



Information Access and Scholarly Communication in Post-publication Peer Review Online Social Networks

Citation

Lapinski, Paul Scott. 2021. Information Access and Scholarly Communication in Post-publication Peer Review Online Social Networks. Master's thesis, Harvard University Division of Continuing Education.

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Information Access and Scholarly Communication in
Post-publication Peer Review Online Social Networks

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A Thesis in the Field of Legal Studies
for the Degree of Master of Liberal Arts in Extension Studies

Harvard University

May 2021

Abstract

Since the late 20th century, scholarly communication, academic publishing and information exchange have migrated almost entirely online. Evaluating recent medical publications with a critical eye towards an author's research methods, data reproducibility and conclusions is a vital stage within the scholarly communication workflow. Publicly available post-publication peer review networks are essential tools in fostering an online forum for scholars to provide commentary on and to debate and augment the most recent published research.

PubMed Commons was launched in 2013 by the National Institutes of Health and established an online community of medical and health science scholars to contribute post-publication peer-reviews to citations indexed within the PubMed literature database. The NIH expressed both satisfaction and disappointment at various times throughout the four year experiment, but on short notice in February 2018, the PubMed Commons service was permanently shutdown.

This thesis explores the online community that was PubMed Commons, and uses qualitative and quantitative methods to analyze the corpus of retrospective data that tracked the online contributions shared by the members. This research will address the following questions. How have online post-publication peer-review networks demonstrated success or faced challenges in sustaining an online community towards the goal of evaluating, augmenting and furthering the published scientific record? Was

PubMed Commons deficient in these ways? What strengths did PubMed Commons offer that may have been overlooked before the decision to shut down?

This study will evaluate the full corpus of publication and comment data that was discussed in the four year term that PubMed Commons was active. A bibliometrics analysis of the articles will demonstrate common themes and publishing trends that prompted members to engage in post-publication review. Additionally, a random sample of 155 comments was evaluated and tagged to assess each review for its level of constructiveness, impartiality, objective aims, and timeliness. Interviews were held with several former members of PubMed Commons, and their feedback will be summarized in context. The results demonstrate a highly engaged and active community, and call into question why the PubMed Commons system was deemed unsuccessful.

Acknowledgments

This thesis project began in earnest during January 2020, only a short time before the World Health Organization declared COVID-19 to be a global pandemic. College towns, libraries, campus buildings and academic events would soon be shut down in March of that year. The on-campus social life that had been so essential in providing students with a sense of community, motivation, and focus... all this, would pause for a time and shift to an entirely virtual experience for the rest of the year and into 2021. Study routines were disrupted, dormitories emptied out, and the entire campus student population was to remain home. These would be only minor disruptions compared to what would happen next in the lives of so many, as family members and friends soon faced greater challenges depending on the eventual impact the virus had on us all.

For so many of us who needed to continue pushing forward on our thesis research during this unprecedented academic year, the familiar identity of our college campus and the routine late-night study among classmates at the library was sadly missing from this final year of the graduate student experience. However, this time was also uniquely special in so many positive ways that cannot be fully described here. I am extremely grateful to Professor Ann Blair for her constant guidance and support throughout this project. Also, to my closest friends who have been a part of this longer journey and shared the road from time to time; Yan, Piya, Taeko and Carolin, thank you all for your sincere friendship, imparting your wisdom and advice, helping to keep me on track, and providing that extra source of strength and encouragement when I needed it the most.

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Chapter I

Introduction:

Peer-Review and Scholarly Communication

The volume of medical information, expanding at fantastic rates, threatens to drown even the most conscientious practitioner who devotes every waking hour of every day to collecting, cataloguing, and assimilating it. Advances in information technology can both fuel the information explosion and contain it.¹

Online social networks which facilitate peer-review are essential tools for navigating contemporary scholarly communication. Within academic publishing, peer-review has a long history of providing a necessary assessment mechanism for journal editors and readers to approach scholarly articles with an element of confidence and trust. This is not to say that readers should be expected to immediately agree with the authors of an article simply because peer-review was part of the process, but the reader will have a reasonable expectation that peer-review conducted on the paper has ensured that it has met certain editorial standards. Over the course of time, a journal's name and reputation will become associated with a predictable set of standards, editorial decisions, and preferences. For the journal to achieve recognition and respect from the audience it hopes to reach, pre-publication assessment of manuscript submissions is an absolute requirement. Conventional wisdom safely presumes that the peer-review process will have weeded out any papers that were not ready for publication for reasons that might range from a weak written presentation to flawed research methodologies. However, the process of journal facilitated peer-review, even when working perfectly, represents a response to a specific

¹ Pon et al., "Information Technology in Critical Care," 75.

article at a specific point in time. That point-in-time, for traditional peer-review facilitated by journal editors, often occurs at a stage well before publication and distribution. By design, the pre-publication peer-review process will begin to evaluate manuscript submissions months if not over a year before an article is finally printed in the journal. While pre-publication peer review adds substantial value through its efforts to maintain research integrity, protect the journal's reputation, and monitor ethical publishing standards, the system is inherently time consuming. Scientific articles have a limited shelf life, and the time consumed by pre-publication assessment can have a negative impact on the immediate utility of the research by the time it is finally published. Increasingly authors are posting their work online before the peer-review process is complete in order to give it the earliest and greatest possible impact. Scientific journals are producing and distributing content exclusively online at ever increasing rates. Whether or not an article is available as a pre-print, it is always important to consider how relevant, accurate, or impactful the article remains post-publication. Where does a reader find a trusted network that continues to assess the published scholarship of yesterday?

Post-Publication peer-review is a response to this need, and an essential component to the continuous research lifecycle of scholarship. But whereas there has been much attention paid to pre-publication peer-review in the scientific process, post-publication peer review has not received much attention. Historians speak of studying the reception of a publication, by gleaning the responses of near-contemporary readers in manuscript sources (e.g. letters and marginal annotations entered in books), and published ones. The latter include articles, pamphlets or other books (especially numerous in cases of controversy) and the book review which emerged in Europe in the late 17th century as the principal content of many of the periodicals which emerged then. Today post-publication peer review takes place online and within digital platforms

allowing readers to evaluate, communicate and record their responses to a specific article using “today’s” perspective. These responses add to our understanding of science in the making and leave a record of an article’s reception that will be valuable to historians too. Yet, facilitating post-publication peer review faces special challenges and limitations.

Unlike the pre-publication peer review network of experts who are carefully selected by journal editors, the publishing industry has little incentive to build a cohort of post-publication peer reviewers. While journal editors will act quickly when errata or retractions are necessary, they are unlikely to coordinate a network of post-publication peer reviewers to continually evaluate the articles that their editors have already refereed and published in the past. Updates to past publications are already accommodated within the journal publishing cycle, as ongoing manuscript submissions will invariably comment on earlier publications via citations, review articles, and opinion pieces. Furthermore, the next wave of new manuscript submissions will also go through the same pre-publication peer review process. In other words, the reviewing process is continuously operating within the traditional journal publication format. And that process can accommodate a critique of a recent article, by the further publication of an opinion piece, letter or editorial in a subsequent issue which allows readers to debate the merits and/or editorial decisions that were given to the questionable paper. A post-publication peer review network within the journal itself may seem less valuable than providing these standard reader-response publishing opportunities. Scholarly journals will generally provide sections devoted to commentary, thereby permitting readers to voice disagreement, concerns or praise for recent articles. Those new publications, whether comments, editorials, or review articles, each bring their authors the usual range of rewards associated with publishing in the journal literature.

On the contrary a system of post-publication peer review that lies outside the control of the originating journal would bring none of the rewards of formal publication. On the other hand a well operating system could provide feedback and responses in a more dynamic way—with faster and more direct interaction between reader and author. However, there are similar controls that should be present in both pre- and post- publication peer review systems if a consistent standard is to be maintained. Most importantly, for post publication reviews a coordinated recruitment effort is needed to find reviewers with the appropriate expertise to review articles after publication. Whereas a journal publisher is motivated and well placed to administer these controls on pre-publication peer review, the publisher has no incentive to facilitate post-publication peer review. As a result other means are necessary to create a crucial element of trust into a system of post-publication peer-review that functions outside the journal publishing system. There are strengths and weaknesses in both pre- and post-publication peer review, as well as benefits and distractions to both reader, reviewers and authors (see table 1).

Table I

Traditional Pre-Publication Peer-Review

Pros	Cons
• Editor selected experts in the field • Quality filter identifying well researched scholarship • Assess authors' success in answering the research question • Assess research methods were appropriate and/or valid • Correct weaknesses in language/grammar • Tighten up argument and presentation • Create stronger, lucid & concise article • Reviewer anonymity provides a shield from retaliation • Less pressure of exposing ones own ignorance.	• Anonymity allows potential biases and competitive motivations to remain hidden. • Pre-publication review process inherently slow and delays publication • Opinions of pre-publication reviewers represents a single point in time...before publication date. • Comments and reviewer reports historically hidden from readers

Post-Publication Peer-Review

Pros	Cons
• Foster discussion of previously published literature and discuss in a current context • Revisit article to expand/update with new data and/or references over time • Authors have opportunity to quickly respond to questions, clarifications and updates to their article • Opportunity for multiple authors and reviewers to continue a dialog on the article's impact, merits or weaknesses • Opinions of post-publication reviewers dynamically entered at any point in time after publication.	• Anonymity allows potential biases and competitive motivations to remain hidden. • Participants may have no expertise in the areas they claim to critique. • Unfacilitated nature of online post-publication peer-review risks quality control, and questionable level of trust • Requires more effort of the reader and author to evaluate the substance of the reviewer's critique. • Little (or no) editorial facilitation on who reviews to what

Addressing the Published Scientific Record Publicly & Transparently

In its ideal form, post-publication peer review expands the researcher's knowledge on the published scientific record. Post-publication peer review could be broadly defined to include any expert opinion that constructively comments on a previous publication. However, to systematically build trust and ensure academic integrity within a scholarly network devoted to post-publication peer review, the definition needs to go further. The response needs to add something to the reader's understanding of the original paper. Therefore, the contribution by the post-publication peer reviewer would need to take some tangible form that could be indexed and discovered by other researchers. Unlike pre-publication peer review which is often a private dialog between author and reviewer, post-publication peer review offers information beyond those two parties, and presents opinion in multiple formats that other readers could then learn from. Possible formats include a recorded lecture, a published commentary, a review article, or a substantial blog posting, to name just a few. Furthermore the format of that response needs to be linked clearly to the original article under discussion. The original citation of the article needs in turn to be connected to the post-publication peer-review comment. It is important that the post-publication review and the citation clearly connected to one another, e.g. by a direct hyperlink, or by embedding the review within the database record for the source article. Discoverability from scholarly article to post-publication peer-review is essential to this workflow. Very few tools have been able to make this interlinking possible given the proprietary nature of the interfaces developed by content providers and the publishing industry. To date, only one publicly funded major journal citation database has integrated a post-publication peer review system within a unified tool, PubMed Commons.

PubMed Commons was an effort lead by the National Library of Medicine (NLM) and the National Center of Biotechnology Information (NCBI) to integrate an online scholarly discussion forum within the PubMed database of biomedical and health science literature. As part of the National Institutes of Health (NIH) the NLM provides public access to the PubMed database which indexes over 6500 medical journals. From 2013 until 2018, PubMed Commons existed as an online social network facilitating post-publication peer-review within the PubMed database to. Access to the PubMed database, and the ability to search and discover medical citations and abstracts is available to anyone with an internet connection. Likewise, any comments or reviews about a publication posted by the PubMed Commons community would be publicly visible on a PubMed citation record. Membership within the PubMed Commons community was strictly limited to authors of scientific papers, and member were not permitted to participate anonymously.

Pre-publication peer review involves a measure of anonymity: in double-blind reviewing the editor serves as a trusted broker ensuring that neither author nor reviewer knows the other's identity, yet both trust the system as a whole. In post-publication peer review, there are benefits when the reader is open and transparent about their identity and credentials; however, an anonymous review can also present unique benefits, if (as in the case of double-blind reviewing) assurances about credentials are present elsewhere in the system. Just as in journal facilitated pre-publication peer review, anonymity has benefits that allow for greater freedom of speech with less fear of retribution from the original author. Whether pre- or post- publication, the peer-review system by definition promises that the reviewer is a peer in this area of scholarship. If the reviewer remains anonymous, the peer review system must include a transparent mechanism that assures the reader that some oversight was involved to vet the expertise of the peer-reviewers.

Journal facilitated anonymous peer-review has become so well integrated into the scholarly publishing process that it operates pervasively and invisibly to the readers of the journal itself. The anonymity present in pre-publication peer-review has become a norm in the traditional journal publishing industry. The assumption and expectation that quality peer-review is occurring within any product that calls itself a “scholarly journal” has given rise to many online publications that have profited from this belief. Predatory publishers and scam journal operations have successfully built a multi-billion dollar industry which has duped countless authors (and readers) who have adhered to that misperception. Post-publication peer review offers a valuable opportunity to flush out weak work that appears within the glut of online publications that may or may not have gone through rigorous peer review.

How can a model that facilitates post-publication peer review assure readers that the reviewers are qualified to assess the scientific publications? In the pre-publication peer review system, a journal’s imprimatur has built up that level of trust over a long time of producing impactful scholarship without making their reviewers’ names known. This concern will be no different when engaging with a post-publication peer-review, but there will be greater challenges to establishing trust in the anonymous reviews when journal imprimatur is absent from the process. Creating a system of post-publication peer review is necessary to ensure that the assessment is more than just an uninformed comment posted on a random blog by a nameless individual. Just as a familiar peer-reviewed journal has built trust with its readers and a reputation for quality, similarly a system of post-publication review can only be successful if it can demonstrate parallels with the peer-review process established by scientific journals.

Online technologies over the past twenty years have created extensive opportunities for new forms of publishing, new methods of sharing scholarship, and new social networks that

facilitate user driven communities around every topic imaginable. It is not difficult to find many responses and counter claims to almost any research topic known to science on the open web. The ease with which anyone can set up their own professionally designed journal online has indeed given rise to many vanity press operations, deceptive journal scams and hack writers promoting fraudulent science and conspiracy theories. In the free-for-all that online information and online commentary enjoys today, it is all the more difficult to determine which publications are legitimate let alone what is an expertly informed post-publication response. Broadly defined, post-publication peer review can and does exist in these open spaces and can be of great value if one can trust the source of the posting. Clear examples exist in blog postings by leaders at the NIH which draw attention to the strengths (or weaknesses) in the recent findings published in recent issues of *The Lancet*, *Nature*, *JAMA*, and others. The ability to freely comment within high quality online journals like *PLoS One* sets a new standard in providing a forum for scholarly engagement alongside the journal article itself.

The growth of post-publication peer review in the online environment is encouraging but its potential still remains underutilized. There is at the moment no system for identifying reviewers and pro-actively soliciting contributions into a trusted online post-publication peer review forum and the incentives to foster it are elusive. What is lacking in post-publication peer review is a coordinated effort to facilitate these activities. Journal editors are able to identify relevant experts in the field and to offer professional incentives that motivate university faculty to volunteer their time as a pre-publication peer-reviewer. Given the many forms of online publishing and the exponential growth of information distributed via internet technologies, developing an incentivized post-publication peer review network would benefit by a similar structure of editors and incentivized recognition for the contributions one makes into the online

forum. Doing so would provide continuity in both pre- and post- publication peer-review process which is an essential part of the scholarly communication life cycle.

Open Science and Open Post-Publication Peer Review

Scholarly communication is most apparent within the ecosystem of research, journal publishing, citation, access and dissemination. In the open web, scholarly conversations and intellectual debate are recorded within an ever-increasing number of online forums. Online journals have occasionally integrated a commenting option for readers to share responses directly below the online version of an article. Pre-print repositories of unpublished working papers (such as arXiv and biorXiv) encourage open peer-review and feedback to be shared publicly as part of the item record. However, post-publication peer-review networks begin with the reviewer choosing what specific scholarship needs to be revisited.

How have online post-publication peer-review networks demonstrated success or faced challenges in sustaining an online community which remains impactful towards the goal of evaluating, augmenting and furthering the published scientific record? Again, the PubMed Commons system hosted at the NIH and the National Library of Medicine provided an open online communication forum for scientists and allowed publicly visible commentary on any citation record within the PubMed database of biomedical literature.

Open post-publication peer-review forums are one of several avenues that provide future researchers with essential critique and assessment of scholarship in an environment where it is becoming ever more challenging to sift through vast amounts of online content that may or may not have received high-quality and/or unbiased peer-review. The experiment that was PubMed Commons was deemed to have been “unsuccessful” in early 2018, due to its low participation

rate. One of the main critiques of PubMed Commons from the earliest days of its inception was that it required contributors to be authors on some paper that was published and indexed within the PubMed database.² Anonymous participation in the discussion forum was not allowed. A number of other restrictions and rules may have constrained potential members from participating at all, but the fact that the authors were required to contribute without anonymity offered an extra layer of authenticity (and/or credentialism) for the reader to consider. The benefit of such a service, even with these requirements, was that it created an open post-publication peer-review forum which had the potential to expand upon the published scientific record. However, after nearly five years of activity, participation was not as high as the NIH expected. For this reason, the decision was made to cancel the service completely, which seemed to go against the objectives of the NIH's own public access policy and open science initiatives more broadly.

While other online scholarly forums exist, and popular social media platforms like Twitter and Facebook are frequently used to establish journal-clubs or blogs to communicate opinions on hot topics and recent scientific articles, PubMed Commons remedied the absence of a coordinated collection of responses by a community of identifiable scholars. Although there are pros and cons to banning anonymous contributions to a post-publication per-review forum, the PubMed Commons model was designed to allow further investigation and open dialog on the published scientific record.

A closer analysis of the comments made to PubMed Commons, can help explain to what degree the members of this forum were indeed providing a value-added service to the published record. Even with the “low participation rate” claimed by the NIH, the data collected from the

² Dolgin, “PubMed Commons Closes Its Doors to Comments.”

participants in the PubMed Commons community can tell us much about the impact of open science initiatives on scholarly communication, and the ability of said community to provide downstream access to information and content that is not within the publication itself. Data analysis of these contributions can provide an important lens into the dynamic scholarly activity that grew as the result of open access policies, open access repositories, open access publishing and the open post-publication peer-review systems. Open science initiatives will drive others to innovate and improve on what PubMed Commons set out to accomplish, and the data analyzed in the chapters that follow can help to inform future open peer-review systems to the benefit of online scholarly communication networks.

Internet technologies have continued to drive innovations in online publishing and further the ability to share all forms of scholarship in the digital environment. Many opportunities exist to integrate post-publication peer review within online discovery tools, e-journals, digital repositories, online social networks, and institutionally recognized web pages hosting scholarly content. The term “online publishing” extends well beyond journal publications. Coordinated scholarly peer-review forums can be tapped to play a greater role than they have so far, extending beyond the pre-publication stage. Online scholarship has not only proliferated in the academic journal literature, but has also increased through the many opportunities that the digital environment allowed over the past decade more easily and inexpensively. Open-source software development has spawned innovations that easily permit the creation of new online journals and digital repositories to disseminate new scholarship. Combined with open access mandates, and new business models within the publishing industry, there will continue to be an exponential influx of high quality scholarship available online. It may become less clear which content online has passed through the traditional pre-publication peer-review systems. Therefore, harnessing

opportunities to develop new forms of post-publication peer-review is a valuable tool in the online publication workflows of today.

