

A review of the review process: manuscript peer-review in biomedical research

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Abstract

Editorial peer review has remained the gold standard for evaluation of scientific research for nearly two centuries. Its importance has increased all the more due to the currently prevailing 'publish or perish' culture. This article reviews the drawbacks in the current peer-review practices and the suggested methods to overcome such drawbacks. A universally acceptable method of peer-review is yet to be designed because of the practical difficulties in the objective analysis of a complex human behaviour such as the peer-review.

Keywords: Peer review, reviewer bias, research misconduct.

Introduction

In this age of 'publish or perish' philosophy, the quality and quantity of scientific output have become vital for the continued survival of researchers. Biomedical journals play a vital role in the dissemination of new information among researchers and students (Lundberg 1998; Vandenbroucke, 1998). The prestige of the journals depends on the quality of the articles and peer reviewers play an important role in quality control. The prestige of the journal is an important factor influencing the authors' choice of the journal for submitting manuscripts (Swan, 1999). Publication in a peer reviewed journal as an important criterion for the admissibility of scientific evidence in courts of law (Goodstein, 2000). Though the peer reviewers and editors have managed to handle their responsibilities well in most instances, there are problems in certain areas that have attracted considerable attention among researchers.

The goals of this article are to review – 1) the available literature on the drawbacks of the traditional peer review process in biomedical research; 2) the methods that have been adopted for improving the existing peer review process; 3) the alternative methods of peer review that have been tried recently; 4) the challenges in peer review research.

Literature search was done through websites such as Pubmed, Google Scholar, Wikipedia, HistCite and electronic publication resources belonging to the American Medical Association, British Medical Journal, Annals of

Emergency Medicine, FASEB, National Institutes of Health, World Association of Medical Editors, Publishing Research Consortium and Council of Biology Editors. In addition, web sites of open access publishers such as Biomed Central, PLoS (Public Library of Science) and certain journals belonging to them were searched for peer review policies. Journals from which information has been obtained belong to one of the 5 categories – medical journals, science journals, psychology journals, management journals and journals related to publication. The medical and science journals convey the information on peer review from the perspective of biomedical professionals, whereas, other 3 categories of journals represent a different perspective.

Traditional peer review and its problems

The prepublication peer review practice of today has evolved since 18th century and not much has changed since then (Kronick, 1990; Burnham, 1990, <http://resources.bmj.com/bmj/pdfs/rennie.pdf>). Current opinion is that manuscript peer review is a process involving decisions on selection and improvement of manuscripts submitted to a journal. Process of selection involves filtering out the manuscripts with "irrelevant, trivial, misleading or potentially harmful content". Process of improvement involves improving the "precision, clarity, transparency, accuracy, validity and utility" of the selected manuscripts (Jefferson et al., 2002). Peer review has become the subject of intense study in the last 2 decades and the opinions concerning its utility have differed. While to some, peer

review is a “non – validated charade”; to others it “is one of the sacred pillars of the scientific edifice” (Horrobin, 2001; Goodstein, 2000). The problems of the traditional peer review process can be divided into 3 groups – problems in selection of the articles and problems in improvement of the selected articles, problems involving time, money and labor.

Problems in selection of articles

The aim of selection process is to reduce the burden of poor quality research on the volume of scientific literature and to facilitate the publication of good quality research. Current peer review process is obviously not helping to do this. The reasons are as follows.

1) *Inability to detect fraud* – The function of detecting ‘veracity’ is notably absent in all the definitions of peer review. Peer review can ensure that a study is important, useful, relevant, methodologically sound, complete and accurate but it cannot ensure whether a study is fake or real! Authors who provide them with ‘false cues’ such as large sample size, complex procedures, statistical significance and obscure writing can hoodwink reviewers (Armstrong, 1997). Examples of failure of peer review include publication of 2 fraudulent papers by Hwang Woo-Suk concerning stem cell research in ‘Science’, publication of 15 fraudulent papers by Jon Hendrik Schön in ‘Nature’ and ‘Science’ and the publication of “Maharishi Ayurveda” hoax in the JAMA (Kennedy, 2006; <http://www.jyi.org/features/ft.php?id=330>; <http://www.aaskolnick.com/naswmav.htm>).

2) *Inconsistency in preventing publication of truthful, but poor quality research* – One of the main problems with selection is the lack of consistency which could be internal (inconsistency in the reviews by the reviewers of same journal) or external (inconsistency in standards of review by different journals catering to the same specialty). Peer review process within a single journal is often not according to standardized protocol and is idiosyncratic with poor inter reviewer agreeability (Rothwell and Martyn, 2000; Cicchetti, 1991; Fiske and Fogg, 1990). Cicchetti’s study showed that referees agree more on rejection than on the acceptance of articles in broad specialty journals whereas in the specific sub-specialty journals agreement was more on acceptance than rejection (Cicchetti, 1991). This internal inconsistency has led to publication of mediocre articles even

in prestigious journals of high standing. On the other hand, peer review has often rejected genuine path breaking research worthy of the Nobel Prize! Examples include seminal research by Sir Frank MacFarlane Burnet (1960) concerning antibody response, Baruch Blumberg (1976) on the Australia antigen and viral hepatitis, Rosalind Yalow’s work on radioimmunoassay (1977), Stanley Cohen (1986) on growth factors, Louis J Ignarro (1998) on the role of nitric oxide and many others (Campanario, 2009; Kilwein, 1999).

