single or double-blinding (Table I). In single-blinding, the referee's identity is hidden from the authors. In double-blinding, both are hidden from each other.[20] Single blinding is more common in the sciences and double blinding in the humanities and social sciences.[11] The trend is shifting towards single blind reviews, and it seems that higher impact journals tend to favour this. In a survey of the practices of editors in orthopaedic journals, 70 journals were approached and of the 42% that responded, 52% used a double-blind review process.[21] Interestingly, 89% of editors had the power to overrule the decisions of the reviewers.

The main argument for pursuing double-blinded reviews is the freedom it gives reviewers to fully appraise and critique a paper without fear of repercussion. It also helps to reduce favouritism and bias, as the author is unknown to the reviewer. Several reports based on reviewer surveys have shown that reviewers think that making themselves known to the author would discourage them from being critical or from reviewing altogether.[11,22,23]

Despite blinding, reviewers can sometimes identify the author or at least the institution,[24] through the writing style, subject matter, opinions put forth, referenced articles or the practicalities of anonymising a submitted manuscript. The accuracy of guessed identities on blinded reviews in a variety of disciplines ranges between 25% and 42%.[24,25] Several authors have reported that blinding does not affect the quality of reviews, and that quality is more likely to be based on the word count than the blinding.[26-28] This has been attributed to the premise that those papers which would most benefit from blinding are the hardest to conceal as the authors would be well-known or reveal themselves through the references.[28] In two randomised controlled trials, Van Rooyen et al[29,30] reviewed the effects of blinding on the quality of reviews. In the first,[29] 113 papers were sent to two reviewers randomised with either the identity being revealed or masked to authors. They found that the only outcome of revealing the identity of the reviewer was a higher likelihood of the reviewer declining the submission, but this had no apparent effect on the quality of the review. In the second,[30] they followed 467 papers and randomised them as to whether the reviewers were blinded, unblinded or unaware of a study taking place. Two referees were then randomised to review the papers, one receiving a blinded version, the other unblinded. The reviews were then assessed with a validated instrument[30] based on seven items (importance of research question, originality, methodology, presentation, constructiveness of comments, substantiation of comments and interpretation of results) scored on a 5-point Likert scale, it was found that it made no difference to the quality of the review whether the authors' identities were revealed or not.

Innovations

In the last two decades, technology, specifically the Internet, has greatly influenced developments and innovations. The technological community has embraced these developments quickly and promoted the concept of 'openness'. With publications being 'open' there has always been concern that quality would be jeopardised as anyone able to access the document could change the content. In December 2005, a paper in *Nature* reported similar rates of error in information in the *Encyclopaedia Britannica* and *Wikipedia*.[31,32] The advantage that *Wikipedia* had over *Britannica* was that all the errors found in *Wikipedia* were corrected within days.[33] Furthermore, *Britannica* only contains 65 000 papers from 4000 contributors compared *Wikipedia's* 3 890 000 articles and 751 426 contributors.[34]

Open pre-publication

Giving open access to scientific material is not new. In the late 1980s the physics community had a multinational list of email addresses, collated manually, to which papers were distributed before publication allowing specialists to review, comment and support submissions. In 1991 this was formalised as the website 'arXiv'[35], described as a 'pre-publication' database which has become immensely popular and noted as a success by the UK government in the Science and Technology Committee.[36] It has since expanded beyond physics to include many mathematical and scientific disciplines.

However, there remain disadvantages with this system. Not all papers will be reviewed as appropriate or reviewers may not be forthcoming. Papers that are reviewed and commented on are not guaranteed publication in a peer-reviewed journal, although some papers are considered influential and remain as 'e-prints', never being published in a peer-reviewed journal,[37] but are still cited. There is also the possibility that fraudulent or inaccurate data may find its way into databases and then circulated into the scientific community.

Another concern is that of intellectual property or data theft, although once a database is available online, it serves as evidence of originality in itself. All data stored on the database are covered by a Creative Commons licence.[38]

Open review

Opening up the review process may have a great impact on the quality of material that is published. There are varying degrees of 'open review'. The simplest has been used by the *British Medical Journal* since 1999,[39] whereby reviewers identify themselves and declare any conflict of interest. They are not, however, revealed to the readers at publication. One of the fears was that the reviewers would be reluctant to sign their name to the review, but in practice this appears to be unfounded. A trial reported in the *British Journal of Psychiatry*[40] in 2000 showed that 76% of reviewers were happy to reveal their names, an increase of up to 70% on previous studies. Signed reviews were also significantly more positive and supportive compared with comments in unsigned reports. The only drawback was the significant increase in time taken to complete signed compared with unsigned reviews.

There have been experiments in opening up the review process by journals, most notably *Nature*'s Open Peer Review experiment in 2006.[41,42] Over a period of four months, they gave authors submitting papers the option to join the open process. A total of 1369 papers were submitted, but the authors of only 71 (5%) agreed to enter the trial. At the end of a complex online procedure calling for open comments, there was poor involvement of authors and reviewers in the project. The journal concluded that for the moment they would not implement open peer review.

A new online initiative Cureus[43], still in the beta stage of development, defines itself as "leveraging the power of an online, crowd-sourced community platform". It is an

exclusively online journal with open reviews. Any visitor can register with the site and comment on submitted articles or submit formal 'reviews'. Each paper then receives a 'Scholarly Impact Quotient' as a score of validity based on these open reviews and comments. Currently, most papers have few comments or reviews, and most comments consist of non-productive or simply encouraging remarks. Each reviewer is rated in order to monitor the quality of their reviews. As yet, it has limited validity as a journal, limited editorial input and no impact factor.

Discussion

Peer review has served the scientific community well over the last 100 years. Medical journals and their editorial staff should consider refinement to their current processes to ensure that they remain effective.

The ability to assess the quality of papers in the scientific literature is clearly fundamental to good practice as a surgeon. Yet, aside from relatively informal journal clubs, which have waned in popularity in recent years, little attention is given to this during the training of junior doctors and most reviewers still learn to review by practice.

Although the recent curriculum for Trauma & Orthopaedics (2013) in the UK includes in its syllabus that a trainee should "understand research methodology including qualitative, quantitative, bio-statistical and epidemiological research methods" and "develop critical appraisal skills and apply these when reading literature", little is currently done to formalise teaching in this essential skill or to provide practice. It would be of benefit to the scientific community and to trainees if the reviewing of papers could be formally taught, with papers to practice on. This should then be expanded to include a requirement, perhaps as a work based assessment section that would necessitate a given number of papers to be reviewed in a year. Co-operation between journals and the Intercollegiate Surgical Curriculum Programme[44] would be required. This would give an opportunity to those who have not been able to practise these skills during their training.

Newer methods of crowdsourcing and peer review may show potential in some disciplines. The accurate review of new work requires the engagement of expert reviewers, a task which peer review performs well in its current form. The addition of many outside, non-expert voices to the process would simply further delay and cloud the purpose of the process. It is important to remember that, by its very nature, peer review needs to be carried out by clinicians who have busy practices, in order to have gained the expertise to do so effectively. It is they who we look to, to continue to find the time to dedicate to this endeavour.

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