An Integral Part of Scholarly Communication

Post-publication peer review fosters scholarly collaboration and complements a researcher's ability to assess the rapid growth of scientific publications. As electronic publishing has become the norm over the past two decades, bibliometric research has frequently demonstrated an ever-increasing number of new articles published in some disciplines.³ For subject areas which dominate the academic journal market, it is becoming humanly impossible for any one reader to keep up with everything that has been recently published in their subspecialty.⁴ Keeping up-to-date and remaining informed about innovative discoveries, prevailing trends, and important retractions is perhaps most challenging within the area of biomedical and health sciences. This challenge has persisted since the earliest days of scientific publishing, but has taken on ever greater proportions. By the mid 20th century Dr Nathan Flaxman, publishing in the *Journal of the American Medical Association*, agonized over the fact that practicing physicians needed to frequently glean through more than 400 medical journals each month in an effort to remain current.⁵ Roughly 55 years later, that same index that Flaxman used to count 400 journals in his day (*Index Medicus*) now includes indexing for over 6500 peer-reviewed academic medical journals. Unfortunately, the pen-and-paper method that Flaxman recommended to physicians in 1954 is no longer feasible, let alone the best solution for the physician today.

³ Tenopir and King, "The Growth of Journals Publishing," 159.

⁴ Brainard, "Scientists Are Drowning in COVID-19 Papers. Can New Tools Keep Them Afloat?"

⁵ Flaxman, "How to Keep up with Medical Literature," 1409.

In a field where scientific breakthroughs, concerns and warnings are capable of immediately affecting human health, it is crucial to provide a scholarly communications network that streamlines the process of bringing the latest research directly to the scientific community. This process requires more than the innovations deployed within the online publishing industry. To their credit, publishers have used technology to advance efficiencies in automating manuscript submission, facilitating peer-review, copyediting, and distributing content. Indeed, innovations in each of these areas have vastly improved the quantity and diversity of scientific research that is published online today.⁶ However, an increased quantity of scientific publishing now requires an increased investment in search, discovery, and assessment on the part of readers. Perhaps the greater challenge for researchers today is the requirement that they must parse through greater quantities of peer-reviewed research in the journal literature, while also keeping abreast of the more immediate release of working papers, reports, guidelines and conference proceedings published online. Among these, papers published in journals that have less rigorous peer-review (or no peer-review at all) need to be approached especially carefully.

Post-publication peer review offers a multi-directional flow of information that allows a conversation to build around a given piece of scholarship. Remaining current requires not only discovering the most recent and relevant publications related to one's field of research, but also being aware of any updates or immediate concerns that have arisen among one's professional colleagues. Having access to post-publication peer reviews either as a contributor or as a reader of the reviews, allows an immediate opportunity to parse through the most recent articles that are stimulating discussion within a specific research area. Better still, this sets up a collaborative opportunity through witnessing (and/or participating in) a dialog with the original author of an

⁶ Tenopir and King, "The Growth of Journals Publishing."

article as well as other reviewers. Observers benefit either by taking note of the post-publication reviewer's assessment, or by adding to conversation around the article in question. The open forum in post-publication peer review networks facilitates a virtual gathering of reviewers and readers. In many ways this shares the burden of scanning and assessing the ever-growing number of articles published. As the post-publication peer review networks build, a community of experts forms over time. Even the silent participant who views comments and critiques made by this collaborative community will have found a trusted new tool that can provide an efficient way to quickly summarize recent publications in a way that scanning abstracts alone does not. The end result can be less time consuming and more informative.

Within a robust post-publication peer-review system, one could find expert discussion of the latest results from clinical trials, of reports from major research centers, and of important scholarly contributions shared online well before entering a journal's peer-review system. Whether or not the peer-review process had occurred on the article in question, the reception and feedback on the article as soon as it is available, is essential in the world of online scholarship. The imprimatur of the journal and its internal peer-review processes serve a specific purpose in providing a mechanism of pre-screening for the reader. However, irrespective of the value added by pre-publication peer review to the original manuscript, these contributions by the journal publishing process are only one piece of a much larger quality assessment that will unfold over time as researchers engage with the published results. The collaborative environment that an online post-publication peer-review network provides, allows for a dynamic platform with a community of qualified voices to critique and share observations on the published record, making it much more dynamic, up-to-date, and potentially more accurate.

Expanding Reach and Scholarly Impact

Apart from the publisher's coordinated peer-review system, what tools are available that allow readers an opportunity to critically assess the reception and impact that an article has had in the scientific community? Post publication peer-review networks supplement impact metrics and enhance scholarly contribution. More than the journal's willingness to publish the article, it is the scientific community's response that helps to fully unpack the strengths and weaknesses of a given publication. It is more important to gauge the article's acceptance in the community over the course of time. Waiting for that response, in the recent past, meant waiting for some future journal article to publish a reference or commentary which cited the original article of concern. Citation counts and subsequent publications that confirm or reject the claims in some earlier article are still useful; however, they suffer from the delay inherent in the traditional journal publishing timeline. Furthermore, even after the time-consuming process stretching from the peer-review stage to editorial production, publishing and distribution, this content is usually only available to those who have the financial means or institutional affiliation to access the journal. While library lending policies will often provide readers with a copy of the article after a special request, this is yet one more delay in access and impact an article can have on potential readership.

Current technologies afford authors and publishers an opportunity to produce and distribute infinitely more pieces of scholarship than the print world of previous centuries. The dynamic nature of online web services provides a blend of closed anonymous pre-publication peer review supplemented by open post-publication review and commentary within social networks. Where online social networks are publicly available for like-minded scholars discussing the most impactful research in their field, post-publication reviews can be uniquely

valuable and immediately relevant. They provide an important ongoing dialog that helps to raise questions or affirm the judgements of original pre-publication peer-reviewers and the article under discussion.

Peer-review within the journal's control is only one piece of the process of evaluation and represents an assessment of the scholarship at that one point in time. The journal's stamp of approval alone is only one metric of potential scholarly impact but says very little about the lasting depth and impact of the article on the author's peers. Indeed, when peer-review is absent, or when the peer-review processes are less strict, post-publication peer-review is the central mechanism that will eventually evaluate the scholarship. Naturally in many cases manuscripts will pass through a strict pre-publication peer-review process, become published, and may stimulate no further comment. Just as some articles are referenced in future citation counts after their initial publication, many peer-reviewed articles will never stimulate further discussion, inquiry or impact. This is true not only of traditional journal articles, but also of the multiple forms of digital scholarship that are so readily available online. Either way, post-publication peer-review will by its very nature only discuss those articles that are making some impact through either their strengths or their weaknesses. Having the perspective of the post-publication peer reviewer adds to our understanding of how the original paper is impacting our peers. Most importantly, post-publication peer review has the opportunity to augment the original publication with references and pointers to external pieces of related scholarship. Datasets, survey forms, supplemental interviews, videos and visualizations are additional scholarly products that offer additional pathways to discover the original article, and are especially impactful when they are made freely available and referenced by post-publication reviews. Greater visibility and discoverability lead to greater impact and reach of the scholarship.

Responding to Urgent and High Demand for Information

When society's demand for information is greatest, we all benefit by having additional experts assess rapidly developing scientific research discoveries. International health crises demonstrate a great need for facilitated post-publication peer-review. As the products of scholarship expand within the digital realm of online publishing options, remaining current in the health sciences does not end with a search through 6500 recent peer-reviewed journals. Indeed, the online availability of scientific reports, working papers, clinical trials, and, sadly, the proliferation of sham-journals, all require the reader to consider them, but also while exercising careful scrutiny before relying on them as sources of high-quality information. While it is no surprise that misinformation and unvetted research claims are more prevalent on the open web, it is not true that all non peer-reviewed material will be worthless. It is not uncommon to find examples online where information on the open web may have great importance to one's research area despite not having been peer-reviewed in the traditional sense.

This has been particularly true during recent international health crises where the open sharing of data and working papers via digital repositories has been instrumental in expediting scholarly communication around critical issues. During the Ebola crisis of 2014-2016 and the Covid-19 crisis of 2020, pre-print repositories biorXiv and medrXiv witnessed a massive surge in the submission rates to and in the number of references made to working papers in their systems.⁷ Out of necessity, and for the greater good of transferring information to the scientific community as quickly as possible, many of these authors have chosen to bypass the slow workflows of journal submission and peer-review, and to avoid the delays that this process

⁷ Vlasschaert, Topf, and Hiremath, "Proliferation of Papers and Preprints During the Coronavirus Disease 2019 Pandemic."

involves in making the scholarship widely and immediately available to the scientific community. Instead, the preference is increasingly to share what has been discovered by a certain point in time and to allow the community of scholars to evaluate and respond within an open forum. Pre-publication peer-review provides a first tier of quality filtering, but the comments and reviewer-reports have traditionally been hidden from public view. By contrast, post-publication peer-review benefits from the first-tier filtering, but then adds much more dynamic and timely content throughout the time that the publication attracts discussion among the scientific community. Only in the post publication peer-review forum is there an opportunity for a direct clear reviewer's voice to be heard and recorded for both the authors and readers to engage with.

Indexing & Discovery : Essential Tools for Post-Publication Review

Post-publication peer review augments information discovery, abstracting and indexing services. The academic community has continued to experiment and adapt the prevailing technologies to help facilitate the exchange of ideas and scientific discoveries. Current systems derive from developments that began over a century ago as the scientific journal became the preferred medium of disseminating scientific research. Scholarly societies, including the earliest examples of abstracting and refereeing in the 18th and 19th centuries, namely the *Royal Academy of Sciences* and the *Royal Society of London*, first devised processes designed to assist scholars to more efficiently identify and summarize the most relevant recent publications within a specific subject area. As learned societies became more sophisticated at facilitating teams of anonymous peer-reviewers for their publications, this trend would spread across many other societies throughout the 19th century, and eventually into general academic publishing houses by the 20th

century⁸. The benefits that this “quality filtering” had for both practitioners and academics within the biomedical & health sciences helped to spawn further innovation in indexing and abstracting.

As greater coordination between scholarly societies, peer-reviewers, and authors was building at this time, so too did technical advances in cataloging, indexing, and information discovery that were being developed by bibliophiles and academic libraries. In what would become the foundations of *Index Medicus*, John Shaw Billings began assembling the “*Index-catalogue of the Library of the Surgeon-General's Office*” in late 1870s. By 1893, the newly published 13th volume of the *Index-Catalogue* received an exceptional positive review in the October 26th issue of *Nature* that year. The reviewer noted that some 4,260 publications (books, journal titles, articles) from the library of the Surgeon-General’s Office had been indexed cumulatively up to this 13th volume.⁹ Meanwhile, the monthly supplements published in the *Index Medicus*, continued to systematically capture indexing of the most recent medical journal publications. Unlike the government supported *Index-Catalogue* (with the goal of indexing all of the holdings within the library of the Surgeon-General’s Office), the *Index Medicus* was funded through arrangements with a variety of commercial publishers between 1879 - 1926. During this time it was applauded for its subject classification scheme, as A.T. Myers indicated: “...such a classification under subject-headings should never be lost sight of in a catalogue which deals mainly with matters of observation and natural science, for, in a large majority of cases, the importance of the record depends more on the observation than on the observer....”¹⁰ Here too, Myers called specific attention to this tool --A detailed medical subject index-- as one that

⁸ Csiszar, “Troubled from the Start,” 306.

⁹ Myers, “Index Catalogue of the Library of the Surgeon-General’s Office US Army,” 611.

¹⁰ Myers, 611.

assisted in the rapid discovery of recent publications relevant to the unique subject area of the researcher.¹¹

In 1927 the *Index Medicus* was merged into an index published by the American Medical Association (AMA) called the *Quarterly Cumulative Index to the Current Literature* which went through several name changes and publishing partnerships until the AMA ended the run in 1956.¹² In 1960 the National Library of Medicine resumed exclusive publication of *Index Medicus*, at the same time it was arranging to automate the entire medical index within a project known as “The NLM Index Mechanization Project” in partnership with General Electric.¹³ The results of this partnership developed the MEDLARS database which evolved over the next 30 years to become the MEDLINE database we have today. The MeSH (Medical Subject Headings) ontology was also developed during this automation project, and became a standard component of the MEDLARS and eventually MEDLINE indexing.

With computation making it possible to automate the connections between the MeSH ontology and articles indexed in MEDLINE, the ability to interlink and discover related articles had become highly sophisticated, and more rapid than ever before. Bringing this technology directly to the public was realized in the release of PubMed in 1996 with MEDLINE and MeSH as core components. As web-based technologies were becoming more prevalent, it became possible for anyone with an internet connection to search through the world’s largest database of academic health science literature completely for free. While the complete journal article was unlikely to be electronically available online during these early years of online databases, the full abstract of the article provided extensive summary for the end-user, and saved the researchers a

¹¹ Myers, 611.

¹² “FAQ.”

¹³ Rogers, “The Development of MEDLARS.”

great deal of effort in unnecessarily hunting down the full print version of an article which would turn out to be less helpful than the title alone might indicate.

As publishers began to adapt to distributing more of their content online, and integrations with academic research databases became more common, direct links to the publisher's article from citations within academic research databases like PubMed became seamless. However, this encouraged research behaviors that fundamentally changed how many researchers would interact with published content going forward. If a researcher discovered that an important article was not accessible electronically via a specific PubMed citation record, rather than make the effort to find a print copy of that specific article, it was "less effort" for the researcher to just remain seated at the computer and keep scanning for articles that seemed similar, and hope to eventually find citations to another article that could be easily accessed online and available for immediate download. A 2014 study of 754 university health science researchers found that 70% of the respondents selected their preferred research articles based on its online availability.¹⁴ The notion of "Paywalls" and "toll access" to online content would begin to create barriers in the eco system of scholarly communication. Nevertheless, as print versions of the journals became less popular, and less affordable for libraries to collect, the monopolistic direction that the publishing industry was heading prompted a reaction. Various leaders in the scientific communities pursued innovations in technology and policy that aimed to ensure the scientific record did not become the exclusive property of the commercial publishing industry.

Open Access Policies and Open Science Initiatives

An old tradition and a new technology have converged to make possible an unprecedented public good. The old tradition is the willingness of scientists and scholars

¹⁴ De Groote, Shultz, and Bleic, "Information-Seeking Behavior and the Use of Online Resources," 172.

*to publish the fruits of their research in scholarly journals without payment, for the sake of inquiry and knowledge. The new technology is the internet. The public good they make possible is the world-wide electronic distribution of the peer-reviewed journal literature and completely free and unrestricted access to it by all scientists, scholars, teachers, students, and other curious minds. Removing access barriers to this literature will accelerate research, enrich education, share the learning of the rich with the poor and the poor with the rich, make this literature as useful as it can be, and lay the foundation for uniting humanity in a common intellectual conversation and quest for knowledge.*¹⁵

- Budapest Open Access Initiative, 2002

In 2002, these words formed what would become the first of three major open access declarations that ushered in a new era of scholarly communication. Known as the *Budapest Open Access Initiative* (BOAI) it was the product of some of the world's leading advocates within the open access movement at that time. Gathered together in Budapest at the invitation of the Open Society Institute in early December 2001, the group hoped to spark a worldwide initiative that would advocate for the free and "open" sharing of peer-reviewed academic research publications via Internet technologies. Important within this plan was that contemporaneous and future researchers would be freed from the financial constraints that were threatening access to scholarly journal articles. During the preceding years, libraries at academic institutions throughout the world were being subjected to unprecedented increases in their journal subscription costs from the major publishers. Scholars, publishers, and academic libraries were furiously debating solutions and collective action to the budgetary challenges that such unsustainable price increases would entail for academic researchers and future access to scholarly journals. Most notably these debates were collected in the 1995 publication of *Scholarly Journals at the Crossroads: A Subversive Proposal for Electronic Publishing*, which brought wider attention to the scale of this problem for stakeholders worldwide. Thus, the primary objective of the *Budapest Open Access Initiative*, and the declarations that would soon

¹⁵ "Budapest Open Access Initiative."

follow, was to remove the prohibitive cost barriers that were threatening access to the scientific and scholarly record, and more broadly to seek alternative options that would permit academic institutions to preserve, collect and disseminate peer-reviewed research publications.

The BOAI and the 1000s of signatories that added their names to the document motivated a collective response from academic stakeholders around the world. It prompted many institutions to begin local outreach and awareness campaigns for their faculty, focusing on copyright management and understanding how to freely share their scholarship within open access digital repositories.

The Budapest Open Access Initiative was soon followed by similar open access declarations, specifically the *Bethesda Statement on Open Access Publishing*¹⁶ and the *Berlin Declaration on Open Access*.¹⁷ Together these would inform, direct, and promote national and institutional open access policies that would affect scholarly communication trends, as well as facilitate greater awareness and participation in open access initiatives over the next decade.

The Budapest, Bethesda, and Berlin declarations prompted various local open access policies to be adopted throughout the world. For over 17 years, beginning in 2003, these policies and mandates have been tracked through the *Registry of Open Access Repository Mandates and Policies*. Naturally with over 800 policies currently listed within the registry, many have taken a variety of forms. Some OA policies offer a simple “commitment” to share scholarship, while more powerful OA policies stem from official “rights-retention” resolutions adopted by university faculty, or through mandatory terms and conditions associated with grant funding agencies.

¹⁶ Brown et al., “Bethesda Statement on Open Access Publishing.”

¹⁷ Max Planck Society, “Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities.”

The first major national open access policy, linked directly to public research and grant agencies, was signed into law by President George W. Bush within the *Consolidated Appropriations Act* of 2008. Known as the *NIH Public Access Policy*, this law went into effect on April 2008, and from that date required all research articles receiving support from NIH funding be deposited at the National Library of Medicine's digital archive, PubMed Central. This new term-and-condition for NIH award recipients required that authors remain in control of specific rights to their publications during copyright transfer negotiation with publishers. Specifically, when authors acknowledge an NIH grant within their research publication, they must ensure that their contract with the publisher includes a clause permitting the author to freely share the publication within the PubMed Central archive.

Over the past 12 years the PubMed Central repository has grown to almost 6 million scientific research publications that have become available to the health science community worldwide. The success of the NIH Public Access Policy prompted other funding agencies and organizations throughout the world to implement similar policies. As a result, the continued drive towards transparency in the scientific record has called for open access policies to also extend to research data, protocols, analytical software, and author-name disambiguation. All of which remain true to one of the central tenants of the Budapest Initiative in its hope to “lay the foundation for uniting humanity in a common intellectual conversation and quest for knowledge.”¹⁸

Chapter Overview

This thesis will explore the evolution of online scholarly communication with specific attention to the challenges, opportunities, impact, and sustainability of post-publication peer

¹⁸ “Budapest Open Access Initiative.”

review social networks. As open access policies and open science initiatives have been instrumental in prompting a more immediate and universal access to scientific publications, how has scholarly communication in an online forum for post-publication peer review successfully contributed to the ongoing scientific record. What lessons are to be learned from the ultimate demise of the PubMed Commons post-publication peer-review forum?