A study that has been rejected by one peer-reviewed journal might be published by some other journal (external inconsistency). Studies have shown that 50% or more of articles that are rejected by major biomedical journals are published in other journals of lesser impact within 2 to 3 years (McDonald et al., 2007; Armstrong et al., 2008; Ray et al., 2000). Manuscript considered unworthy of publication by one set of peer reviewers is considered worthy by another set of reviewers.

3) *Inability to distinguish content from writing* - Shashok has referred to these as expertise in judging an article based on content criteria and writing criteria (Shashok, 2008). Non-English speaking authors often have valuable hypotheses or data but lack the linguistic skill to present them in a persuasive manner (Misak et al., 2005). Peer reviewers who do not distinguish between contents and style of writing may reject manuscripts by these authors.

4) *Susceptibility to bias* - Bias such as gender bias, patriotism and linguistic preference have been known to affect peer review. Studies have shown that reviewers from the U.S have a significant preference for U.S papers. When U.S reviewers have reviewed articles from outside the U.S, preference has been shown towards authors from English speaking countries and articles from prestigious academic institutions. Older reviewers in senior faculty positions have been shown to down play the contribution of juniors (McLellan, 2001; Lloyd, 1990; Wenneras and Wold, 1997; Link, 1998; Kliever, 2004; Peters and Cesi, 1982). The anti-French sentiments in the U.S after the French veto of U.S military action in Iraq was thought to have spread to scientific publication also. The editors and peer reviewers acted as conduits of such sentiments (Bégaud and Verdoux, 2001; Shashok K, 2004). Address bias refers to articles from prestigious institutions being more readily accepted than articles from

lesser-known institutions (Gannon, 2007). Publication bias refers to the bias towards allowing publication of articles declaring positive results (Dickersin, 1990; Easterbrook et al., 1991). Confirmation bias refers to the tendency of reviewers to reject articles that do not fit in the framework of existing knowledge of their disciplines (Nickerson, 1998; Mahoney, 1977).

5) *Susceptibility to unethical practices* - Rennie says that peer reviewers being human, may be "partial, biased, jealous, ignorant, incompetent, malicious, and corrupt or incapacitated by conflicts of interest" (<http://resources.bmj.com/bmj/pdfs/rennie.pdf>). The main ethical problems with peer review include conflict of interest and plagiarism of manuscripts.

a) Conflict of interest - Peer reviewer is usually a researcher in the same field as the author and may be tempted to delay publication of a rival or find fault with a rival's effort. Reviewer may be less critical of research from collaborators and of research involving a product in which he or she holds a personal interest (http://opa.faseb.org/pdf/FASEB_COI_paper.pdf).

b) Plagiarism - Reviewers could abuse the 'inside' information they gather during review process. The reviewer may reject a good study on minor grounds of technicality and use the same data to publish a similar study himself (plagiarism of ideas by reviewers) (Cantekin, 1990; Marshall, 1995; <http://grants.nih.gov/grants/guide/notice-files/not93-177.html>). It is said that "as the pressures on researchers grow – bureaucracy from institutions and funding agencies, incentives to apply the outcomes of research – the very motivation to do a conscientious job of peer review is itself under pressure" (Anonymous, 2007). Anonymous peer review has been labeled as 'power without accountability' and as 'malice's wonderland' (Rennie, 1998; Osmond, 1983). Referees themselves may be competitors in the intense competition for scarce resources (research funds or space in top quality journals). Goodstein fears that the situation will only worsen with time as more and more authors who have received unfair reviews will become reviewers in future and propagate the erosion in ethical standards (Goodstein, 1995).

6) *Suppression of new ideas* – The history of biomedical research is replete with examples

of trivializing attitude towards new ideas and inventions (Barber, 1961; McCutchen, 1991; Horrobin, 1990). Nobel Laureate Rosalind Yalow has remarked, "The truly imaginative are not being judged by their peers. They have none!" (Yalow, 1982) Reasons for suppression of new ideas are as follows.

a) Hostile review - Discouragement of a hostile, condescending peer review may inhibit the author from re-submitting the article, especially young authors in their early academic career (Boice and Jones, 1984; Benos et al., 2003). Harsh reviews generate defensive reaction from the authors, precluding objectivity in their response to the reviews (Rindova, 2008). Reviewers may choose to be harsh and negative in their style in order to be perceived as more intelligent or competent by the editors, thereby generating higher esteem from editors (Amabile, 1983; Glenn, 1982).

b) Closed mind set - Peer reviewers may be susceptible to tubular vision and closed mindset. A randomized controlled trial by Resch et al showed that reviewers displayed significant bias against unconventional treatments (Resch, 2000). Reviewers tend to believe data that fall in line with the existing paradigms beliefs. However, science has so far progressed through shifts in paradigms of knowledge when new ones replace existing beliefs (Kuhn, 1970). Repetitive mediocrity is encouraged by the closed mindset of reviewers (Stehbens, 1999).

c) Elitist culture - This may develop in small, specific fields with few researchers and the elite group may control publications according to their own philosophy (Keally, 2006). Reviewers tend to be respected authors in the same field and they tend to agree with authors whose conclusions are similar to their own and disagree with authors whose conclusions contradict their own beliefs (sacred cows versus stupid cows?).

7) *Vulnerability of authors* – The traditional peer review process is based on the central premise that referees are more competent than the authors (Badeian, 2003). It also expects the authors to comply with all the changes enforced by the reviewers, so much so that the author's individuality of writing may be lost through multiple rounds of review to satisfy the reviewers (Frey, 2003). For many reasons, the editors usually tend to side with the reviewers than authors, leaving the author defenseless against the whims of the reviewer.

Ashforth says that in the traditional review process the “scales are tipped decisively in favor of the reviewer” (Ashforth, 2008).

Problems in improving the quality of selected manuscripts

Opinion has differed with regard to the second goal of peer review concerning the post selection improvement of the articles. While some authors have expressed that peer review does not add much value to the quality of a scientific paper, others have felt that peer review induces substantive changes to the manuscript before publication (Abbey, 1994; Enserink M, 2001; Purcell et al., 1998; Lock, 1994; Yankauer, 1985; Goodman et al., 1994; Roberts et al., 1994; Wager and Middleton, 2002; Pierie et al., 1996). The feedback from different reviewers may be conflicting and cause more confusion to the authors.

Horton considered that expertise is required in two areas to improve manuscripts – expertise in the subject and expertise in language (Horton, 1995). When the author is not able to understand whether the reviewer is commenting on the contents or the writing style, the revisions made by the authors may not improve the manuscript at all. At present, it is felt that the ability of the peer review to improve the factual content of a manuscript may be better than its ability to improve the writing style (Shashok, 2008). While the peer reviewers are acknowledged experts in their subjects, the same expertise cannot be assumed of their language skills (Burrough-Boenisch, 2003). A survey among medical writers (who help the authors to prepare manuscripts) reported that around 33% of peer reviewer comments on the writing style were unhelpful in improvement of the manuscript (Shashok, 2008). The peer reviewer's insistence on rephrasing certain sentences may actually lead to distortion or decreased impact of the original arguments by the authors (Aalbers, 2004). Authors may resign themselves to accepting these undesirable changes to get their articles accepted (Lillis and Curry, 2006).

Problems related to time, money and labor

1) *Delay in publication* – The process of peer review consumes a lot of time, thereby leading to a prolonged lag time between manuscript submission and eventual publication (Laufer, 2007). Delay in publication is said to decrease interest in publication among authors (Swan, 1999; Garfield, 1986). Majority of the authors

would be happy if the time taken for is around 30 days as against the average 80 days at present (PRC, 2008). Time for review has reportedly ranged from 30 to 810 minutes (Snell and Spencer, 2005). Reviewers for medical journals spend an average 5 hours per review (spread over many days) and it is said that spending more than 3 hours per review is not probably essential as it does not increase the quality of review (Snell and Spencer, 2005; Black et al., 1998; Cicchetti, 1997). Delay might deprive the authors of priority over research and publication. In principle, a journal should authenticate ‘priority’ of an article by publishing the date of receiving the initial manuscript, date of receiving the revised script if revision has been made and date of acceptance of the article. However, not all journals publish these dates.

2) *Cost of the process* – Peer review involves significant amount of correspondence and even though the reviewers are not usually paid, the transactions add to the cost. Peer review reportedly cost the British Medical Journal around £ 1.5 million per annum according to the figures released in 2002 (Rowland, 2002). Peer reviewing costs reportedly account for 10 to 30% of the first copy costs of the article (http://www.welcome.ac.uk/stellent/groups/corporatesite/@policy_communications/document_s/web_document/wtd003184.pdf).

3) *Difficulty in finding reviewers* – There is a scarcity of good quality reviewers and the existing ones are overloaded (PRC, 2008). Lack of time is probably the main reason for reviewers declining to review (Tite and Schroter, 2007). *Scalability* (ability to increase in scale or size) is a major problem with traditional peer review process. Its ability to cope with the increasingly large number of submissions to journals is questionable.