Following on this chapter's overview of open science and the importance of open access publishing, dissemination and evaluation of medical and health science research, chapter two will offer a historical review of technological developments that set the stage for online scholarly communication in the Internet age. Chapter two will also explore the prevailing trends that have taken shape in online communities since the ARPANET of the late 1960s through more dynamic and interactive online social networks users engage with today. Specific focus will address the unique PubMed Commons post-publication peer-review system and its attempt to facilitate an online social network for health science experts. Chapter two will conclude with a consideration of several questions that can be asked of the PubMed Commons data, and how revisiting the successes and challenges that resulted in its ultimate demise can inform and improve post-publication peer-review fora in the future.

Chapter three will describe the data that is available to facilitate a comprehensive analysis of PubMed Commons. The preserved PubMed Commons data elements and their significance will be defined in detail. Additionally, the method of extracting and analyzing all related citation and publication data of the articles discussed in the forum will be described. As much of the analysis will rely on a qualitative assessment of the peer-reviews that were contributed to the PubMed Commons community, a series of qualifiers will be assigned to each comment to identify and rank the comment's value-added-contribution. Chapter three will itemize each of

these qualifiers and indicate how they are to be used in the study. The data analysis software, randomized data selection, and external comparands are further described in this methodology chapter.

Chapter four will present the results from the analysis of PubMed Commons data, and offer a discussion in the context of each finding. This section will be supplemented with the results of a series of interviews which were conducted with former PubMed Commons members. Interviewees shared their observations, experiences, disappointments and triumphs as they looked back at the PubMed Commons method of facilitating post-publication peer-review. This chapter will also provide a comparison and contrast to an alternative post-publication peer-review system known as PubPeer. Following chapter four, a concluding section will summarize the lessons learned from the PubMed Commons experiment, provide some broad thoughts and recommendations based on the results, and consider some modern day challenges that open science initiatives and post-publication peer-review will face.

Chapter II

Online Social Networks and the Path Toward PubMed Commons

Online Communities, Open Dialog and Expanding Participation

Online social networks have been a common fixture of the Internet since the earliest days of access. Well before CompuServe introduced a consumer market to dial-up Internet subscriptions in 1989,¹⁹ colleges and universities enjoyed the benefits of internet access and online communities more than a decade earlier. The modern origins of today's Internet grew out of the Cold War necessity for the Department of Defense to communicate rapidly with specific agencies and research institutions across the nation in the event of a nuclear disaster.²⁰ This required developing an interoperable communications system between the disparate computer networks at a select group of ARPA funded research institutions and the Department of Defense. The result was the "Advanced Research Projects Agency Network" (ARPANET), begun in 1969, with most of its infrastructure built by 1971, connecting 15 of the original ARPA sites.²¹

The ARPANET of the late 1960s and early 1970s formed the backbone of a communications network that would extend well beyond the original intentions of the Department of Defense. In the immediate years that followed, many other colleges and universities would connect into the ARPANET for the vast number of collaborative opportunities and communication benefits that it could provide. Internet historian Janet Abbate observed that the ARPANET quickly became viewed "not as computing system, but rather as a communication system" and the foundations of virtual online communities was rooted in the origins of email

¹⁹ Lee, Yvonne, "CompuServe, MCI Mail Introduce Gateways to Internet Network," 32.

²⁰ Naughton, "The Evolution of the Internet," 7.

²¹ Abbate et al., *Inventing the Internet*, 78.

technologies.²² It is also believed that term “networking” evolved during this time to expand beyond a definition of physical connections between machines, to also include virtual connections formed between people and communities.²³

Communications in early online communities would quickly grow beyond the academic and utilitarian needs that prompted the creation of ARPANET. By the late 1970s and early 1980s, Bulletin Board Services (BBS) and USENET groups were becoming an alternative means of engaging in conversation with like-minded people in a shared messaging system. Covering just about every topic imaginable, USENET servers hosted a seamlessly interlinked network of discussion groups attracting worldwide participation for Internet users throughout the 1980s and 1990s. Data collected in Brian Reid’s “USENET Readership Report” for March 1995 identified over 3,000 USENET groups with a collective total of 3.3 million messages per month.²⁴ A full corpus of the postings and USENET communities which existed since the early 1980s have not been preserved, so an exact count of groups and postings is difficult to confirm. However, recent efforts have been made to restore legacy postings from the 1980s and 90s with the “USENET Archives.”²⁵ Statistics reported at the USENET Archive show over 11,000 newsgroups with more than 347,000,000 postings dating back to 1981.

The 1980s also saw the rise of BITNET and the earliest LISTSERV technologies, the latter of which continue to operate in some form now 30 years later. Although not as visually appealing as the online experience that the World Wide Web and web browsers would demonstrate by the mid 1990s, the text-based world of these early online communities was capable of bringing together like-minded individuals from across the world to engage in

²² Abbate et al., 111.

²³ Naughton, “The Evolution of the Internet,” 9.

²⁴ Reid, “USENET Readership Report.”

²⁵ Cole, “2.1 Million of the Oldest Internet Posts Are Now Online for Anyone to Read.”

asynchronous conversation. It was easy for anyone with Internet access to discover a community that focused on shared interests, from scholarly discussion to the most mundane topics.

Participation was easy, allowing anyone to join, and frequently did not require using a legitimate name or email address.

Online conversation in these early social networks could appear disjunct and not have an orderly flow. Posting thoughts or opinions into the most popular groups meant adding to a long list in which the latest postings could quickly bury and obfuscate the original contribution that someone hoped to share. Sifting through the most recent contributions was always an exercise in itself to try and discover all of the related responses that might have been directed at one of the earlier postings. Identifying posts with similar information was difficult so it was not easy to group posts together in any meaningful way. Similarly, search and discover within the full archive of posts was not an intuitive option, if it was an option at all. A great deal of patience was required if one chose to participate in these online communities as they were little more than an electronic bulletin board. Indeed, many of the early online communities were part of a loose network of modem-to-modem dialup Computer Bulletin Board Systems (BBS). Using a discussion group with a BBS system was analogous to posting a note on a bulletin board, and then waiting to see if your comment elicited a response from some other member in the online community. It was a slow process, and a reply directed at the contributor might arrive days or weeks later, and a post could easily get buried without ever being seen in its full context. But the delight in finding that your posting had reached another interested voice with whom to share or discuss the most esoteric topic compensated for these travails; and the ensuing exchanges could be both fascinating and exciting.

Not all contributions stimulated a response, and while many lists claimed to have a moderator, inappropriate or irrelevant postings were not uncommon. Largely unmoderated, unregulated, and uncensored, even the most interesting conversation threads could easily degenerate into a series of tedious rants. Many online communities would experience a participant who enjoyed posting deliberately provocative comments and disrupting the group discussion with vitriolic attacks to create what Paul Baker defined as “moral panic.”²⁶ Users who enjoyed trolling the discussion boards with intent to muddy the waters of conversation and stir-up anger in the community would bring a new definition to the noun “troll” by the mid 1990s,²⁷ and no USENET group was immune from their unwelcome presence.

Finding interesting scholarly discussion within these early communities was always possible, but that hope was tempered by the knowledge that each online community would have its share of trolls and imposters. Peter Steiner captured the inherent truism of online anonymity in 1993 with the timeless cartoon “On the Internet, nobody knows you’re a dog.”²⁸ Tolerating those inconveniences in these early online social network experiences seemed a reasonable cost to bear for the greater benefit of sharing knowledge and collaborating with international colleagues and like-minded individuals. For example, users participating in the USENET group “alt.hypertext” in 1991 would have been among the first to see a novel idea posted by Tim Berners-Lee, with an invitation to experiment with some new code he was working on at CERN, the hypertext transfer protocol or HTTP.²⁹

With the advent of the World Wide Web, and the 1993 release of the first significant web browser, NCSA Mosaic, by the National Center for Supercomputing Application at the

²⁶ Baker, “Moral Panic and Alternative Identity Construction in Usenet.”

²⁷ Donath, “Identity and Deception in the Virtual Community,” 45.

²⁸ Cavanaugh, ““Nobody Knows You’re a Dog.””

²⁹ Goldsborough, “The Web In Its Mid-Twenties,” 7.

University of Illinois, online communication and information sharing entered a new era. The online experience was quickly becoming more dynamic, immediately interactive, and visually appealing through graphically enabled web browsers. Non-proprietary open-source software development was fueling innovations in web browsers and server-side applications that would equalize information delivery. Irrespective of the computer platform the end-user preferred (Windows, Mac, UNIX etc.), the web browser could deliver the same information from server to client. Interacting with other transfer protocols online was also simplified within the single web browser, allowing users to easily connect to chat groups, and to browse, read, and post comments and information as online interfaces continued to improve throughout the 1990s. With significant increases in bandwidth, internet connectivity options and freely available open-source software, the communication landscape across the Internet experienced rapid growth and innovation.

Perhaps most significant during the decade that spanned 2000-2010 was the development of freely available and instantly customizable personal web pages. MySpace and Facebook were introduced to the world of internet users in the mid 2000s, and would finally remove the tedium and constraints that excluded many users from the burden of coding HTML directly to create their own web presence. Within a personalized Facebook account or consumer targeted web hosting service the ability to create a web presence for an individual, group, or community, was easily within reach for anyone. If not completely free in the case of a simple Facebook account, registering one's own personal domain and using a hosted service with an internet provider could be obtained at a modest monthly subscription.

Wiki based technologies for the web (known as the WikiWikiWeb) became publicly available in the late 1990s and were promoted as collaborative authoring tools to share

information.³⁰ These tools gave groups and organizations an ability to post and share web-based information easily and collaboratively. Managing a new online Wiki space for virtual communities to gather, contribute and share information was now possible without everyone in the group needing specialized coding skills. Search and discovery tools were vastly improved by Yahoo and Google during this time and provided completely free indexing and aided the discoverability of the growing corpus of web-based information.

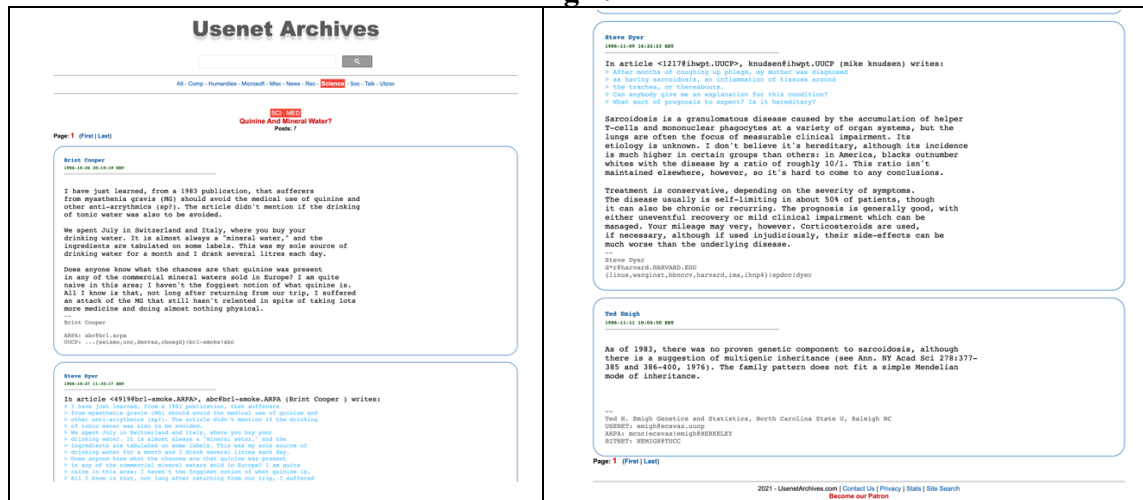
As the online collaborative web spaces evolved, group owners were allowed much more granular control in monitoring who, when, and what was being posted into these virtual communities. Today further improvements in version control and more sophisticated monitoring tools allow discussion group owners the ability to quickly purge undesirable content, remove disrespectful members from the group, and maintain an online presence that stands to build a greater sense of professionalism, trust and confidence among members of the community.

Web Innovations and Evolving Dynamics of Online Discussion.

Research and scholarship were central topics of discussion online throughout the decades, and examples of these discussions can be easily found in some of the USENET communities dating back to the 1980s. Various threads discussing differential diagnoses, experiments or recent publications in the “sci.med” community are visible in some of the earliest postings in the group which persisted from 1986 until 2015 (Figure 2.1).

³⁰ Sumner, “Promoting Scholarship Through Design,” 609.

Fig 2.1



USENET community sci.med discussion 1986³¹

As scholarly information has become more accessible and discoverable through databases publicly available online, innovations in collaborative web-based applications began to take hold in the mid 2000s. In 2001, C. M. Johnson recognized the growing potential and challenges for online collaboration and virtual communities of practice within the medical sciences. Johnson believed they “can exist within Web-based technologies. However, adequate scaffolding in the form of both technical support and usage of the technology for communication and collaboration is necessary.”³² Soon thereafter, web-based collaborative tools would continue to become more sophisticated and their ease of use predominantly required no “technical support” to participate beyond a local computer to launch a web browser and an occasional simple download. Publicly available tools developed by the NIH and the National Center of Biotechnology Information spurred innovation within the medical informatics community that led to new web applications that could easily connect with popular social networks including Facebook.³³ Other tools

³¹ “Med Discussion: Quinine And Mineral Water?”

³² Johnson, “A Survey of Current Research on Online Communities of Practice,” 56.

³³ Bedrick and Sittig, “A Scientific Collaboration Tool Built on the Facebook Platform,” 41.

developed by NCBI in the mid 2000s allowed medical researchers to create online bibliographies and publicly share recommended readings, datasets, and bioinformatics data and code with teams of collaborators. Independent web developers would build on the publicly available tools and databases that were freely available from the NIH. Many NIH services offered application programming interfaces (APIs) that allowed 3rd party computational programming access into the many NCBI databases including citation data within PubMed/MEDLINE, the primary database of medical publications. APIs provided backend access to automate search and retrieval of structured data from a source (like NCBI's PubMed) which enabled opportunities for programmers to develop new web applications which utilized the open data innovative ways.

Collaborative tools like Mendeley, first introduced in 2009, or the Open Science Framework, launch in 2013, are just two examples of web-based platforms where users can create free accounts and share not only citations and publications, but also commentary, data, images, and audio files. The account holder has the ability to choose whether or not to make the hosted information public or private. The dynamic environment is enabled by a simple web-browser, permitting any online user to access the information, enter the collaborative space and engage with the virtual community. As scholarly communities continued to grow within these individualized collaborative social networks so too did these technologies offer a more coordinated opportunity for post-publication peer-review.

Mendeley was an early example of a web-based application that provided the online tools for a group of scholars to instantly create an online community and come together to share articles and opinions within their customizable space. Mendeley was not tied to any one subject area, and easily allowed its members to upload any citations and publications that would be relevant to the group. The specific account holder could choose whether access to the online

community should be open or closed. Community members could invite others to join and contribute to the group. Within Mendeley, members could join a network of groups and potentially discover new collaborators and or opinions responding to important articles. Once a user was allowed into the community, adding their comments into the group and recommending additional publications for the group's bibliography could be part of the exchange. This became an additional strength of the Mendeley model as it provided the end-user with a view into the reading list of a community of scholars in specific subject areas. Many collaborative communities that expanded across the Mendeley system had chosen to make their bibliographies publicly visible, and by seeing what articles were grabbing the attention of a specific scholarly community, one could be guided towards the most important readings that caught the attention of like-minded researchers.

Post-Publication peer-review was not the original goal of Mendeley, but it was clearly happening throughout the system through crowdsourcing in much the same way as a virtual journal club might regularly meet to discuss the strengths and weaknesses of recent publications about a specific topic. In 2013, Mendeley's Head of Academic Outreach, William Gunn, posted "What makes Mendeley more than just a reference manager is the community of researchers who use our tool to share research, recommend papers to others, and collaboratively work together."³⁴ In the same October 2013 blog Gunn acknowledges the newly launched PubMed Commons and PubPeer as important new developments in the post-publication commentary landscape, and in response, Mendeley was piloting a new post-publication commenting project with another online

³⁴ Gunn, "Crowdsourcing and the Value of Curation – Mendeley Pairs with F1000 Prime to Recommend Great Research."

collaborative scholarly network, F1000, in hopes to foster “high-quality comments with high-quality research.”³⁵

Converging Norms of Online Consumer Endorsements

Post-publication, or more generally, post-production review has become widespread outside the scholarly context. Endorsements and evaluations of products from third parties have come to be standard in many areas of internet shopping. Posting reviews and comments about purchases became common during the decade that stretched from the late 1990s to about 2010. The online origins of a well coordinated system allowing customer feedback has been attributed to Amazon’s “customer review” feature introduced in 1995.³⁶ The popularity and success of Amazon and eBay rested not only on the ease of quickly finding and ordering goods online, but also on the ability to read reviews and comments posted by other customers. While the origins of Amazon’s business model are rooted in a long tradition of print based mail-order catalogs, the online integrated feedback system that Amazon and eBay deployed is directly connected to the content that the consumer is potentially interested in. The systems also provide a review and scoring system for the seller of the product. In most cases, these reviews are not provided by anyone the end-user specifically knows, and yet the ranking system, comments, and overall assessment by the community is given a measure of weight by potential customers. One of the key findings in a 2016 study which examined establishing trust in online reviews and by extension the vendor selling the product was not so much in the quality of the reviews, but in the fact that reviews were present on the system for the end-user to engage with and enjoy evaluating

³⁵ Gunn.

³⁶ Dohse, “Fabricating Feedback,” 366.

them for themselves.³⁷ Whether or not the user intends to purchase the goods through Amazon, the site has become one of many where people look for assessments of the product under consideration. Furthermore, Amazon and similar sites allow participants to ask questions and discuss pros and cons about the product, the seller, and their strengths and weaknesses. Additionally, the interface provides direct links to competing products proposed as similar alternatives in a selection that may appear as unbiased. This “also bought” feature can also inform consumers of any products, updated items or editions that should be evaluated against the original object of the user’s attention.

The utility of scanning through these reviews, even when intending to purchase the product elsewhere, has become a common practice among many consumers. Commercial websites regularly implement review and evaluation systems for their products. Naturally, marketing experts have thoroughly analyzed human online shopping behaviors, and have become aware of the triggers that prompt an end-user’s trust in positive online feedback.³⁸ Vacation destinations, restaurants, cars, and just about any service industry that consumers will interact with are all represented in some online review forum. While some implement controls to verify that a potential reviewer has indeed purchased the product under review, other online sites do not integrate such controls into their reviewer verification algorithms.³⁹ Online reviews at Amazon and elsewhere need to be viewed critically, but in some cases it is easy to spot when a product is being suspiciously overly praised in a way that suggests that the reviewer is actually working for the company selling the product. Gaming the system is nothing new, and most mature consumers are aware that this is always a possibility. Marketing firms hiring writers to pose as happy

³⁷ Elwalda, Lü, and Ali, “Perceived Derived Attributes of Online Customer Reviews,” 316.

³⁸ Aral, “The Problem With Online Ratings,” 49.