Improving the existing peer review process

If peer review is accepted as the basis of the respectability and authority of science, it is mandatory that the review process is made as flawless as possible. Table 1 lists the characteristics of good reviewers as suggested in literature (Laine and Murlow, 2003; Estrada et al., 2006). The FAITH model of peer review proposed by Turner consists of Fairness, Appropriate selection of reviewers, Identifiable and publicly accountable reviewers, Timely review and Helpful critical commentary (Turner, 2003). Authors desire a favorable review but at the same time, do not want a

superficial review (Nickerson, 2005). The common causes of author dissatisfaction include reviewers misunderstanding the manuscript, reviewers missing the vital points of the manuscript, condescending review, lack of constructive criticism and rejection with little explanation (Bartels et al., 2009). One report has suggested that better quality reviewers tend to be younger, have a lower academic rank, belong to strong academic institutions, have previous research training, have postgraduate qualifications and are well known to the editors (Evans et al., 1993).

Relman has stated “despite its limitations, we need it. It is all we have, and it is hard to imagine how we would get along without it” (Relman, 1990). Since there are no easy alternatives, it would be useful to improve what we have. Of course, one alternative is to get rid of peer review completely. However, this may allow grossly poor quality research and increase the noise to signal ratio in scientific literature much more than what it is now (Wyer, 1978). It may also lead to situations that are more embarrassing to the journals than the ‘Schon affair’ and the ‘Hwang Woo-Suk affair’. Eric Berger draws our attention to the “Sokal affair” that embarrassed a journal called ‘Social Text’ (Berger, 2006). The vulnerability of peer review process to defects has attracted the attention of the U.S Supreme Court which introduced a caveat in its ‘Daubert standards of scientific evidence’ that the peer review is not an unequivocal criterion of admissibility of scientific evidence in the courts of law (Daubert v. Merrel Dow, 1993). Many studies have suggested improvements but none has bettered what Ingelfinger suggested years ago – “despite deficiencies, the reviewing system is important to maintain standards. It could be improved if studies of its operation were carried out, if reviewers were indoctrinated, if the work load of reviewers were lessened, if reviews were signed, and if the reviewing process were more rewarding to reviewers” (Ingelfinger, 1974).

An ideal peer reviewer would be unbiased, objective, prompt, mindful of the requirements of the author, editor and the reader in addition to being versatile in five knowledge domains – in-depth knowledge of the subject, knowledge of designs of experimental and clinical trials (and some idea of statistics), knowledge of language, knowledge of ethical aspects of research and knowledge of methods to enhance the communicative power of the script (rhetoric). Such an “supernatural”

character does not exist in reality (Ingelfinger, 1974).

Attempts to enhance the quality of existing review process can be grouped as follows –

1) *Proactive editorship* - Editorial inaction tends to compound the flaws in peer review. An editor should not be just a ‘rubber stamp’ that legitimizes peer reviewers passively (Baker, 2002). Efficient editors (Anonymous, 1999) can tackle significant proportion of the review errors, abuses, incompetence, delay and biases. A comment reported by the PRC survey was that good editors use peer review system well and it is “the less able who follow reviewer comments uncritically bring the system into disrepute” (PRC, 2008). Table 2 lists the characteristics of proactive editors (Cooper, 2009; Tsang and Frey, 2007; Schwartz and Zamboanga, 2009).

Concerning re-reviews, if the author has responded to all the queries by the reviewers, editors should take decision regarding publication proactively. Repeated juggling of the article between the authors and reviewers is time-consuming and it is felt that iterative review does not improve the manuscript very much (Cooper, 2009; Tsang and Frey, 2007). The Journal of Biology of Biomed Central has embarked on an experimental policy of allowing authors to opt out of re-review. If the author opts out of re-review, the manuscript that has been revised once will be published after screening by the editorial staff (Anonymous, 2009). Criticism against it is, of course, less quality control.

Editors of the Croatian Medical Journal have set an excellent example of author – friendly policy (Marusic et al., 2004). One of the editors reads the manuscript first and if it is deemed worthy of further consideration, the editor himself acts as an “intra mural peer reviewer” and suggests improvements to the authors. Only after the authors submit the revised script, external reviewers send it for “extramural” review. If the script survives this review, the technical editor, language editor and the production editor further improve it in sequence.

2) *Increasing the appeal of peer review* - Peer review could be made attractive in certain ways. Paying the reviewers is one option but it is usually not possible due to funding restrictions. Other options include awarding CME points for review work, giving consideration for academic promotions and

tenure, giving complementary journal subscriptions, giving discounts on memberships and conventions, offering positions such as associate editors or editorial board members to good reviewers and acknowledging their invaluable assistance by publishing their names at frequent intervals (<http://www.wame.org/wame-listserve-discussions/managing-peer-reviewers>). Surveys have shown that reviewers do have altruistic motives for their job and most reviewers welcome non-financial incentives much more than financial incentives (Snell and Spencer, 2005; Tite and Schroter, 2007).

3) *'Blinding'* – Blinding has been used to minimize chances of biased reviews. Single blind peer review can be of 2 types – 'blind-author' type where the reviewer knows the identity of the author and the author does not know the identity of the reviewer and converse of this – the 'blind reviewer' type. The good aspects of 'blind author' type of review are as follows. The reviewers can compare the author's new manuscript with his earlier work to ensure that the new work represents real progress. It helps to spot conflicts of interests of the authors easily and to stimulate the reviewers to ask pertinent questions (Anonymous, Nature editorial, 2008). The disadvantage is that only reviewers can question while the author cannot. In double blind peer review, both the reviewers and authors remain anonymous to each other. In triple blind peer review the authors, reviewers and editors are blinded to the identity of each other (Tharyan and Adhikary, 2007). However, there is conflicting evidence on whether blinding increases the quality of peer review (McNutt et al., 1990; Black et al., 1999; Labland and Piette, 1994; Davidoff, 1998; Ross et al., 2006; Cho et al., 1998; Godlee et al., 1998). Studies have shown that many manuscripts, though 'blinded' contain hints to unmask the authors. Self-referential writing and small research fields have been considered to be the most common reasons for failure of blinding (Cho et al., 1998). Authors should be instructed to avoid self-referencing style of writing. Benos et al advocate a soft ware to detect self-referencing phrases (such as 'we have shown' or 'we have earlier described') to alert the editor to the possibility of unmasking (Benos et al., 2007).

4) *Enlisting the help of language professionals* - Benfield has suggested that peers can work with language professionals to improve the quality of articles written by authors whose first language is not English (Benfield, 2007). As

Shashok has suggested, young peer reviewers should be provided with opportunities to work with word face professionals (medical writers, translators, author's editors) and academic literacy researchers to improve and streamline the linguistic skills of the reviewers (Shashok, 2008). Academic literacy researchers deal with methods of improving the written communication. It is heartening to see the recent perception of some journal editors that high quality research can overcome the language barrier and rejections based on language problems should no longer be a major cause of manuscript rejection (Ehara and Takahashi, 2007; Anonymous, Biol Conserv editorial, 2008). Since authors from developing nations are under represented in international literature, Phyllis Freeman and Anthony Robbins, co-editors of the Journal of Public Health Policy, introduced the concept of 'Author AID' in 2004 (Freeman and Robbins, 2006). It consists of web-based programs that provide editorial assistance to researchers from developing countries in the task of manuscript preparation. Senior researchers from developed nations as well as authors' editors participate in these programs as mentors of the researchers.

5) *Training potential candidates in the art peer review* - Training the reviewers in the art of peer reviewing may help to a certain extent. Wider usage of online reviewer accreditation courses has been suggested (<http://resources.bmj.com/bmj/reviewers>; <http://www3.us.elsevierhealth.com/extractor/graphics/em-acep/index.html>; <http://www.wame.org/syllabus.htm#reviewers>). A survey of reviewers has shown that most reviewers welcome formal training in the review process and facilitation of interaction with fellow reviewers regarding manuscripts and feed back from the editors about their own review as well as reviews from other reviewers (Snell and Spencer, 2005). Studies have suggested that short term training packages and feedback to the reviewers has little benefit on the quality of the reviewers (Callaham et al., 1998; Schroter et al., 2004). The effect of long-term training remains to be observed. Training should educate the reviewers to distinguish the actual content from the language of the presentation and comment separately. In this age of increasing scientific misconduct, education of reviewers in academic ethics is important.

6) *Setting up agencies to address grievances of authors and reviewers* – It has not been easy to investigate cases of possible abuse by

reviewers. Peer review has been a concealed process and editors have insisted on maintaining the confidentiality of the peer review related correspondence. With the increase in electronic publication, many journals now put up the 'prepublication history' of the manuscript on their web site. COPE (Committee on Publication Ethics) is a U.K based charity established in 1997 whose members (around 5200 at present) are mostly chief editors of scientific journals from all around the world. It investigates any complaints of malpractice from authors, reviewers or editors (http://publicationethics.org/files/u2/Forum_Agenda.pdf).

Alternative methods of peer review

Since the percentage of articles rejected, far exceeds the percentage of articles accepted by the journals, Ginsparg feels that it is a "hopelessly paradoxical and inefficient effort to devote the majority of time to the material that won't be seen" (<http://people.ccmr.cornell.edu/~ginsparg/blurb/pg01unesco.html>). As Forsdyke has suggested, improving the traditional peer review can be compared to evolution in biological animals, which has always been slow, inefficient and carries forward the baggage of the past mistakes for long periods. Revolution is better than evolution in achieving a better system quickly (Forsdyke, 1993). Several alternative models of peer review process are being tried at present.

Open peer review – Fabiato's paper in 'Cardiovascular Research' was one of the earliest to support the concept of open review (Fabiato, 1994). In open peer review, both the authors and peer reviewers know each other. This is said to make the reviewer more accountable and avoid hidden conflicts of interest. It also gives credit for the reviewer's efforts.