³⁹ Aral, 50.

customers by writing extended reviews, and corporations reviewing their own products with high praise have been endemic to online review systems from the start.⁴⁰ Estimates of the number of reviews which were written purely as a marketing ploy or by a “fake” reviewer are believed to comprise 10-15% of all online review activity.⁴¹ Meanwhile legitimate unhappy customers are capable launching into an angry rant that offers very little in the form of context or feedback for the readers but is as “normal” in online reviews as the “troll” in online discussion groups. With so much potential for unconstructive, biased, and disruptive participation, how then might acceptable norms of internet behavior be merged with reviews attached to scholarship, and the scholarly communities that are building within online social networks?

Augmenting PubMed Content with PubMed Commons Reviews

The NIH was certainly aware of the online scholarly communities that were developing in tools like Mendeley and elsewhere, and in 2013 it announced that PubMed Commons would serve as a post-publication peer review forum for health science scholars. The PubMed Commons social network would be integrated with the PubMed database and provide “a system that enables authors to share opinions and information about scientific publications.”⁴²

However, unlike other online social networks of the time, PubMed Commons was founded with careful controls on participation within the community and strict rules governing participants’ behaviors. Failure to comply with these rules would result in the cancelation of the user’s access to the forum. Members were expected to adhere to the following rules:

- PubMed Commons Members had to:
- Establish their account with their real name (no pseudonyms or anonymous accounts were allowed)

⁴⁰ Dohse, “Fabricating Feedback,” 364.

⁴¹ Dohse, 365.

⁴² “NCBI Insights,” October 22, 2013.

- Follow the current guidelines when they used PubMed Commons
- Grant other users a worldwide, royalty-free, non-exclusive, perpetual license under the [Creative Commons Attribution 3.0 United States License](#)
- Disclose potential conflicts of interest
- Make comments that were directly relevant to the particular work in PubMed on which they are commenting
- Refrain from using PubMed Commons to spam or systematically promote a product, position or the members' own publications or to target others

Member's Comments were not allowed to contain:

- Discriminatory, racist, offensive, inflammatory, or unlawful language
- Partisan political views
- Plagiarized content
- Descriptions or content of unpublished work by others without permission
- Allegations of misconduct on the part of authors, reviewers, editors and publishers
- Speculation about the motivations of authors, reviewers, editors and publishers

-PubMed Commons User Guidelines ⁴³

The reason for such strict oversight was related to the design of the PubMed Commons system, whereby each comment thread would become publicly visible on the official citation record within the PubMed database. The expectation that the comments would provide added value to the carefully prepared PubMed citation record was evident in these rules. Distractions from the expertly prepared MESH headings, abstract and indexing on the citation record would not be tolerated.

Maintaining the integrity of the PubMed database was clearly a factor in developing such strict rules by the NLM. By this time, in 2013, PubMed had become the primary research database for scholars within the health sciences, and included over 23 million bibliographic citations to articles published within roughly 6000 journals. Prior to inclusion in the database, each journal went through a strict review process under the National Library of Medicine's "Literature Selection Technical Review Committee". The journal was reviewed by the committee to ensure it met the high ethical standards expected of scholarly publishing. First and

⁴³ "PubMed Commons - Usage Guidelines."

foremost, the committee sought to verify that the journal had a firmly established peer-review process well integrated into their editorial workflow. The criteria for inclusion in PubMed were never trivial. Furthermore, the citations themselves underwent a detailed and complex indexing process by the NLM, which culminated in mapping each PubMed citation record to a set of expert-assigned subject terms that derived from MeSH (Medical Subject Headings) ontology.

With the launch of PubMed Commons in 2013, for the PubMed record to now also include the unpredictable comments of participants in an online social network was a cause for concern. However, the controls and policies that PubMed Commons put into place were successful at maintaining a social network of specialized subject experts. The limited number of eligible members that joined the group would in turn produce a limited number of reviews that would eventually be added to PubMed citations. The success of that policy seemed to be at the root of the slow participation rate that would eventually bring the online community to an abrupt end in 2018.

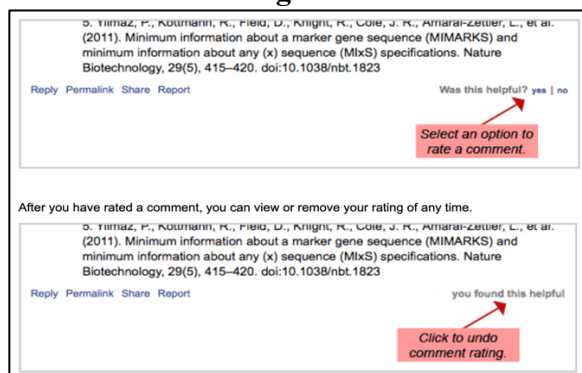
PubMed Commons: Post-Publication Peer-Review

PubMed Commons set out to control participation in the post-publication peer Review process by first ensuring that contributors had some identifiable association with scientific publishing. Their parent system, PubMed, was already designed to take on this task since it had an index of author names, and as PubMed only indexes the highest quality medical and health science journals, the author index provides a vetted list of authors in scientific fields. However, there was an additional constraint on the validation process. The registration utility required not only a matching name in the author index, but also required a match on the email address that was included on the author's published article indexed in PubMed. This was an immediate

hurdle for even those in the author index, because email addresses were not always present for all authors on an article. The corresponding author might routinely have an email indexed, but the coauthors might not. Setting up accounts for those without an email on file was still possible but would require several extra steps along with contacting the PubMed Commons moderator.

Once the account was verified the participants would have their official email address and name visible to everyone whenever they posted a comment in the system. Any post-publication review that they submitted would be clearly visible with their name directly under the abstract section of a PubMed citation record. Should any other member choose to reply or add additional comments, the thread would continue on the PubMed record. Each comment also integrated a utility where users could vote on specific comments that they “Found Helpful” (Figure 2.2). It was also possible to click onto the name of a specific reviewer, and view a single page of all the comments and responses that an individual had written. From the single page of comments by an individual, one could click directly on the comment to return to the PubMed citation record and see the full abstract with any additional replies from other members.

Fig. 2.2



PubMed Commons “Found Helpful” endorsement

This linking between resources, authors, reviewers, and publications became one of PubMed Commons’ great strengths. Contributors to the post-publication peer-review forum would occasionally share additional information that would direct the reader to additional

materials that would be stored externally to PubMed. Furthermore, some supplemental materials may have been resources that the publisher was not able to include with the publication. It may have been some update that the authors were hoping to share as a follow-up to the publication, or it could be some pointer to an errata list or correction that was still not visible on the PubMed record itself. The most useful postings would share a dialog with the author or other post-publication peer reviewers who together weighed the pros and cons of the paper under discussion. However just as one sees in commercial online retailers, some contributors gamed the system by adding glowing reviews to their own article, or used the citation record from their article to point users to additional publications they had authored. Sometimes the self-promotion offered an opportunity to draw attention to the scholar's materials that were not indexed in PubMed due to the journal exclusion rules that the selection committee employed. However, what may seem like self-promotion in some contexts, could still offer a valuable contribution, e.g. to counterbalance a challenging comment. Here it is an advantage to know the name of the post-publication peer-reviewer. By knowing that the person posting was also the author, the reader has a little more context about who and why this comment may or may not be completely neutral.

Moderation of the list was tightly enforced. Violators would receive warnings that were posted on the comment thread directly in a bold red font. The warning would state the violation next to a contributor's post and be visible for everyone to see (see figure 3.2). The act of shaming the individual publicly with an indication that their comment was removed by the moderators was a way to reinforce to the community that rule violations will not be tolerated. Several persistent violators did get excluded from the community after the warnings were ignored. One of several examples was seen when moderators purged anti-vaccine conspiracy theories from a

PubMed Commons review for “Carcinogenic human papillomavirus infection” published Dec 2016 in *Nature Reviews*, and reprimanded reviewer Sin Han Lee for posting exceptionally long diatribes about issues that had debunked by the scientific community. The comments have long since been deleted, but a transcript of the PubMed Commons transaction remains at an anti-vaccine/pseudo-science website sympathetic to the Dr Sin Han Lee’s bogus claims.⁴⁴

The vast majority of the comments and participants all stayed within the boundary of the rules, posting thoughtful, sometimes extensively detailed reviews with supplemental supportive material. However, claiming that participation was disappointingly low, the NIH abruptly announced that PubMed Commons would shutdown in February 2018.⁴⁵

Defining “success” in Post-Publication Peer-Review

Deciding that the “low” rate of activity warranted the abrupt termination of PubMed Commons seemed to forget that the restrictions that kept the participants small in number had been adopted by design. As it was deemed important to establish an exclusive community of identifiable authors who had publications indexed in PubMed, the site excluded anyone who did not have an email address indexed in PubMed. Mechanisms were put in place where one author could invite other authors who did not have email addresses identified in the index, but this added one more hurdle for creating new accounts. It was anticipated the restrictions would impact participation as early as the Oct 2013 launch of PubMed Commons. In an interview that same month, Stanford Professor Rob Tibshirani (one of the key figures in bringing PubMed Commons online) expressed concern about the many highly qualified individuals what might be excluded from participation, including “graduate students, patient advocates, science

⁴⁴ Erickson, “NIH Marketing HPV Vaccines via Censorship?”

⁴⁵ “NCBI Insights,” February 1, 2018.

journalists...”, and stating “I’m a little worried about this restriction...”⁴⁶ However, Tibshirani also explained the reasoning behind this decision was to “make the situation symmetric” in that users who would be allowed to comment in the system also had publications in the system on which other members could comment on.⁴⁷

A further psychological barrier discouraged participation from those who would much rather leave anonymous reviews for fear of retaliation or the discomfort of an awkward power dynamic. Here Tibshirani mentioned that the organizers debated whether or not to allow anonymous contributions and could not find common ground, but as a starting point, it was decided to restrict users from posting anonymous reviews, and perhaps this could lead to higher quality contributions. It was anticipated that the policy on anonymity and author-only membership would be re-evaluated after the pilot period of PubMed Commons. However, in December 2015, a full two years after its launch, the PubMed Commons pilot was deemed a great success,⁴⁸ and the policy on anonymity remained in place.

The decisions in how PubMed Commons chose to design its post-publication peer-review service would inevitably keep contribution numbers low. A more complete assessment of the value of the post-publication reviewer’s comments on the original article was not carried out. Rather than relying on numbers alone in determining whether PubMed Commons was a success, a thorough assessment of the site should have included a qualitative analysis of questions like these: How did PubMed Commons model post-publication peer review? How did the post-publication peer reviews in PubMed supplement the original articles under discussion? While the

⁴⁶ Oransky, “PubMed Now Allows Comments on Abstracts — but Only by a Select Few.”

⁴⁷ Oransky.

⁴⁸ The PubMed Commons Team, “Commenting on PubMed: A Successful Pilot | PubMed Commons Blog.”

number of contributions may have been lower than the NIH anticipated, did the context of the reviews add to the existing literature in an effective way?

The NIH has preserved the entire corpus of PubMed Commons data which was collected between 2013 and 2018.⁴⁹ The dataset includes 7,630 post publication peer-review comments made by 1,906 scholars discussing over 6000 articles indexed within the PubMed citation database. The 6000+ bibliographic citations represent a second dataset for the purposes of carefully identifying the articles and subject matter under discussion within PubMed Commons. The two datasets are valuable together as each contains a unique key-identifier, the PMID (PubMed Identifier). The PMID is unique number assigned to each article indexed within PubMed. By having this unique identifier in both sets of data, statistical software can reliably automate and visualize intersections between the comments entered by PubMed Commons reviewers and the bibliographic indexing that links to subject matter, publication dates, journals, as well as author affiliations and external citation metrics. With the PMID as the interlinking mechanism between these datasets, more specific questions and associations can be addressed across the corpus of publications, comments received, and commenters. Furthermore, the PMID allows us to identify the medical terms which map onto the subject matter under discussion, as this identifier allows for a direct link into to the MeSH subject headings that have been assigned to the article.

By analyzing the PubMed Commons data from the perspective of overall activity within the forum, as well as its response to medical and public health concerns discussed at that time, I intend to assess the contribution of this mode of scholarly communication in augmenting the scientific record. As a post-publication peer-review system, PubMed Commons was unique in

⁴⁹ “Index of /Pubmed/Pubmedcommons.”

that the participants were prescreened and required to operate in an open review system. The PubMed Commons planners debated the potential benefits of obtaining higher-quality contributions at the potential cost of lower participation due to excluding anonymous contribution. Was this policy effective in reaching its objectives? In the trajectory of online communication from the most mundane BBS services and to highly focused USENET discussion groups, where anonymity, trolls, and irrelevant rants were frequent fixtures derailing online conversation, was it true that PubMed Commons had much more success in fostering scholarly communication than its summary dismissal and shutdown warranted? Since it was unique in its membership and participation requirements, there is no comparand against which the NIH could measure the success or failure of PubMed Commons. However, a qualitative assessment of its impact is possible by revisiting the discussions, comments, and voices that are preserved in the PubMed Commons data archived at the NIH NCBI servers.

Chapter III

Exploring PubMed Commons Data: Research Design and Methods

Aligning Research Questions to PubMed Commons Data

PubMed Commons accepted its last contribution on February 20th, 2018, a little over 4 ½ years since it launched. In that time span, PubMed Commons had accumulated 7629 contributions by the participants. Contributions ranged from brief comments on published literature, to more extensive post-publication reviews with supplemental content within the contribution. Each contribution was originally visible on a PubMed citation record within the PubMed/MEDLINE database of biomedical and health science literature. The freely available PubMed database and its many related online tools, included PubMed Commons, and is hosted at the National Center of Biotechnology Information (NCBI) within the National Library of Medicine at the National Institutes of Health. The PubMed Commons comments appeared just below the abstract on the PubMed record of the article under discussion. The PubMed Commons community posted 1 or more comments onto 6,018 unique PubMed records. These reviews, critiques, and discussions first appeared in the Fall of 2013 and were removed from public display on March 3, 2018. The corpus of comment data collected through PubMed Commons has been preserved as a standard CSV data file, and openly available on an NCBI file server.⁵⁰

To date, a qualitative review of the data collected from the PubMed Commons contributions has yet to be assessed. The decision to close down the service was based primarily on the number of contributions and contributors that participated in the forum during that 4-year period.⁵¹ The PubMed Commons administrators noted that the PubMed database included over

⁵⁰ “Index of /Pubmed/Pubmedcommons.”

⁵¹ “NCBI Insights,” February 1, 2018.

28 million article citations, and yet only 6,000 of these had received some comment by the PubMed Commons community.⁵² What was absent from their evaluation was some indication about what “success” should have looked like. Neither a numerical target nor an intellectual threshold of what constituted a value-added service was offered. PubMed Commons went dark 5 weeks after the announcement to fold. Public feedback directed at the NIH for the unfortunate demise of PubMed Commons criticized the agency for not taking the time to assess the quality of the comments, specifically those that lead to retracted papers.⁵³

How could we now, in retrospect, assess whether this controlled online post-publication peer review social network was a “success” or a “failure”? Even if the numbers of contributors and comments are not large relative to the number of articles in the database, did they add significant value to the scholarly community? Within the 6018 articles that received comments, did the PubMed Commons model supplement the original articles with additional scholarship? With open science initiatives at the center of recent advocacy by the National Academies of Science, Technology and Medicine, did PubMed Commons succeed in fostering those goals? The retrospective data of archived PubMed Commons contributions can help answer these important questions.

Data Extraction & Description

The final extraction of PubMed Commons data was collected and transformed into a single dataset by NCBI on February 22, 2018. The data was converted into a standard CSV format and stored at a publicly accessible FTP server at NCBI. The preserved data includes each field relevant to identifying the PubMed record and the corresponding PubMed Commons

⁵² McCook, “PubMed Shuts down Its Comments Feature, PubMed Commons.”

⁵³ McCook, 6.

contribution. The dataset is comprised of the following fields; CommentID, PubMedID, DateCreated, FirstName, LastName, and Content (the reviewer's comment as submitted).

Unfortunately, the NIH dataset has omitted 1 field from the archived PubMed Commons data collection. PubMed Commons had a feature which permitted users to submit a "Found Helpful" checkmark next to a reviewer's comment (Figure 2.2). The running total of users who appreciated the review and checked "yes" was tallied against those who did not find the review helpful. The endorsement feature provided one more layer of feedback from the PubMed Commons community to evaluate the reviews posted by other members. The result was presented in the form of a numeric ratio; "X of Y people found this helpful." Seeing the running total of "Helpful" votes added an extra layer of assessment in reviewing the reviewers. The behavior mimicked the prevailing norms in online shopping environments like eBay and Amazon where both product and sellers receive feedback rankings from the participants.

While the NIH dataset does not include the "Found Helpful" information, these data were captured by data scientist Neil Saunders who routinely scraped the PubMed Commons data to conduct his own bibliometric observations. The final NIH data capture that Saunders downloaded includes all 4 ½ years of "Found Helpful" data whenever a PubMed Commons review had received any endorsements. As the dataset is in the public domain, Saunders shared this version of the PubMed Commons data on a GitHub repository.⁵⁴

The official NIH/NCBI dataset represents the source of data that will be used in this study. However, to include the "Found Helpful" data, I created a new field within the official dataset and inserted these values as captured by Saunders. This was possible because each PubMed Commons contribution contains unique ID number. By matching on the PubMed

⁵⁴ "Neilfws/PubMed."

Commons ID number between these two datasets, merging the “Found Helpful” data into the proper location in the official dataset within Microsoft Excel was easily automated. The resulting fields in the PubMed Commons dataset that will be used in conducting the analysis in this study are represented below.

PubMedID.

Each record in the PubMed database is assigned a unique acquisition number as soon as the citation is uploaded into the system. Publishers regularly upload new data into the PubMed system to provide NCBI with basic citation information for articles that are forthcoming in their journals. As soon as a new article is added to the PubMed system, the record receives a PubMed ID (PMID). Each PMID is a unique number which provides a quick reference to locate the citation record and abstract of the indexed article. Within the context of the PubMed Commons dataset, the PMID and the unique CommentID are provided together in each row of the dataset and identify a specific article and a specific comment respectively. This is crucial to understanding which article in the PubMed database received which comments in the PubMed Commons dataset. When the CommentID is associated with a PMID it is then possible to extract article-level metadata that was created in the PubMed indexing process, including MeSH (Medical Subject Headings), keywords, journal names, author affiliations, abstracts and publication dates. Harnessing the PMIDs as a batch is essential in determining specific focal points of discussion, and the timeliness of the comments on the published literature. Likewise, the PMID makes it possible to extract each PubMed record of the corpus of articles which prompted the discussions in PubMed Commons during the 4 ½ years while the service was active. By extracting each PubMed record that has been associated with a PubMed Commons

reviews, I will form a dataset of citations which will be used in a bibliometrics analysis of the published content that was under discussion in the forum.

DateCreated

This field is a time stamp representing the moment when the comment went live on PubMed Commons. This will be important from the perspective of understanding how much time elapsed between the date of publication and the appearance of the post-publication peer review. The time stamp here, compared to the publication date of the article under discussion will help to inform the immediacy of the review offered into the PubMed Commons system. This is an important metric to calculate as it is crucial to understand the number of recent articles that had received some post-publication peer-review attention within PubMed Commons. Indeed, NIH concluded that the system had failed because only 6000 PubMed records had been commented on while the entire database had 28,000,000 records of citations dating back (predominantly) to the 1980s.⁵⁵ It will be more helpful to consider what percentage of recent articles were discussed in the forum, rather than how many in the 28,000,000 records received attention. Within the final combined dataset of PubMed Commons data and the PubMed citation data, it will be possible to calculate the timeliness between publication date and date of post-publication review. Most reviews are anticipated to be written less than five years after the date of publication.

CommentId.

⁵⁵ “NCBI Insights,” February 1, 2018.

The CommentID is a unique ID number assigned to the PubMed Commons contribution. The comment IDs numbering increments in 3 (1,4,7,10 etc.) for the first 3 years of contributions. For unknown reasons, in July 2016 the CommentID numbering system begins to increment intermittently by 3000 before resuming to increment at intervals of 3 again. Judging by the dates of the subsequent comments CommentIDs, the gap of 3000 in the Comment ID sequence does not show evidence of missing records. The first record in PubMed Commons dataset with CommentID “1” on June 12, 2013 by one of PubMed Commons’ founders, Professor Robert Tibshirani of Stanford. The final comment on February 20, 2018 was by Professor János Gyuricza of Federal University of São Paulo, receiving the CommentID 78,712.

The occasional break in the intervals of 3 seem to offer a clue into when a contribution may have been deleted. Deleted comments did occur, and these are not retained in the dataset. Unfortunately, the PubMed Commons dataset has no record of what these comments were nor does it indicate which article had one or more reviews deleted from it. In some instances, the comment may have been deemed inappropriate, and removed by the PubMed Commons moderators due to a clear violation of the rules governing participation. Figure 3.1 shows the PubMed Commons guidelines and community behavior rules.

Fig 3.1

Comments should not contain:
• Discriminatory, racist, offensive, inflammatory, unlawful, or derogatory language • Partisan political views • Plagiarized content • Descriptions or content of unpublished work by others without permission • Allegations of misconduct on the part of authors, reviewers, editors and publishers • Speculation about the motivations of authors, reviewers, editors and publishers

PubMed Commons comment guidelines

Two additional rules required that comments must be directly relevant to the work under review in PubMed, and never be used to “systematically promote a product, position or the members’ own publications or to target others.”⁵⁶

When violations occurred moderators would flag a comment and offer the user an opportunity to revise or delete the contribution. If a reviewer revised their comment, the entry would indicate a new time stamp and include the word “Edited” next to the modified comment. If the reviewer refused to edit or delete their inappropriate comment, moderators would step in and delete it. When a comment was deleted in the forum, the reviewer’s name and time-stamp remained, but next to their name was an indication that the moderators had removed the reviewer’s comment (Figure 3.2).

Fig 3.2



Comment removed for violation

(Reviewer accused author of research misconduct.⁵⁷)

One of the lead moderators at PubMed Commons, Hilda Bastian, reported that by the end of 2016 there had been 268 comments deleted by moderators, and “a similar amount” had been deleted by the original reviewer.⁵⁸ When reviewers deleted their own work, it is not clear if the action was triggered after receiving a warning or simply removed on their own initiative. Bastian also indicated that there had been 5,483 comments made on 4372 PubMed records by the end of 2016. Therefore, the total amount of reviews deleted by PubMed Commons moderators was roughly 5%.

⁵⁶ “PubMed Commons - Usage Guidelines.”

⁵⁷ “Hilda Bastian, PhD on Twitter.”

⁵⁸ Bastian, “Innovations in Peer Review and Scientific Publishing.”

The CommentID field is preserved within the final dataset assembled for this study as it helps to establish an association between unique comments and the publication they refer to.

FirstName; Last Name

The PubMed Commons dataset provides the First and Last name of the reviewer who has posted the comment. The email address and affiliation of the reviewer is not present in the dataset, however it is understood that the individual must have at least one publication indexed in the PubMed database. PubMed Commons membership required that new members confirm their identity by entering their email address. Names and email addresses needed to be matched against the PubMed author index or found within the NIH or Wellcome Trust researcher profile directories.⁵⁹

To set up a new account in PubMed Commons, applicants would submit their credentials and include an email address on the initial sign-up form. If the email address and author name could be matched to a PubMed record or NIH profile, then the contributor would be instantly authorized. Many authors would not be so lucky to easily discover their email address within the PubMed index. If the author's email address was not included in the publication (which was more common for co-authors rather than the corresponding author), the PubMed index would have no email indexed for the middle-authors on the paper. If the requester had never participated on an NIH grant project, then their name will not appear in the relevant NIH directories. If the system found no match, the user would not be allowed to join PubMed Commons. Instead, they would need to receive an invitation by some other PubMed Commons member.

⁵⁹ "PubMed Commons - Getting Started."

Within the final dataset used in this analysis, the participant names will help calculate the frequency of participation, the total number of active post-publication peer reviewers, and help to identify “self-citation” when it is apparent within the content of the review they contribute to the forum.

Content

The Content field in the PubMed Commons dataset represents each comment that was posted by reviewers in the community. The comment is captured in full, and together with the date/time stamp, reviewer name, and PMID, the row of data provides all of the interconnected pieces that help answer the larger research questions that have been posed, notably: Does the post-publication peer-review comment provide some value-added content to the original article indexed in PubMed? Do the post-publication reviewer’s words attempt to provide additional information to update or enrich a potential reader’s understanding of the original article? A careful review of the content in a random sample of PubMed Commons data is essential to answering these questions.

Data Assessment Methodology

During the 4 ½ years of its existence, the entire corpus of PubMed Commons contributions added no less than 1.5 million words to over 6000 PubMed citation records under discussion. While the NIH saw these numbers as insignificant, the potential value in the contributions was never systematically analyzed. It is easy to simply count up the number of words, records, and participants in the PubMed Commons forum, however assessing the value and context of the post-publication peer-review itself is the aim of this study. Numbers only tell

part of the story and are insufficient without evaluating the nature of the contribution provided into PubMed Commons by the members of this community.

To conduct this analysis, a random sampling of the 7629 records in the PubMed Commons dataset was selected. This was executed using a simple tool that provided unique numbers between 1 and 7629. These 155 records were extracted from the complete PubMed Commons dataset and placed into an Excel spreadsheet for a detailed review and qualitative tagging (ex. Appendix 1). The subset of comments will be assessed to identify the percentage of contributions that fall into one of several categories identified below.

Intent

The intent of a contribution was evaluated based on the dominant goal of the reviewer. There are frequent occasions where the contributions simply praise an article or offer a complaint without providing constructive reasons. More frequently the contributions direct readers to supplemental data, additional scholarship and/or digital objects that support or contradict the claims voiced in the article itself. Identifying the frequency with which the intent of the contribution is motivated to add something new to the conversation is in line with the criteria for “success” that PubMed Commons set out to achieve. Simple praise or complaints without adding further evidence to the publication under review, seemed less helpful to the scholarly communication objectives of PubMed Commons. The comment data will be tagged for *Intent* based on these seven options, noting whether it:

1. Directed reader to a more recent version/edition of the article under discussion
2. Directed reader to a free version of the article (avoiding paywall)
3. Directed reader to supplemental data
4. Directed reader to external “supporting” material/evidence
5. Directed reader to external “contradictory” material/evidence
6. Offered simple praise and gratitude

7. Offered simple contradiction or complaint

Reception

The *Reception* field assesses the reception of the article by considering the commenter's impression of the publication. Capturing this metric will help bring to light whether there is a dominant motivating factor in the post-publication reviews based on a desire to express positive or negative critique on the article. Just as satisfied customers are less likely to take the time to write a joyful letter to a store manager than the angry customers quickly are to write a lengthy letter of complaint, is there a similar pattern in the general reception of the article among PubMed commenters? Tagging each of the 155 comments within the sample set for their general tone is also helpful in identifying whether a positive or negative voice dominated the contributions into the PubMed Commons community. While a persistently negative tone can be tiring and uninviting to participate in, a perpetually positive reception of the content under review may also provide little added value to what has already satisfied the senior editor of the journal itself. Balancing these extremes and assessing pros and cons in the article from a neutral standpoint, would demonstrate a post-publication peer-review that has attempted to engage with the article in more detail. Each contribution will be tagged for *Reception* according to 1 of these 3 options:

1. Positive Reception
2. Neutral Reception
3. Negative Reception

Impartiality

The *Impartiality* of the contribution assesses the post-publication peer-reviewer's connection with either the article under review or the evidence/recommendations presented

within the comments. For example, it is not uncommon to discover that the post-publication peer-reviewer is actually the author of the article under discussion. On many occasions it is quite useful for the author to provide a quick update to the findings in the article or to share a link that connects to some supplemental data or video that might not have been included in the publication. There are also times when the aim of a reviewer other than the author of the article is to direct the reader to their own publication which may or may not be something that adds a substantial critique upon the original article under review. There is a delicate dance between vanity vs. utility in some of the self-citations that occur in the forum. Identifying those which fall into these three categories that determine *Impartiality* can then be weighed against other qualitative tags (*Intent* or *Constructiveness*) to assess overall utility. The *Impartiality* of the contribution is recorded with one of these three assessments:

1. Post-Pub Reviewer is 3rd party to source and external reference
2. Post-Pub Reviewer is Source Author
3. Post-Pub Reviewer is External Reference Author

Constructiveness

The *Constructiveness* tag provides an overall assessment of the post-publication peer-review content. Constructive feedback is at the core of any helpful critique. Irrespective of the tagging that is assigned to the *Intent*, *Impartiality*, *Reception*, or *Timeliness* of the contribution, the value-added benefit of the post-publication peer-review should demonstrate some constructive criticism or relevant additional support to the article under discussion. In the assessment of the 155 records in the random sample, one of these 7 tags identifies the predominant way in which the review's contribution provided *Constructiveness*.

1. Reviewer discusses their own work
2. Reviewer provides link to supporting data/publication (Toll Access)
3. Reviewer provides link to supporting data/publication (Open Access)

4. Review offers opinion without support
5. Retraction
6. Brief update to the article and/or some additional information
7. Nothing constructive to offer

Timeliness

The time gap between an article's publication and the appearance of the post-publication peer-review is assessed to determine how timely the review is. While post-publication reviews can offer constructive feedback and helpful supplemental data at any time after an article's publication, the more immediate comments should have the greatest impact on recent publications. Was the PubMed Commons community engaging with the most recent scholarship and issues of the day? How immediate and constructive were the contributions into the system? Did the comments quickly catch errors and weaknesses that slipped through the peer-review/editorial process of recent literature or did they focus more on older articles that were nearing the end of their shelf life and perhaps warranted revisiting with an update? Each of the publications under review is identified by their publication date, and the duration between publication and post-publication peer-review is assigned one of the following *Timeliness* tags:

1. 6 months from date of publication
2. 6 to 24 months from date of publication
3. 3 to 5 years from date of publication
4. 5+ years from date of publication

PMIDs: Article Level Metadata within PubMed Commons

After evaluating each of the reviews, and making the tagging assessments described above, it is important to learn more about the articles in the dataset. Each of the PMID numbers is used to extract the complete PubMed bibliographic data of each citation that is included in the sample dataset. The bibliographic data comprise a dataset that is entered into an R statistical

application designed to calculate bibliometrics analyses, Bibliometrix and Biblioshiny.⁶⁰

Biblioshiny is the web application layer developed within the Bibliometrix tool, and allows one to render citation analytics directly from the extracted PubMed data. Biblioshiny will provide reports on the citation data and calculate frequency of the specific journal names, article dates, authors, and subject headings, of the articles under discussion in PubMed Commons.

The Biblioshiny application will also be useful in identifying health topics within the entire corpus of PubMed Commons citation data, by specifically identifying which of the 7629 contributions may have been responding to major crises or discoveries in the health sciences that arose during the years in which PubMed Commons was active. The data will be queried to determine if current events bear any perceptible influence on dominant subject matter under discussion within the PubMed Commons community. Was there any perceived effort to contribute to the published literature that was addressing health concerns that dominated the news and pop culture during the 4 ½ years that the PubMed Commons community was active? These questions can help guide an assessment of the utility of PubMed Commons during public health concerns of the day.

The sample dataset of PubMed Commons reviews provides a lens into the effectiveness of this strictly controlled post-publication peer-review forum. As the threshold to membership within this community was tightly controlled by the moderators, measuring success with a simple count of participants seems to neglect the efforts that may be present in the reviewer contributions. The assessment cannot simply look at the number of reviews and the quantity of PubMed records that elicited some comment, but rather the percentage of contributions that offered some value-added information. Obtaining percentages does not require an in-depth

⁶⁰ Aria and Cuccurullo, “Bibliometrix.”

analysis of the entire 1.5 million words that span across the 7629 comments, but rather inferential statistics can provide a sufficiently accurate reflection of these percentages by using this substantial statistical randomized sample of PubMed Commons data.

Comparison with PubPeer

The demise of PubMed Commons has often been attributed to its strict rules against anonymous participation.⁶¹ As an alternative, users hoping to participate in a post-publication peer-review forum and still remain anonymous could easily join PubPeer. and also avoid the exclusive membership requirements monitored by PubMed Commons. To evaluate the prevalence and utility of anonymous participation, it will be helpful to compare the conversations and debate that swirls around the same articles as discussed in these two separate platforms. In what ways do the number of contributions and prevalence of anonymous participation differ between the PubMed Commons community and the PubPeer community when the same paper is being critiqued and debated? By comparing the frequency of anonymity between the two systems on an article which is creating extensive discussion and viewpoints, it may be possible to judge whether there is a greater willingness contribute and if a more constructive dialog will persist.

Interviews with Participants

As a complement to this quantitative study of a random sample of entries, this study includes an additional qualitative component based on interviews with several former members of the PubMed Commons community. The interviews are designed to collect the participants' impressions of post-publication peer review, the PubMed Commons model, and the role of

⁶¹ Dolgin, "PubMed Commons Closes Its Doors to Comments."

anonymity in the process of post publication peer review 9. PubMed Commons participants are easily identifiable within the publicly available dataset (ex. Appendix 1). Five former members of the PubMed Commons community participated in 30 minute one-on-one interviews. The random selection of potential interviewees was limited to members who participated in PubMed Commons between 2014 and 2017 inclusively and for whom a valid email address could be found. Twelve invitations were sent, eight individuals responded, and five interviews were accepted. Three individuals were unable to participate and the remaining four did not respond. Interviews were conducted over a Zoom video conference call. Four open ended questions were asked to prompt an open-ended response in which interviewees shared their opinions and suggestions for optimizing post-publication reviewing:

1. As a contributor to a post-publication peer review forum, what do you feel were some of the strengths and weaknesses of this activity?
2. What were some of the incentives that you felt were important in motivating you to devote the time and effort to contribute to the online forum?
3. Did you also offer post-publication feedback/commentary in other venues and formats (letters to editor; follow-up publication; critique in conference presentation etc.)? What are some of the pros/cons of these alternatives?
4. Have the reviews within some post-publication peer review forum prompted your own research (or understanding) to evolve in ways that might not have been possible without having access to that reviewer's comments? If so, please tell us how?

The responses and impressions of the interviewees will be compared to the results reflected in the qualitative analysis of the PubMed Commons data. Summarizing common themes, observations and concerns expressed by the interviewees will help to shed light on the strengths and weaknesses in the forum from the end-user perspective. In retrospect, how might the user experience for those closest to PubMed Commons help us inform recommendations for the

future success of online scholarly communication fora where post-publication review is facilitated.

Chapter IV

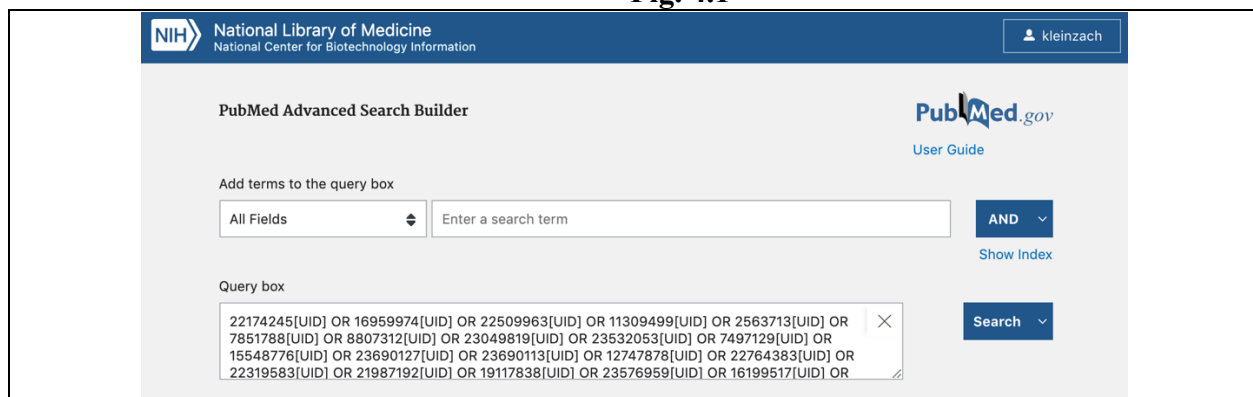
Data analysis: Results & Discussion

PubMed Commons: Medical Literature Reviewed between 2013 and 2018

The PubMed Commons data contains unique numerical identifiers (PMID) that make it possible to identify and locate each article under discussion. The PMID is a unique number assigned to a PubMed record whenever new article citation records are created in the database. Knowing the PMID allows one to directly access the PubMed record and the specific article level metadata for each publication. PubMed Commons has captured the PMID for each PubMed Record that contained post-publication peer-reviews by the PubMed Commons community.

To extract each publication discussed in the forum between 2013-2018, a simple search strategy was executed in the PubMed database. Every PMID represented in the PubMed Commons dataset was added to the PubMed search query. The example illustrated in figure 4.1 demonstrates the structure by combining each PMID in the search query box using the Boolean operator “OR”.

Fig. 4.1



The screenshot displays the PubMed Advanced Search Builder interface. At the top, the NIH logo and text "National Library of Medicine National Center for Biotechnology Information" are visible, along with a user profile "kleinzach". The main section is titled "PubMed Advanced Search Builder". Below this, there is a section "Add terms to the query box" with a dropdown menu set to "All Fields" and a text input field labeled "Enter a search term". To the right of this input field is a blue button labeled "AND" with a dropdown arrow, and a link labeled "Show Index". Below the "Add terms" section is a "Query box" containing a long string of PMID numbers separated by "OR" operators, enclosed in a text area with a close button (X) and a search button labeled "Search".

Example of PubMed search strategy to recall all articles discussed in PubMed Commons

The result of this search strategy retrieved 5,994 PubMed records representing the articles which were discussed in the PubMed Commons forum during the 4 ½ year period. The citation

data from this list of PubMed results was then exported into a single datafile. The single datafile allows one to examine the bibliographic details more closely. The datafile was analyzed using the open-source software application Bibliometrix using the R programming platform and the Biblioshiny interface.⁶² The analytical and reporting tools in Biblioshiny provided a clear lens into the scope of the articles, journals, topics, and publication dates that fostered the post-publication peer-review comments in PubMed Commons.