Walsh et al conducted a randomized controlled trial about open peer review that concluded that "signed reviews were of higher quality, were more courteous, took longer to complete than unsigned reviews" (Walsh et al., 2000). In addition, signed reviews were more often associated with recommendation to publish. However, a randomized trial by van Rooyen et al found that open review had no effect on the quality of review, the time taken for review and the recommendation regarding publication but significantly increased the likelihood of

reviewers declining to review (van Rooyen, 1999). As far as the preference of the scientific community, surveys have concluded that around 56 to 70% of authors as well as reviewers still favored double-blinded peer review model (PRC, 2008; Regehr and Bordage, 2006). Some editors do not favor double open review as it "tends to select against incisive critique" (Editorial in 'Nature Cell Biology', 2005). It also increases the reluctance of many reviewers to take up reviews. They fear controversy, negative publicity and possible retribution from authors of rejected articles especially if the reviewer is relatively junior in hierarchy (Garfield E, 1986; Ingelfinger J, 1974; <http://www.nature.com/nature/peerreview/debate/nature05535.html>).

Open peer review without suppression of publication – This was introduced in the journal 'Biology Direct' launched by 'Biomed Central' in 2006 (<http://www.biology-direct.com>). The author chooses reviewers from a panel of reviewers pre-selected by the editors. The author can either revise the article in response to the reviews or publish it without revision. Reviewers critique and identity is published along with the article (including the negative comments). In this system, reviewers cannot suppress ideas just because they disagree with them. Some journals belonging to the open access publishers 'Biomed Central' and PLoS (Public Library of Science) display the 'prepublication history' of each paper (submitted manuscripts, reviewer's critique and author's responses) along with the published article.

Post publication review – Electronic publication has facilitated this type of review greatly. In fact, the changes in culture as well as the purview of peer review are closely linked to changes in technology, starting with typewriters and carbon papers through printing and photocopying to the present age of electronic publication (Spier, 2002). A group of researchers from the U.K advocated post publication review in 2006 who started an online journal called 'Philica' (<http://www.philica.com>). In post publication review of the 'Philica' type, all articles are published immediately and anonymous or open peer review takes place after the article is published. The editors do not choose reviewers but anyone who wishes to review the article can do so. Reviews are displayed at the end of the article and readers can use the reviews for guidance regarding the quality of the article. A problem of using post publication

review as the sole method of review is that, following publication the authors may not have sufficient inclination or motivation to respond to the criticisms. Studies have shown that author response to reader criticisms have been rather low in post publication reviews. Quality control is not enforced in this kind of refereeing (Horton, 2002; Bingham and van der Weyden, 1998). Secondly, if the topic of the article is off the main stream and not very interesting, no one may provide a peer review!

Hybrid system of peer review - This is a combination of traditional peer review with post publication review (Suls and Martin, 2009). In Smith's words, "publication is not the end of peer review process but a part of it" (Smith, 2006). Traditional peer review may either precede or follow post publication review. Post publication review occurs *after* traditional peer review in some established journals (such as the BMJ). The manuscript undergoes traditional peer review followed by publication. Readers to which the author is given the chance to respond in print allow post publication review in the form of open peer-commentary and letters to editor.

Online journals such as Atmospheric Chemistry and Physics (ACP) allow post publication review *before* traditional type of review (<http://www.atmospheric-chemistry-and-physics.net/review/index.html>). After submission, the editorial board screens the manuscript for major defects and provided such defects are absent, the paper is posted on the web site of the journal, inviting signed or anonymous reviews from other researchers. Editorial staff for content and language screen reviews. After 8 weeks, the manuscript can be submitted for traditional peer review. If accepted, the paper is finally published along with the pre-publication history. In life sciences, some journals of Biomed Central (<http://www.biomedcentral.com/info/about/peer-review>) and PLoS (Public Library of Science, <http://www.plosone.org/static/guidelines.action#postpublication>) follow this hybrid type of review process.

CARMA (Community-based Assessment of Review Materials) – This variant of hybrid review was suggested by Carmi and Koch (Carmi and Koch, 2007). Following submission, anonymous peer review happens, but the article is published online with the full pre-publication history and post-publication review by the readers is also allowed. The identity of the reviewers remains concealed.

Dynamic peer review - Electronic publishing has facilitated post publication peer review by allowing comments to be posted anytime after publication. Web sites such as 'Naboj' dedicated purely to peer review have been created to allow researchers to write peer reviews on articles published in the preprint media (<http://www.naboj.com>). Review process in this site is a continuous process (dynamic peer review). Authors to establish priority of publication by the authors can use preprint servers and reviewers would be wary of plagiarizing, as the scientific community already knows the work before the peer-reviewed version appears in print. This also helps to avoid time lag between manuscript submission and eventual publication that occurs in the traditional review process. An example of preprint server is the 'arXiv' developed by Paul Ginsparg in 1991 and widely used by physicists (<http://www.arXiv.org>). After pre-printing their work, the researchers can send the papers to standard peer reviewed journals.