Before examining the results of the 5,994 citations, it should be noted that this number of retrieved records is a little less than the total number of 6,008 unique PMIDs that are included in the raw data from the complete PubMed Commons dataset. To reconcile this discrepancy, the extracted citation data and PMIDs were reviewed more closely. It became clear that 14 PMIDs from 2013-2018 are no longer in the PubMed database. This is not unusual, and there are several reasons why a PubMed record (and its associated PMID) might eventually be deleted from the database. Regular annual maintenance of the MEDLINE/PubMed database will sometimes remove, merge or significantly update the PubMed records in the index.⁶³ The most common circumstance is when multiple versions of the same paper are indexed in PubMed more than once. For example, a post-print manuscript or early release of an “ahead-of-print” publication, combined with the published version of the article may each trigger new PubMed record (and new PMID) at different times in database. Therefore, it was not surprising to find that 14 of the PMIDs in the PubMed Commons dataset were no longer included in the PubMed database now over 3 years later.

⁶² Aria and Cuccurullo, “Bibliometrix.”

⁶³ “MEDLINE®/PubMed® Data Maintenance Overview.”

Observations of Articles in Forum Discussion

Most comments in PubMed Commons concerned recently published articles, although older articles (more than 5 years old) were also revisited with important updates and reassessments. Articles that formed the bulk of the discussion on PubMed Commons were published between 2012 and 2017. As this five-year time frame roughly corresponds to the same time frame that PubMed Commons was active (2013-2018), it demonstrates that the community was most interested in discussing recently published scientific papers. It is interesting to note the 12-month shift in the span of publication dates compared to the lifespan of the PubMed Commons service. PubMed Commons was active for only a few months in its first and last calendar-year of its existence, 2013 and 2018. Only the years from 2014-2017 (inclusively) comprised a full 12 months of PubMed Commons activity. Therefore, it is not surprising to see that articles published during the year 2014 received the majority of post-publication peer-reviews in the system with a total of 1,144 papers receiving attention. The year 2015 contained reviews for 942 publications, 2016 with 777 and in 2017 545 articles received some attention in the PubMed Commons community (Table 4.1).

Table 4.1

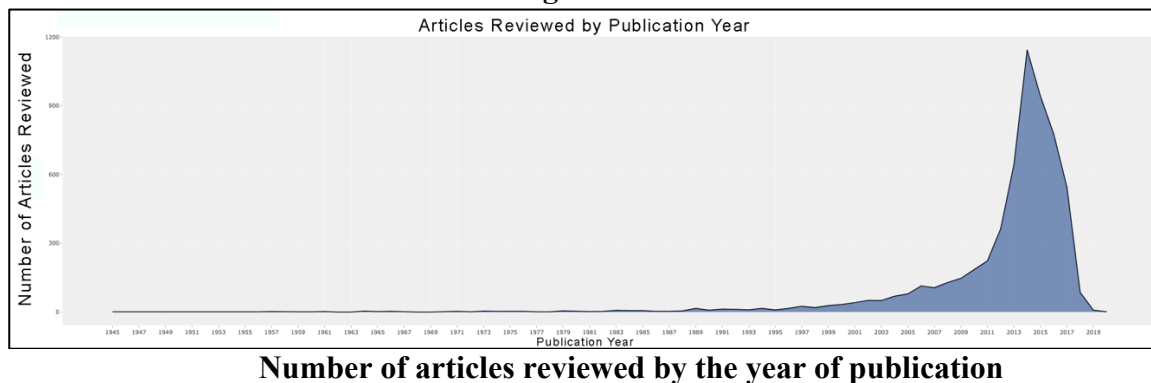
Year	Articles		Year	Articles
1945	1		1988	5
1946	1		1989	16
1947	1		1990	8
1952	1		1991	13
1955	1		1992	12
1956	1		1993	10
1957	2		1994	16
1958	1		1995	9
1959	1		1996	16
1960	1		1997	25
1961	2		1998	19
1964	4		1999	28
1965	2		2000	33
1966	3		2001	41
1967	1		2002	51
1970	1		2003	50
1971	3		2004	69
1972	1		2005	79
1973	4		2006	114
1974	3		2007	106
1975	3		2008	129
1976	3		2009	147
1977	1		2010	185
1978	1		2011	223
1979	5		2012	363
1980	4		2013	643
1981	2		2014	1144
1982	3		2015	942
1983	7		2016	777
1984	6		2017	545
1985	6		2018	85
1986	3		2019	8
1987	3		2020	1

Distribution Dates of Articles Reviewed in PubMed Commons

Articles published in 2014 benefited by having 3 full years of exposure on PubMed Commons for the community to retrospectively discover and engage. Publications from 2015 to March 2018 received a significant number of reviews in PubMed Commons at a steady pace, albeit fewer in number. This steady reduction in reviews during the years following 2014 cannot be dismissed as evidence of waning popularity. Neither can the slightly lower number of articles under review from 2015 to 2018 be interpreted as a decline in user interest. Instead, the numbers need to be considered in the context of the time-gap between the date of publication and the duration in time that allowed a reviewer to enter comments into the system. For example, articles published in November 2017 would have only 3 months of opportunity to be picked up for a review in PubMed Commons. Articles published in 2014 had over 36 months to make an impact on a wider readership and prompt a new review. This longer exposure to the PubMed Commons community naturally provided greater opportunity for the 2014 articles to receive the most commentary. Considering this factor, the pace of reviews for years 2015, 2016, 2017 should not be read as a “decline”, but rather need to be placed in the context of time-lag between the citation’s availability on PubMed and eventual discoverability, impact, and response by the PubMed Commons community.

The publication dates represented in the articles discussed in PubMed Commons span 75 years. However, as Figure 1 shows, the total number of papers discussed between 1945 and 2003 amounted to no more than 384 papers (6%).

Figure 4.2



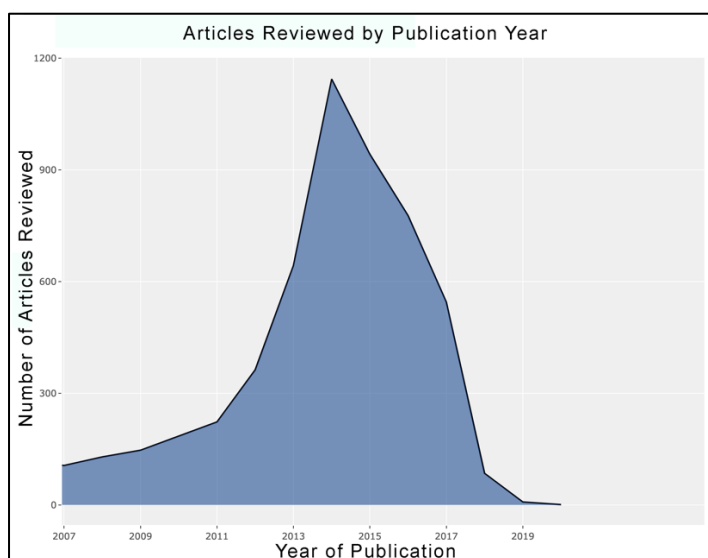
Most of the publication years represented in the group only have 1 article under discussion, while several years prior to 1970 are not represented at all. Indexing in PubMed prior to 1990 is sporadic, but these numbers would be low for two obvious reasons; the article's waning impact on scientific research over time, as well as the fact that fewer items have been indexed in the PubMed database prior to 1990. PubMed Commons activity begins to pickup with several dozen articles only after the year 1997.

The data also shows PubMed Commons activity on 8 publications dating from 2019 and 1 from 2020. This may seem curious in light of the fact that PubMed Commons activity ceased in March 2018. These updated citation records are another example of the dynamic nature that records may have in the PubMed database. The 2020 PubMed record refers to a new edition of a freely available online book. In 2017 the PubMed Commons reviewer posted a comment on the PubMed record for the previous edition of this online resource. The PMID for the most recent edition of this online resource remains the same. In this case, the older edition of the online textbook is taken down, but the PubMed record remains the same with the only change being the link to the 2020 edition of the e-book. Judging by the review that was entered on PubMed

Commons in 2017, the reviewer seems to be pointing out some error in the vocabulary or misuse of the terms “Mycobacterium” vs “Mycoplasma”.⁶⁴

Of the 5,994 articles that prompted the PubMed Commons community to participate in the system, over 75% (4,508) were published between 2012 and early 2018, when PubMed Commons ceased accepting contributions. (Figure 4.3) The majority of post-publication peer review activity concerned scientific literature that was still very current to the medical fields represented in PubMed. A more detailed observation of this trend was confirmed in assessing the “Timeliness” of the reviews, as will be discussed later in this chapter.

Fig 4.3



PubMed Commons Quantity of Reviewed Articles by Data of Publication

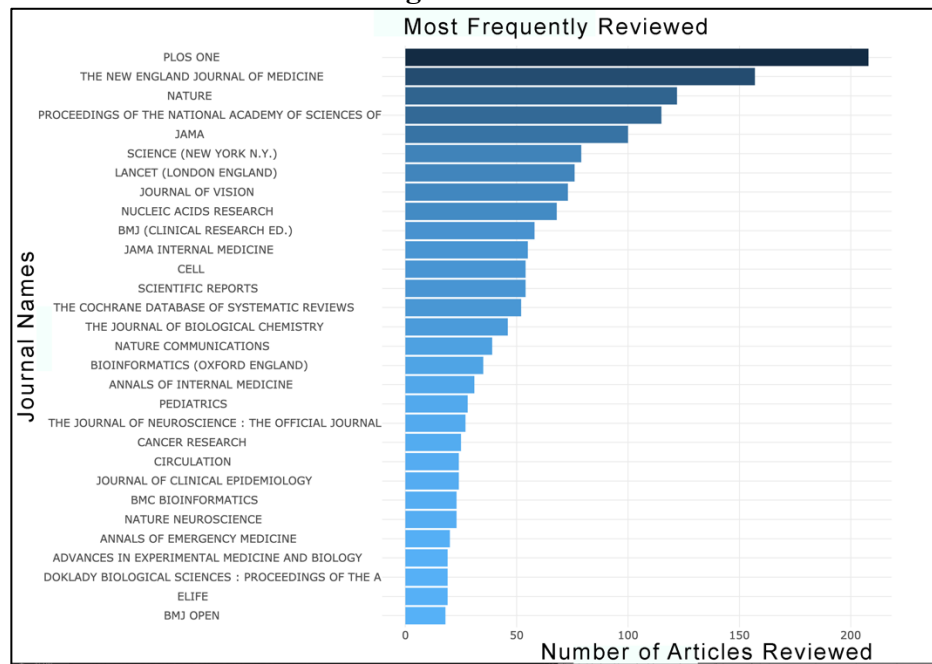
While PubMed indexes over 6500 journal titles, the PubMed Commons discussions focused on a narrow subset of the journals in the database. The literature discussed by the reviewers in the forum comprised a total of 1881 journal titles. Many of the journals that had an

⁶⁴ DANIEL BROWN: “Mycobacterium is not the same thing as Mycoplasma. Never has been, never will be.”. PubMed Commons 6/30/17 13:14. Commenting on PMID 28613762.

article reviewed in the PubMed Commons forum are only represented by 1 article that was published in the journal title. Canonical high impact journals dominated the attention of the reviewers.

More than half (52%) of the reviews in PubMed Commons came from 188 journals. The journal *PLoS ONE* contained the most articles (208) reviewed in the PubMed Commons forum, followed by *New England Journal of Medicine* (157), *Nature* (122), *PNAS* (115), *JAMA* (100) *Science* (79), *Lancet* (76), *Journal of Vision* (73), *Nucleic Acid Research* (68), and *BMJ* (58). As figure 4.4 shows, the top 20 journals in the listing roughly correspond to the canon of high-impact medical journals. It is not surprising that the discussion by the health science authors contributing to the PubMed Commons forum focused on these journals. However, the list is dominated by a journal with a less familiar name by comparison and also a much lower journal impact factor than the major medical journals here, which warrants discussion. Publishing volume and open access availability of the research articles appear to also play a role.

Fig. 4.4



Top 30 Journals of articles reviewed in PubMed Commons

The 208 articles from PLoS One reviewed in PubMed Commons form an interesting case from a few perspectives. It is the only journal publisher in the top 10 that operates on a fully open access business model. All authors are charged a fee to publish within the PLoS journals, but this business model allows immediate access to read, download and redistribute the PLoS articles as soon as they are published. No subscription is necessary by the readership. Thus, each article in PLoS One would have been immediately accessible (from the date of publication) to any participant within the PubMed Commons community. Studies have shown that open access publishing is frequently associated with increased scholarly impact and clear citation advantage over other journals with the same readership.⁶⁵ This phenomenon is evident also in the articles accessed and reviewed by the PubMed Commons participants.

⁶⁵ Sotudeh and Estakhr, "Sustainability of Open Access Citation Advantage," 572.

Another reason why *PLoS One* significantly surpasses the other journals in the list of articles reviewed on PubMed Commons, is due to the sheer volume of publishing they produce every year. Table 4.2 below shows the top 20 journals that were discussed in PubMed Commons ranked by the publication output for the year 2017. (Appendix 2 shows a larger image for comparing all three sort columns.) In spite of its modest journal impact factor when compared to other prestigious medical journals in the grouping.

Table 4.2

Journal Title	Articles in 2017	Impact Factor	PMC List
PLoS One	17,879	2.776	1
Scientific Reports	17,152	4.011	13
Nature Communications	5,058	11.878	16
PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES	3,269	9.58	4
JOURNAL OF BIOLOGICAL CHEMISTRY	1,579	4.106	15
NUCLEIC ACIDS RESEARCH	1,279	11.147	9
NATURE	904	43.07	3
BIOINFORMATICS	861	4.531	17
SCIENCE	799	41.063	6
JOURNAL OF NEUROSCIENCE	777	6.074	20
Cochrane Database of Systematic Reviews	644	7.755	14
PEDIATRICS	558	5.401	19
CELL	454	36.216	12
NEW ENGLAND JOURNAL OF MEDICINE	321	70.67	2
LANCET	264	59.102	7
JAMA-JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION	212	51.273	5
JOURNAL OF VISION	204	2.089	8
BMJ-British Medical Journal	167	27.604	10
ANNALS OF INTERNAL MEDICINE	128	19.315	18
JAMA Internal Medicine	124	20.768	11

PubMed Commons Journal Title Ranked by publishing volume.
“PMC List” indicates ranking on most frequently reviewed journals.

As of Sept 2017, *PLoS One* had published 175,000 research articles since its launch in 2006,⁶⁶ the majority of which was published during the years that PubMed Commons was active, when *PLoS One* published over 20,000 research papers each year.⁶⁷ With the exception of *Scientific Reports* (Springer-Nature’s competing publication to the PLoS One mega-journal), the

⁶⁶ Admin, “A Publishing Milestone to Celebrate.”

⁶⁷ Davis, Phil, “PLOS ONE Shrinks by 11 Percent.”

PLoS One publishing volume outstripped the publishing rate of other scientific journals by over 250%. In addition to *Plos One*, *Scientific Reports*, *Nature Communications*, *BMC*, *BMJ Open*, *Elife*, and other journals operating on Open Access business models are all represented in the top 30 journals for the PubMed Commons most actively reviewed journals. The open access business model sets up an opportunity where more readers, reviewers, and content could be identified and commented upon. Additional journals which regularly make their content freely available after an embargo period, are also prevalent in the top 30 journal titles. Extensive research has shown a citation advantage for articles which are freely available in open access publishing options,⁶⁸ and the PubMed Commons response to freely available articles appears no different. Of the 6000+ articles discussed in PubMed Commons, 3,572 articles (59%) are freely available as of October 2020.

One final observation on the prevalence of reviews that are directed towards articles published in PLoS One and similar open access journals. On the publisher's site for PLoS journals as well as some other journals, there is a mechanism to leave comments within the publisher's web-based representation of that article. For example, post-publication reviews are encouraged within the PLoS One online journal system, and occasionally PubMed Commons reviewers would post cross-references to their reviews posted in the other system(s). In doing so the reviewer increases the exposure of their review efforts, but also catches the attention of the readers at the point of accessing the article via the article level on the publisher's website, and the database level in the case of PubMed Commons. Creating a link between the two locations by the reviewer introduced different participants into the dialog in which post-publication

⁶⁸ Piwowar et al., "The State of OA," 17.

reviewers on the PLoS site might not have had access to comment and contribute to the PubMed Commons forum due to the membership restrictions.

Research Subject Areas in Forum Discussion: Citations and Abstracts

Gathering together the dominant themes which attracted the PubMed Commons reviewers at a given point in time was another unique strength of the integrated model between PubMed and PubMed Commons. The most frequently occurring words in the metadata of the articles reviewed provides a lens into the article topics that prompted the most interest. Word frequency analysis on the titles and abstracts from the 2013-2018 data showed “cancer” as the most prevalent word for a disease. “Cancer” appears in 361 titles and is the second-most common word within the title index for the articles discussed on PubMed Commons. (The word occurring most frequently in the article titles is “trial”). Table 4.3 below shows the top 15 words that appeared in titles of articles under review.

Table 4.3

	Words	Occurrences
1	trial	373
2	cancer	361
3	patients	326
4	study	324
5	disease	293
6	human	254
7	randomized	252
8	review	245
9	treatment	243
10	clinical	234
11	cells	227
12	meta-analysis	217
13	systematic	207
14	analysis	204

Frequency of words in titles of articles discussed in PubMed Commons

Likewise, a word frequency analysis on the abstracts of the articles show “cancer” as the first disease that appears in the results list with 1,827 occurrences. “Cancer” is the 12th word in the order of frequency. The previous 11 words are general nouns that all reflect standard discourse in medical vocabulary (patients, study, data, group, treatment, cells, risk, methods, and clinical).

However, in a medical database the term “cancer” is still too vague to pinpoint the specific disease that is generating the most interest. Analysis on MeSH headings assigned to the articles tended to be a little more useful than title words in specifically understanding the focus of the subject matter and reviewer interests. While the data shows that “cancer” is the most frequent topics to appear in titles of the article, MeSH provides an extra level of definition to help map the article subjects to the areas under discussion in the PubMed Commons forum.

The MeSH vocabulary does not use the word “cancer” in its ontology. Instead, the specific medical term for cancer is Neoplasms. “Neoplasm” is defined by MeSH as “New abnormal growth of tissue. Malignant neoplasms show a greater degree of anaplasia and have the properties of invasion and metastasis, compared to benign neoplasm.”⁶⁹ The MeSH ontology also recommends that those who wish to search on the topic of “cancer” search under the MeSH term “Neoplasm” instead. Table 4.4 shows the frequency of the top 15 MeSH terms appearing on indexing of the articles reviewed. Many of these terms are “sub-headings” which are easy to identify by their lower-case. The Capitalized Mesh headings represent major subject headings.

⁶⁹ “Neoplasms - MeSH - NCBI.”

Table 4.4

	Words	Occurrences
1	Humans	4316
2	Female	1988
3	Male	1947
4	metabolism	1516
5	genetics	1382
6	Animals	1267
7	Methods	1190
8	Adult	1037
9	Middle Aged	998
10	physiology	919
11	Aged	738
12	drug therapy	699
13	drug effects	651
14	Pathology	604
15	therapeutic use	599

**Word Frequency : Top 15 Medical Subject Headings
(Highlight shows sub-heading examples)**

The index term “Neoplasm” appears 915 times in the headings assigned to the articles under PubMed Commons review. However, the MeSH term “Neoplasm” tells us very little about the type of Neoplasm (cancer) discussed in the articles. Cancers are often mentioned in the context of the physical location on the body where the disease is present. The Neoplasm term in the MeSH vocabulary also uses the specific anatomical location of the cancer in the official MeSH term, for example there is a MeSH term for “Pancreatic Neoplasms” (assigned to 37 articles), “Prostatic Neoplasms” (assigned to 61 articles), and many more examples. The MeSH heading for “Neoplasms” (without specific anatomical designation) was assigned to 156 articles (Table 4.5). Breast Neoplasms, accounted for the most occurrences in the dataset with 103 articles, as this was the most frequently used MeSH term for a specific form of cancer (Table 4.6).