Author suggested peer reviewers - The practice of 'author suggested peer reviewers' has been used by several journals recently, in an effort to allay the anxiety among authors concerning bias and unfair rejection. Few studies have been published on this subject. Earnshaw et al reported that reviewers selected by the editors of the 'British Journal of Surgery' were more critical than those chosen by authors especially in the criticism of scientific importance of the script and the decision to publish (Earnshaw et al., 2000). Rivara et al found no differences in quality of review and time taken for review but author suggested reviewers were more likely to recommend acceptance or revision of the manuscript (Rivara et al., 2007). Schroter et al reached similar conclusions and went on to suggest that editors can be confident about the quality of the reviews by author suggested reviewers but should exercise caution about recommendations for publication (Schroter et al., 2006). Wager et al found that author suggested reviewers tend to recommend acceptance at earlier stages of manuscript appraisal but the acceptance rates between author suggested and editor nominated reviewers are similar at the final stages of review (after the authors have responded to reviewers' comments) (Wager et al., 2006).

Author initiated peer review - Kaplan has suggested an 'author initiated peer review' system (Kaplan, 2005). He has called for separation of the two components of peer

review (selection and improvement) and allotting each component to different sets of reviewers. At first, the author sends manuscript to colleagues or friends to do the 'improving' job. After improvement of the script, the author sends it to 2 or 3 independent reviewers to assess the technical content (selection component) and write reviews on the suitability for publication. The script is then sent along with the reviews to the editor of a journal who will decide on publication. While the system has many advantages for authors, the down side is the possibility for manipulation since authors control the peer review.

Adversarial model of peer review - An adversarial model of peer review has been proposed wherein the reviewers are called upon to act as adversaries of the author and to make all efforts to refute the claims of the author (Bornstein, 1991; Finke, 1990). The author submits a reply defending against the critique by the reviewers and the editor is the judge who will decide the fate of the article after hearing both sides of the argument. The reviewer would be careful, as he knows that the author would be refuting his criticisms. The reviewer is not a friend or confidante of the editor in this system. The authors and reviewers are on the opposite sides of a level playing field (like prosecution and defense lawyers). This system needs a confident, proactive and authoritative editor to act as the judge.

Peer review consortia - The Neuroscience Peer Review Consortium (NPRC) is an interesting development in the peer review process (Saper et al, 2009). It was conceived at a conference of the editors and publishers of neuroscience journals in 2007. The consortium permits the authors of manuscripts rejected by a neuroscience journal in spite of supportive reviews, to send their scripts to another member journal of the consortium along with the reviews of the first journal. This has been thought to speed up the review process and reduce duplication of work for editors and reviewers.

Each method has its own advantages and drawbacks. The British Academy Report of 2007 stated that "there is not one single model of good practice that all should follow, but there are principles that good peer review should follow, namely timeliness, transparency and verifiability. These principles cannot guarantee the identification of the best quality work on a fair basis, but without them, quality

and fairness will suffer" (<http://www.britac.ac.uk/reports/peer-review/>).

Challenges in peer review research

Kassirer and Campion wrote in 1994 that peer review is indispensable despite being crude and understudied (Kassirer and Campion, 1994). Fifteen years later, the numbers of articles on peer review have exceeded 200 per year, but peer review continues to be a mystery (Berger, 2006). Even though a lot has been written about peer review, most of the articles have been reviews, editorials, opinions and retrospective studies. Few prospective randomized trials have provided conflicting evidence. There is scope for improvement and the JAMA and the BMJ have led the research on peer review by holding peer review congresses once every 4 years, the first congress held in Chicago in 1989 (Rennie, 1986). Truly valid randomized study of peer review in health care research would be a large-scale project, where the articles are divided into 2 groups – articles published after peer review and articles published without peer review. A long-term follow up should compare the two groups for the impact of the articles in their contribution to improvements in health care (8). Since such a trial is very difficult in practice, other methods have come into place. The problems that peer review research need to overcome are as follows.

1) *Difficulty in defining outcome variables* - Attempts have been made to introduce outcome assessment instruments to 'measure' peer review (Landkroon et al., 2006; van Rooyen et al., 1999). Direct outcomes of peer review such as *importance of the article* (in its impact on future of science) and *comprehensibility of the article* do not easily lend themselves to objective measurement. In the absence of defined outcome measures, most of the studies on peer review have used proxy or surrogate process-based outcomes (inter-reviewer agreeability, reviewer bias, effect of blinding etc) as indirect indicators (Wager and Davidoff, 2002; <http://resources.bmj.com/bmj/pdfs/overbeke.pdf>). As far as the importance of the article is concerned, the 'impact factor' and other citation statistics have been around for quite some time but they are influenced by multiple factors apart from the quality of the article (Seglen, 1997). Further advances in 'scientometry' should improve this situation (Hobbs and Stewart, 2006). Regarding comprehensibility of the articles, the goal of separating peer review process into

assessment of content and the assessment of language has been identified. However, widespread awareness of this goal has not yet been observed in actual practice. Academic and word face research has contributed significantly to the understanding of the second goal, namely language of the script (Shashok, 2008).

2) *Uncertainty as to who are the best judges of the reviewers* – is it the editors, authors or the reviewers themselves? As far as author perceptions are concerned, studies seem to suggest that author satisfaction is associated with acceptance but not with the quality of the reviews (Weber et al., 2002; Gibson et al., 2008; Garfunkel et al., 1990). Gibson et al reported that authors and reviewers differed in their perception of the most important aspects of the manuscript. In addition, authors' ratings of reviewers did not correlate with the ratings of reviewers by the senior editors of the journal studied (Gibson et al., 2008).—Whether they liked the peer review or not, most authors of rejected manuscripts have utilized the reviews to modify their manuscripts before submitting to another journal (Garfunkel et al., 1990).

3) *Different expectations of peer review process by different groups* – The poor peer reviewer has to balance the expectations of the editors, authors and readers and remain agreeable to all (http://www.councilscienceeditors.org/editorial_policies/whitepaper/2-3_reviewers.cfm). Goals of the peer review themselves are variable from journal to journal but researchers tend to make generalized assumptions. Some journals want to publish only cutting edge research and have a low threshold for rejection on the grounds of novelty where as other journals are mixed bags of original studies, reviews and reports. The goal of selection dominates in the former journals whereas the goal of improvement dominates in the latter journals (Anonymous, 2009).

4) *Complex nature of mental activity* – Peer review activity represents the abstract nature of human psychological endeavor and research within one branch of science may be insufficient to unravel its mystique. Collaborative research involving fields such as biomedical sciences, psychology, sociology, linguistics, management and other social science specialties may be useful in enabling a more objective understanding of the peer review process. So far, studies on peer review have ignored the value of inputs from collateral disciplines on the 'mind set' of reviewers. A

good development is that some presentations at the sixth international peer review congress (September 2009) have focused on this issue (<http://www.ama-assn.org/public/peer/peerhome.htm>).

Conclusion

Until universally acceptable alternatives are available, traditional peer review continues to hold sway in scientific research. It has many supporters still, as evidenced by a large scale global survey of over 3000 academics by PRC (Publishing Research Consortium) in 2008, in which, over 80% of academicians felt that peer review is required for quality control (PRC, 2008). Peer review research is now beginning to look into areas of human behavior such as psychology and management to gain further insight into the behavior of reviewers. Peer reviewers are just one part of the whole philosophy of scientific publishing which needs to change from being a 'game of numbers'. Emphasis on quality rather than quantity of publications (for faculty appointment, promotion and research funding) would reduce the burden on the peer review system and perhaps reduce many of its problems (Angell, 1986; <http://www.hms.harvard.edu/integrity/scientif.html>).

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Table 1: Characteristics of good peer reviewers.

<p>Good reviewers –</p> <ul style="list-style-type: none"> ● behave as a polite ‘scholarly friends’ instead of being a ‘nitpicking fiends’ disrespectful to the sentiments of the manuscript writers ● direct their criticisms towards the manuscript and not the author ● temper their criticisms with suggestions for improvement ● do not give undue importance to minor flaws and focus on the content, validity and relevance of the article ● finish their review in reasonable time ● are not vague in their criticisms; they offer specific instances in support of their criticisms. If the novelty of the study is questioned, evidence of earlier published studies is provided by the reviewer ● will <i>not</i> convey different messages to the author and the editor ● offer constructive criticisms even when they are not recommending publication of the manuscript ● do not stop with just the assessment of the subject and the language of the manuscript; they provide the authors insight on how persuasive their arguments are ● are neither “assassins” who destroy manuscripts nor “zealots” who push extra hard for their publication (Siegelman, 1991) ● go into the process with the understanding that the goal is to be helpful to the editor and fair to the authors without being unduly critical (Bordage et al, 2001) ● do not force their own preferences and biases on to the authors, there by becoming anonymous coauthors of the manuscript (Diener, 2006) ● maintain a balance between quality control and encouragement of innovation (Horrobin, 1990)
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Table 2: Characteristics of proactive editors.

<p>Proactive editors -</p> <ul style="list-style-type: none"> ● triage the manuscript soon after submission and will not waste time of reviewers and authors by sending articles unsuitable for publication by the journal. ● provide check lists for peer reviewers to make the review more systematic and to minimize over sight errors (Bordage et al., 2001; Seals and Tanaka, 2000) ● maintain quality control of reviewers on their panel by sending them regular news letters and testing them with mock papers every now and then (Benos et al., 2007) ● send to reviewers copies of the reviews made by fellow reviewers so that they can compare their own work with those of their peers ● rate the quality of the review using a numerical or non numerical scale (from poor to excellent) ● obtain feed backs from their authors at regular intervals regarding the quality of the peer reviews and the time taken for it ● add their opinion of the articles to those of the reviewers ● indicate to the authors as to which points raised by reviewers are mandatory to address and which are optional ● advise the reviewers not accept the job of reviewing if they feel that they are not the best persons to do it ● advise the reviewers not to hide any potential conflicts of interest and if it is there, to avoid reviewing that article ● send manuscripts for peer review only once or twice on rare occasions ● publish dates of receiving and accepting the manuscripts so that authors are not deprived of priority even if the peer review process delays actual publication ● provide written feed back to the reviewers (but some studies have shown that this does <i>not</i> improve the quality of reviews (Callaham et al., 2002)