Table 4.5

	Words	Occurrences
45	Double-Blind Method	197
46	Molecular Sequence Data	196
47	Cell Line, Tumor	193
48	Follow-Up Studies	181
49	Randomized Controlled Trials as Topic	180
50	antagonists & inhibitors	179
51	classification	179
52	diagnostic imaging	164
53	Brain	162
54	microbiology	162
55	Child, Preschool	161
56	Rats	160
57	enzymology	159
58	Retrospective Studies	157
59	Neoplasms	156
60	surgery	156

Medical Subject Headings (Frequency)
Main Subject Headings (capital letter)

Table 4.6

	Words	Occurrences
86	Base Sequence	118
87	economics	118
88	Computational Biology	117
89	Gene Expression Profiling	117
90	Magnetic Resonance Imaging	117
91	Information Storage and Retrieval	116
92	Disease Models, Animal	115
93	Sequence Analysis, DNA	113
94	growth & development	107
95	Severity of Illness Index	106
96	Biomarkers	105
97	Internet	104
98	Obesity	104
99	Breast Neoplasms	103

Medical Subject Headings (Frequency)
Example additional “Neoplasm” terms

The MeSH indexing was helpful in obtaining a general idea of the dominant subject matter of the articles that interested the post-publication peer reviewers. However, the MeSH terms alone cannot explain why a given article elicited interest within the PubMed Commons community. In other words, an analysis of the subject matter does not indicate what caught the attention of the post-publication reviewer to write about the paper. Did they choose to review it because the article was about a rare cancer, or did they review the paper because of something in the methodology or treatment that turned out to be the central issue or problem in the paper? Indexing of abstracts, titles and controlled vocabularies like MeSH are essential for discovery and access, but when an index can also integrate the conversational language as in the PubMed Commons reviews, a more holistic assessment of the article and its reception by commenters is possible.

The dominant themes in the corpus of articles discussed in the PubMed Commons forum shows similar parallels to the dominant words written in the comments by the post-publication peer-reviewers. The data analytics above looked specifically at article citation data. Below we will turn to the comment data. By analyzing the words used in the PubMed Commons postings, one learns much more about how Neoplasms (cancer) are being discussed, including the specific cancerous exposure or elements of treatment and prevention that has interested the reviewers within forum.

Post-Publication Peer Review Discussion: Themes, Subjects, and Indexing in Context

The contributors to PubMed Commons posted over 7629 post-publication peer-review comments on over 6000 citation records within the PubMed database between June 12, 2013 and February 20, 2018. During the 4.5 years that PubMed Commons was online, the members of the community posted between 120-170 comments into the system each month. Table 4.7 shows the contribution totals per year with an estimate of average contributions per week. The highest number of contributions in PubMed Commons occurred during 2014, its first-year full year of activity, with 2032 contributions. The level of activity remained steady for the next 3 full years with 2015 dipping down slightly to 1566 contributions before rising back up in 2016 with 1866 more reviews added into the forum. The year 2017 saw the least amount of activity in the system, but still included 1452 reviews posted by the members. When the contributions are viewed on their weekly averages, there was minimal fluctuation in the level of activity throughout the period. Even when estimating the pace of contributions that contained the final 51 days that began with Jan 2018, PubMed Commons was on track to come close to matching the average annual rate of contribution. The pattern of contributions over the 4 ½ year period does

not indicate a steady decline but seemed to be leveling off to about 1700 post-publication reviews contributed each year.

Table 4.7

Year	Total Annual PPR Contributions	Total Weekly PPR Contributions
6/2013 [begin]	537 (est. 1040 per year)	20
2014	2032	39
2015	1566	30
2016	1866	35
2017	1452	27
2/2018 [end]	176 (est. 1300 per year)	25

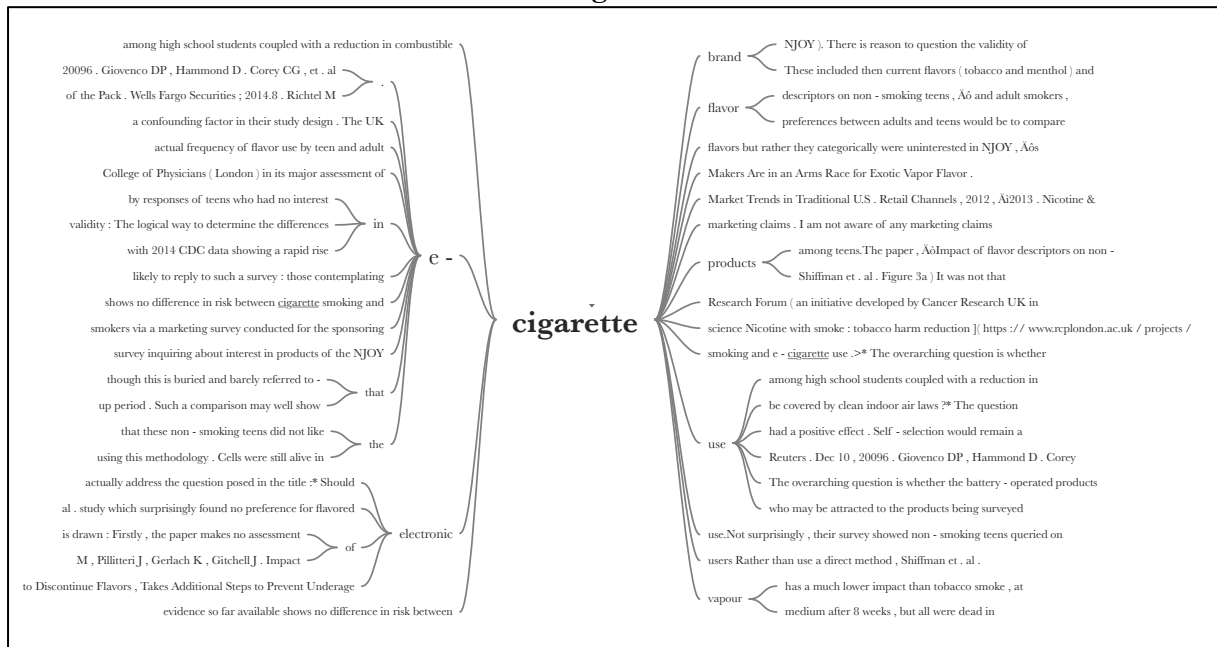
Annual Rate of contributions on PubMed Commons with weekly average

The PubMed Commons dataset indicates that 2044 reviewers posted comments into the forum. The majority of the participants (1,237) contributed only 1 review, however this only accounted for 16% of the total amount of reviews. Of the 7629 reviews posted into the PubMed Commons forum, 50% were written by 100 reviewers. The data also shows that the ten most prolific reviewers in the forum provided over 1400 reviews. With roughly half of the contributions coming from only 100 PubMed Commons members, the forum activity was dominated by less than 5% of the active membership. If the assessment of PubMed Commons was based entirely on the fraction of highly active voices in the forum, then indeed this small percentage might seem to be problematic. However, the consistent participation of these 100 reviewers should not detract from the efforts and quality of the contributions that stemmed from the infrequent participants.

The topics that the reviewers were discussing in their comments align with the subject matter of publications as analyzed in the section above. Interestingly, the word-analysis in the comments provide a more direct window into the specific topics the articles triggered in the

reviewer's response, rather than viewing the article's assigned MeSH terminology. Here too, cancer, cigarettes, and autism are all high on the list of diseases and exposures that were under discussion in the PubMed Commons reviews. However, it is easier to identify the specific context of these broad subjects under discussion, because the reviewer's writing follows a more conversational tone rather than the esoteric details in the abstract. In many ways the additional context provided in the reviewer's comments adds a new discovery layer to the index which augments the more formal MeSH vocabulary and Title/Abstract index. Searching within reviewer comments was an option that PubMed had configured into the search engine. For example, "cancer" and "cigarettes" were among the most highly mentioned diseases and exposures in both publication titles and PubMed Commons discussions, however, it is only in the natural-language clustering from the PubMed Commons reviewers that we learn that "E-Cigarettes" were generating a vast amount of the posted comments during this time (Figure 4.5).

Fig. 4.5



Word Map for “cigarette” - identifies E-Cigarettes as a dominate theme in comments

The MeSH vocabulary at the time did not include an entry term for E-Cigarettes until finally introducing the term “Vaping” during the last full year that PubMed Commons was active in 2017. The discoverability of many of these earlier articles on the rising popularity of E-Cigarettes and vaping became more discoverable through the inclusion of the common discourse used by the reviewers within the PubMed Commons reviews posted to the PubMed record. Separately, the specific context and forms of “cancer” that were also discussed in the forum are also more directly referenced in laymen’s terms within the post-publication reviewer’s comments. Here too, the comments follow the more casual written dialog between two experts in the field, but not overly condensed technical summary that formed the standard abstract submitted to the PubMed index by the publisher. The voice of the reviewer summarizing their observations of these articles post-publication not only enriches the indexing of the database, but also brings another layer of discoverability which could ensure the article is included within an

end-user's list of search results. The dialog in the comments and reviews will contain the evolving vocabulary in the profession well before the creation of a new MeSH term.

PubMed Commons Contributions: Qualitative Review & Assessment

The qualitative analysis was conducted on a random sample of 155 post-publication peer-reviews posted to PubMed Commons between June 2013 and February 2018. This represents the full term for which PubMed Commons was accepting contributions from reviewers participating in the forum. Each of the 155 reviews was read in full and assessed using the criteria outlined in Chapter 3. The results continue to demonstrate that the overwhelming majority of contributions were providing value-added content which was unique to the PubMed database and created direct connections between related scientific publications and online content.

In both the random sampling of 155 reviews and the full dataset of 7629 reviews, the two most common “words” within the batch of reviews are the acronyms “HTTP” (or “HTTPS”) followed by “PMID”. Together these acronyms appear over 10,000 times and signify that the comment is providing a direct link to connect users to related external online content. The HTTP references are followed by a URL pointing to additional content and the PMID indicates that some unique PMID linking to recommended readings in the PubMed database. The HTTP and PMID references within the comments will provided access to additional scientific information, supplemental content including open data, public versions of otherwise restricted content, immediate corrections and updates to outdated findings, software or methodologies. This benefit did not require any more than one review to contribute to the PubMed record via PubMed Commons, nor did it matter if it was a one-time participant or a contributor listed in the top 10 most-active list, the result successfully served one of the most beneficial goals that PubMed

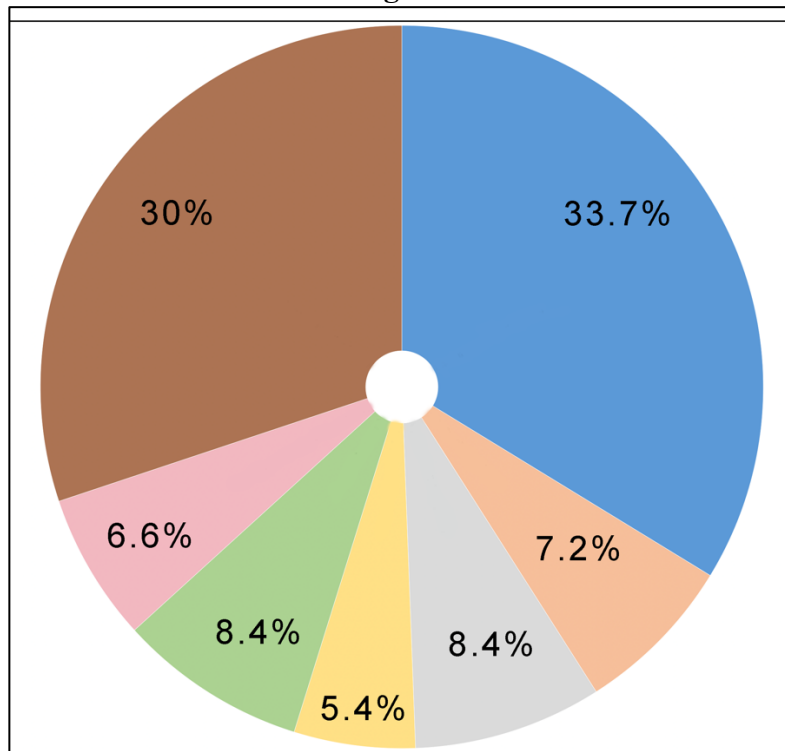
Commons set out to achieve – to build on the scientific record with dynamic contributions from the scientists who read and publish within the discipline.

Looking more closely at the reviews and the qualitative assessment categories, the contributions continue to show a high level of value-added benefit. The post-publication review data was evaluated for its overall constructiveness, impartiality, contributor intent, timeliness and reception. Using the NVivo software to track and quantify the tagging of each comment in the PubMed Commons sampling, the engagement of the community participants became much more visible. Irrespective of the total number of persons who might have qualified to join PubMed Commons, the data analysis shows the scope and dedication that had been invested in the post-publication reviews. The random sampling of comment data below provides further strong evidence supporting the fact that the PubMed Commons entries contained substantial contributions which addressed challenges and affirmations to the article under discussion.

Assessment Results: Contributor Intent & Reception

In the measure of “Intent”, each post-publication review was evaluated to ascertain the overall objective of the reviewer’s posting. Over 86% of the contributions (A+B+C+E+F) in PubMed Commons provided a reference to additional research that supplemented the article under review (Figure 4.6). The remaining 14% of contributions (D+G) offered short commentaries, unsupported contradictions, or simple praise without citing any additional references. This is not to imply that these simple commentaries were uniformly weak additions into the forum, but unlike the majority of contributions, these commentaries did not support their argument (or praise) with any additional literature or supplemental data.

Fig 4.6



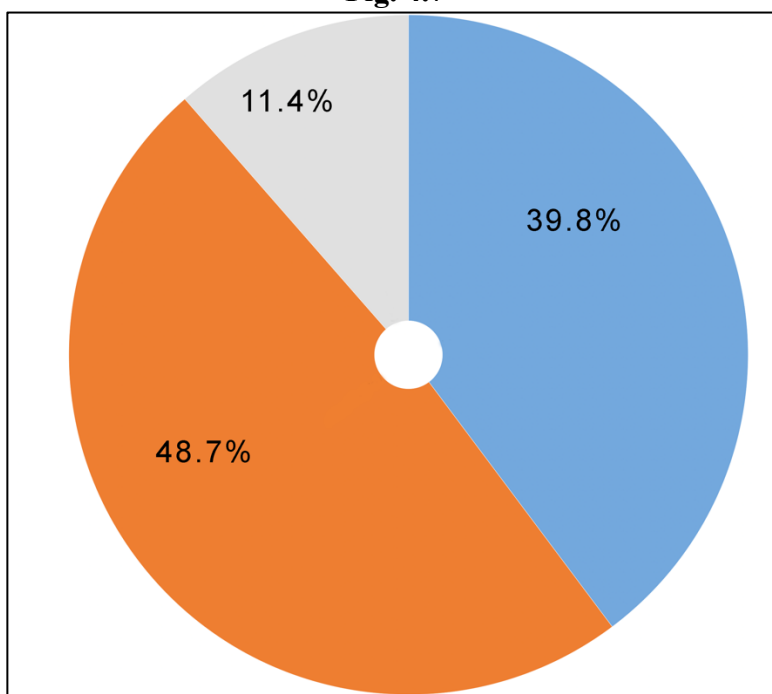
**Grouping commenter objectives that motivated participation
(Contributor Intent)**

- 33.7% - [A] Directed reader to external “contradictory” evidence
- 30% - [B] Directed reader to a more recent external content
- 8.4% - [C] Directed reader to a free version of the article (avoid paywall)
- 8.4% - [D] Simple praise and gratitude
- 7.2% - [E] Directed reader to research data
- 6.6% - [F] Directed reader to external “supporting” evidence
- 5.4% - [G] Simple contradiction or complaint

Within the contributions that contained references to supplemental publications and research data, over 33% of the comments (A) did so as part of a reviewer’s challenge to the original author’s article. The contradictory argument or concerns raised by the reviewer were often supported by additional scientific publications as a recommendation for other readers to locate and consider. The other 53% (B+C+E+F) of the comments that referenced supplemental content intended to strengthen or augment the author’s original argument or add perspective. Indeed, in 46% of the contributions (B+C+E) the reviewer often pointed to either an updated

version of the article, supplemental information & data or direct users to a freely available copy of the article which readers could then easily download. Included in that number were frequent occasions when the comments, updates, or external links to supplemental data were directly provided by the authors of the article under review.

Fig. 4.7



Distribution of reviewer reception to the article under review

11.4 % - [A] Positive Reception
48.7% - [B] Neutral Reception
39.8% - [C] Negative Reception

The overall tone in the reviewer's comments and the reception of the article under review was predominantly either neutral or negative. Almost 40% of the comments [C] struck a negative or contradictory tone towards the original article, where the reviewer was clearly expressing disagreement, challenges or concern with the authors of the original paper. The majority of reviews (50%) maintained a balanced tone without overtly praising or dismissing the findings in the original article. The neutral reviewers remained non-critical in their assessment of the paper,

however they frequently offered links to additional content and related research on the same topic. The neutral reviewer would often raise a few questions that were prompted by the original paper, but only indirectly point out where (or whether) the original paper displayed flaws or weaknesses. Unlike the negative reviewer, the neutral reviews do not critique nor endorse the paper, but instead will typically suggest where additional references to related (or more recent) information is available. The reviewer might indicate that the external reference raises another viewpoint or alternate perspective, but they do not expose their preference for one author's view over the other. Interestingly, the reviews which offered only positive praise (without any constructive additions) were in the minority comprising only 11% of the contributions.

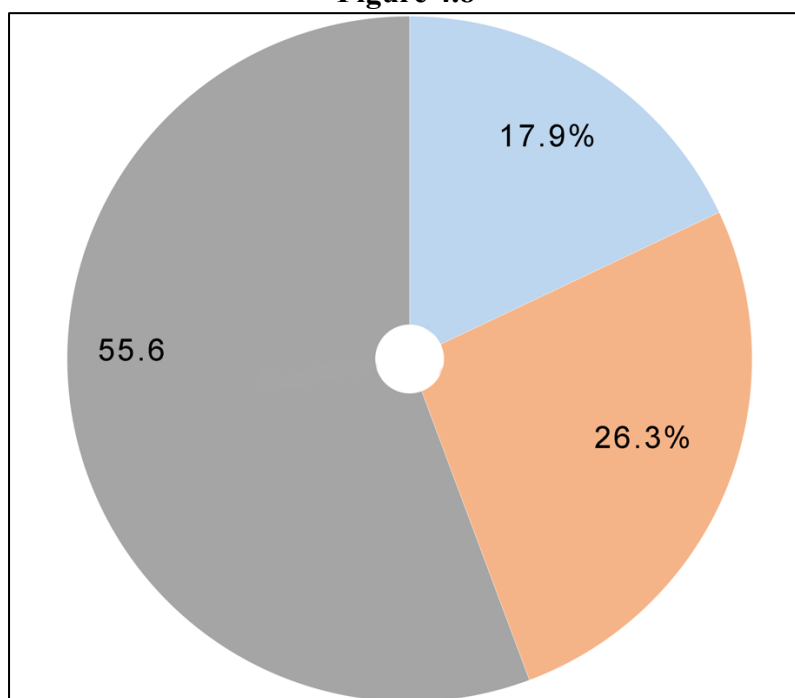
According to the data in the sample set, the majority of contributions in PubMed Commons intended to direct readers toward additional content that supplements the articles under review. This occurred whether it was to highlight immediate concerns that the reviewer encountered in a particular article, or when reviewers provided some update or concurring opinion to the conclusions in the article. The low percentage of contributions that offered no supplemental information demonstrates a consistent effort by the PubMed Commons community to ensure that their comments remained constructive, well informed, and sensitive to the important questions that peers might ask of the underlying research. This also correlates with the observation that so few comments were overtly positive. If indeed the post-publication reviewer has nothing more than praise for the article, then the effort to write a review does very little to add to what the traditional peer-review system had already affirmed in publishing the article in the first place. The study of this sample suggests that the predominant motivation to participate lay in the incentive to create value by updating a weakness within the publication or providing some thoughtful response to problems and questions raised by the article.

Assessment Results: Impartiality or Potential Bias

If the primary intent of the contributors was to provide both a review of the article and helpful links to additional publications, data, and online resources, to what extent did the reviewers do so with impartiality? Self-citation and referring to one's own publications as a source of evidence are not unexpected within publishing. Neither is it always a problem. However, if authors only refer to their previous publications as a source of authority, then any good argument can quickly seem diluted and appear biased. In PubMed Commons there would seem to be ample opportunity to use the forum as a means of promoting one's own work under the pretext of offering a post-publication peer-review. The assessment data showed that self-citation bias was not overly abused by the PubMed Commons community and, when it did appear, it was easy to identify. The rules regarding the lack of anonymity in the forum helped to provide an automatic disclosure when reviewers used only their own publications as supporting evidence to their critiques on another paper. Readers could then assess the reviewer's comments with either greater confidence or more suspicions as they thought best in each case.

Each contribution in the randomized sample data was reviewed for evidence of self-citation in the PubMed Commons contribution. Post-publication peer-reviewers referred to their own publications in 18% of the comments (Figure 4.8). The most common type of self-citation-comment involved the author of the original article using the PubMed Commons forum as a mechanism to post new information about their own article.

Figure 4.8



Percentages of comments demonstrating Impartiality or Potential Biases

55.6% - [A] Post-Pub Reviewer is 3rd party to source and external reference

26.3% - [B] Post-Pub Reviewer is Source Author

17.9% - [C] Post-Pub Reviewer is External Reference Author

Over 26% of the comments [B] were entered by one of the authors of the same article under review. Thus, the majority of these self-citation-commentaries were contributed by the same author for whom the PubMed citation record was created. This demonstrated another novel use and benefit to having PubMed Commons integrated with the PubMed database. The PubMed Commons forum offered an immediate opportunity for the author to provide updated data, methodologies or supplemental information. As was the case in many past contexts as well, authors today like to engage in post-publication review of their work. The flexibility for the author to provide dynamic content within the PubMed record had less to do with self-citation vanity and more about ensuring that their article was supplemented with relevant updated

information for future researchers. Authors would occasionally enter into a discussion when other reviewers posed questions specifically addressed to the author within the posted review.

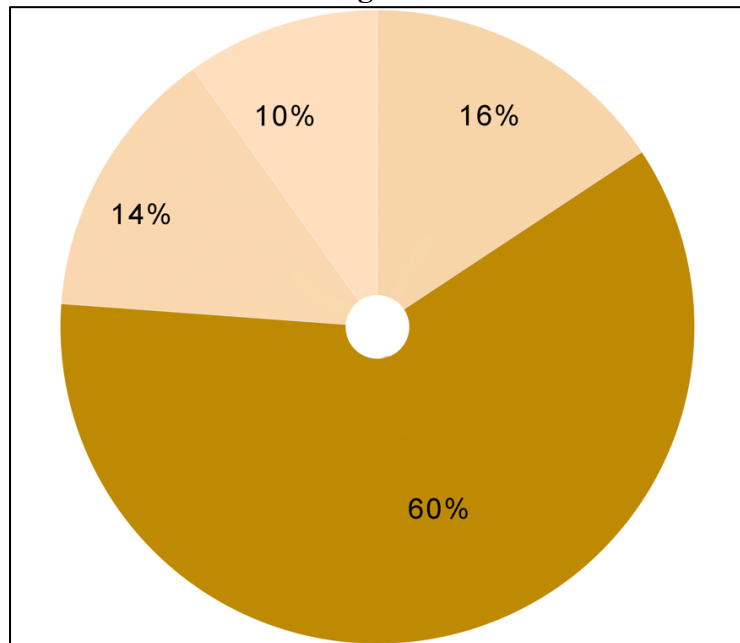
The majority of the post-publication comments in PubMed Commons did not demonstrate bias or partiality toward the original article or the externally cited references recommended by the reviewer. In over 55% of the reviews [A], the reviewer had no visible connection as an author of the resources that were being cited or commented on.

Assessment Results: Contribution Timeliness and Constructiveness

The time gap between the publication date and post-publication reviewer's response is important to consider in tandem with the constructiveness of the comment posted in the forum. As reviewers' critiques and recommendations were instantly visible on the PubMed record, the forum provided an opportunity to rapidly respond to the most recent publications reflecting current trends in the health sciences. Were the reviewers predominantly discussing and responding to recent literature? To what degree were the contributions attempting to provide substantial constructive feedback?

The PubMed Commons data showed that 76% of the reviews (A+B) addressed publications that were less than 2 years old at the time when the reviewer posted their comment (Figure 4.9). More importantly, 60% of the comments (A) focused on articles that were published less than 6 months prior to the date of the PubMed Commons review. The timeliness of the vast majority of postings demonstrates another marker of success in the PubMed Commons system by offering a platform to immediately respond to the most recent publications within the primary health science database that indexes the literature.

Fig. 4.9



**Article groupings based the time-gap between publication date and review
(Contribution Timeliness)**

- 60% - [A] 6 months from date of publication
- 16% - [B] 6 to 24 months from date of publication
- 14% - [C] 5+ years from date of publication
- 10% - [D] 3 to 5 years from date of publication

Platforms like Twitter, Facebook and personal Blogs are certainly capable of allowing the owner of the account to immediately post reviews of new literature. However, this is not as effective as distributing the reviews immediately within the PubMed database where most biomedical researchers go to discover recent literature. The PubMed Commons forum provided the double benefits of immediacy and discoverability by the widest possible readership with its connection to the very tool (PubMed) where the indexing of medical literature occurs. Given that PubMed Commons reviews were posted on the PubMed record, they were available to the broadest possible readership at the immediate point of need, as medical professionals were not the only individuals who could access the database. As a public resource supported by the National Library, the PubMed abstracts, expert commentary contributed by PubMed Commons,

and an ever increasing collection of freely available open access journal content had the broadest reach possible from the general public to consumers health advocates and expert scientists.

Interestingly, literature published over 5 years before the comment data was more frequently discussed (14%) than articles published between 3 and 5 years before the posted review (10%). The largest time gap between a publication date and a review stretched back 70 years: in May 2015, David Mage revisited a paper published in 1946 which looked at the dangers of certain sleeping positions as they relate to suffocation and Sudden Infant Death Syndrome (SIDS). His comment points out the significance of this early paper and how its discoveries and recommendations were largely forgotten until the 1960s. There are 57 articles dating before 1980 that were discussed in the PubMed Commons forum. The usefulness of the contributions ranges from a proud reviewer (Enrique de-Madaria) simply indicating that a 1945 publication was written by his grandfather:

“This case report was written by my grandfather José de Madaria in Spanish, in a local medical journal from Alicante, Spain in 1946, it’s amazing it has been detected by Pubmed!”

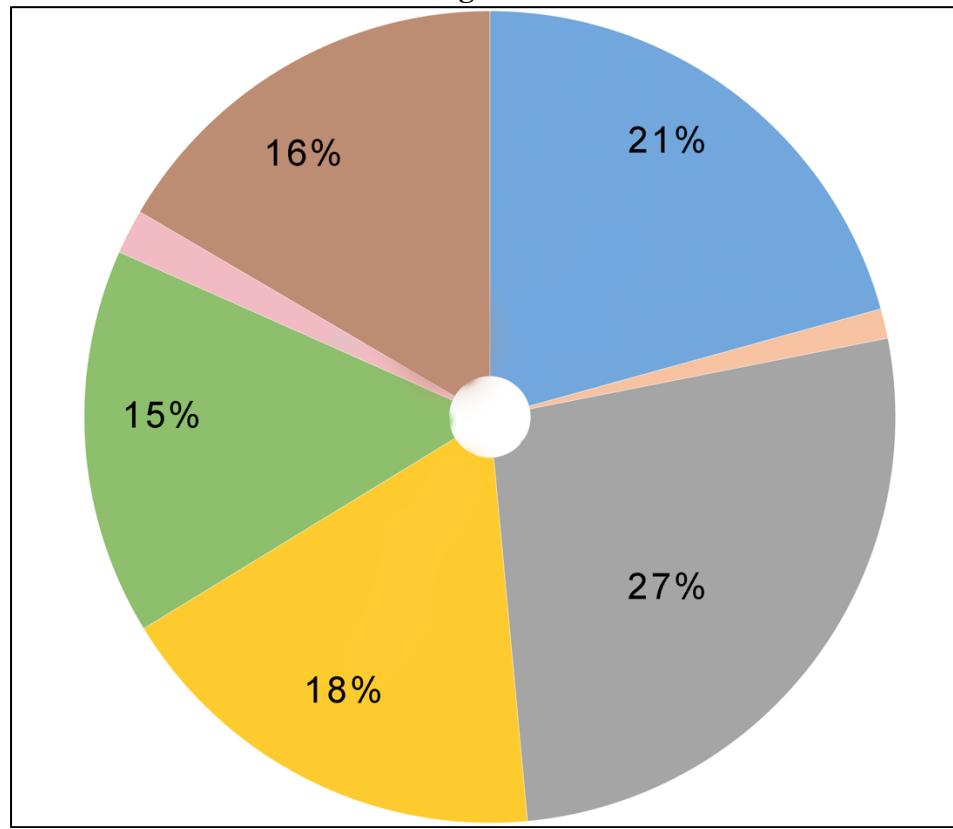
to the more constructive contributions where authors return to their earlier work from the 1970s to post updates and corrections to their earlier publications. Other examples provide historical commentary by revisiting earlier publications to note the significance of the research within the trajectory of medical history. Other reviewers look back at the earlier publications with commentary to indicate that the seemingly outdated publication has stood the test of time. The reviews for these much older papers seem to be triggered either by the historical importance of the paper or by a personal attachment to the earlier work when the original author (or grandson)

wishes to re-establish some connection to the earlier research. Where added historical context and new updates and open data is retrospectively attached to these older publications, the value added can be unique and otherwise impossible to obtain without the crowdsourcing contributions provided by the PubMed Commons community members.

The constructiveness of each contribution broadly correlates with whether or not the review added some new information or content that related to the article under review. The PubMed Commons community benefitted especially when a constructive critique or supplemental information was provided in the process. Reviews that created additional context for understanding the article provide another measure of success in the objectives that the PubMed Commons service set out to achieve. The overwhelming majority of post-publication contributions offered a constructive value-added context to the original article, and by extension, enriched the PubMed record with new content and information. Here too, the PubMed Commons system was unique in that it allowed a dynamic solution to ensure that authors and their peers could provide updates to an otherwise static record in the PubMed database.

The comment data in the sample set showed that 83% (A+B+C+E+F) of the PubMed Commons contributions contained constructive discussions, supplemental information, updates, and raised important questions for the article under review (Figure 4.10). All of which are examples of clear value added content that would otherwise not be easily known to the researcher interacting with this citation record on PubMed.

Fig 4.10



**Modalities of Constructively in the post-publication review
(Constructiveness)**

- 27% - [A] Reviewer provides link to supporting data/publication (Open Access)
- 21% - [B] Reviewer discusses their own work
- 18% - [C] Reviewer provides link to supporting data/publication (Toll Access)
- 16% - [D] Nothing constructive to offer
- 15% - [E] Review offers opinion without support
- 2% - [F] Retraction
- 1% - [G] Brief comment to the article minimal new information

In 21% of the post-publication reviews (B), the article authors posted a response or updated information to their own article at the center of the discussion. An additional 45% of the reviews (A+C) provided both contextual commentary, and recommendations and external links to related data and/or publications. Also included in this grouping of constructive critiques, 15% (E) did not include references to supplemental material, but contributed a thoughtful analysis of

the article in question. Retraction notifications and brief comments accounted for an additional 3% (F+G).

Approximately 16% (D) of the contributions appeared not to offer any constructive feedback to the article under review, but it is important to note that individual comments in the sample set were no longer seen within the full context of threaded discussion. Thus, the 17% figure includes several replies and general acknowledgements between reviewers and authors. In other words, it is not surprising to find comments in the system which serve only to offer a brief reply to an ongoing conversation rather than to provide additional constructive critique with every posting into the forum. The reviews lacking any constructive context would be much lower in number than this percentage implies.

One additional datapoint is available to help analyze the constructiveness of each review. Each contribution to the PubMed Commons forum was eligible to receive a simple indicator showing whether or not an end-user found the review to be helpful. The “Found Helpful” endorsement feature mimicked the now standard “thumbs-up” or “likes” aggregators that were at the time becoming common on Facebook postings, Amazon reviews, and online retailers. In the PubMed Commons version of this ranking system, the ratio of users who found a comment “Helpful” would be displayed next to the review on the PubMed record. For example, when a reviewer’s comments were posted on the PubMed record, if someone found a comment to be unhelpful, they could click the word “No” next to a prompt that asked, “Was this review helpful?”. Thus, if 2 people only clicked on “No”, the system would display “0 of 2 people found this helpful”. These end-user endorsements appeared on roughly 50% of the reviews in the PubMed Commons system. Endorsements predominantly expressing a negative (‘unhelpful’) impression of a review appeared on only 5% of the total number of reviews in the forum.

Positive endorsements were added to 45% of the total number of reviews. If a review gathered a “Found Helpful” response, the data shows that 87% of the respondents found the review to be helpful.

This feature was an important way for the community to anonymously express agreement or disagreement from the comments that were posted by the PubMed Commons reviewers. Unlike the commenting feature, the “Found Helpful” function allowed an easy way for anyone to either endorse or express disagreement without needing to identify themselves.

Comparison to PubPeer: An Alternative to PubMed Commons

During the years that PubMed Commons was active, PubPeer was also gaining attention as an online post-publication peer-review forum. In 2012 PubPeer launched as an online journal club encouraging post-publication review and commentary to foster discussion and help maintain scientific integrity.⁷⁰ The ability to participate in PubPeer was much less restrictive than PubMed Commons and open to anyone who chose to contribute a review. The key difference between the two systems was in their treatment of anonymous participation.

During its first year of activity, PubPeer did not have a mechanism to provide users with complete anonymity, and their early contribution rates roughly mirrored the same modest level of participation seen in PubMed Commons. However, in 2013 PubPeer enhanced its capabilities to accommodate fully anonymous contributions in the forum, and according to statistics shared by PubPeer in 2015, their comment activity dramatically increased after permitting complete anonymity.⁷¹ By 2015 PubPeer had seen over 37,000 contributions. In contrast, PubMed

⁷⁰ Couzin-Frankel, “The Web’s Faceless Judges.”

⁷¹ “Vigilant Scientists.”

Commons had seen about 4,000 contributions on 3,300 publications within that same time frame.⁷²

When the same article was available for comment in both PubMed Commons and PubPeer one can witness the impact of onymity vs anonymity and its effect on a willingness to participate. On controversial articles, it is particularly easy to find examples where the level of participation is greater when anonymity is permitted on PubPeer vs the same article on PubMed Commons. In a 2013 review discussing the recent launch of PubPeer, the author noted: “While anonymity can spur discussion, it does not elevate it.”⁷³ Likewise, in a lengthy response to criticisms against PubPeer that alleged potential attacks and abuse by anonymous reviewers, the PubPeer moderators wrote: “From our accumulated experience of moderating the 37000+ comments on PubPeer, we consider worries about abuse to be overblown.”⁷⁴ As it is, PubPeer does not allow immediate unmoderated postings by anonymous reviewers, and instead these contributions are screened by moderators to ensure they remain professional, constructive, and demonstrate verifiable facts when making claims or criticisms that target flaws in data visualization, methods, and research integrity. Writing in 2018, PubPeer founders Brandon Stell and Boris Barbour stated “These guidelines, combined with the constraints of the scientific discourse, which is inherently fact based, have, we believe, enabled a very high accuracy of user comments and allowed the site to avoid most of the problems associated with anonymous commenting elsewhere on the internet.”⁷⁵

An example of the increased level of participation and constructive dialog offered by the anonymous voices in PubPeer can be seen in the comment activity surrounding Michael R.

⁷² The PubMed Commons Team, “Commenting on PubMed: A Successful Pilot | PubMed Commons Blog.”

⁷³ Couzin-Frankel, “The Web’s Faceless Judges.”

⁷⁴ “Vigilant Scientists.”

⁷⁵ Barbour and Stell, “PubPeer: Scientific Assessment Without Metrics,” 152.

Blatt's October 2015 *Plant Physiology* editorial "Vigilante Science". On PubPeer, Blatt's controversial article regarding the pitfalls and dangers of anonymous post-publication peer review received 371 comments engaged in heated debate. Of the 371 comments, 256 were posted anonymously. It may not be relevant for each anonymous reviewer, but Michael Blatt was the editor-in-chief of *Plant Physiology* at the time of the editorial. It is reasonable to assume that the power dynamic between Blatt and those who posted strong contradictory arguments against him prompted a desire to remain anonymous. By contrast, on PubMed Commons the very same paper received only 27 comments exchanged between 9 people, three of whom comprised the author and two founders of PubPeer, Stell and Barbour.

Permitting anonymous contributions in PubPeer had been controversial from the start. Not only has PubPeer's policy on anonymity been criticized for encouraging a lack of transparency in the open science movement it is trying to promote,⁷⁶ it has also required PubPeer to legally defend online anonymity in a major 2014 defamation lawsuit, *Sakar vs. Doe*.⁷⁷ PubPeer eventually prevailed at both the trial court and again at the court of appeals in 2016, but it is important to point out that the essence of the complaint in *Sakar vs Doe* was a fight over a subpoena demanding that PubPeer identify an anonymous reviewer whom Sakar blamed for permanently damaging his reputation, career and employment opportunity. Had the reviewer's name been clearly posted along side of the (allegedly slanderous) review in the first place, Sakar's target in the defamation lawsuit might have been the reviewer rather than PubPeer.

The guarantees that protected anonymous contribution on PubPeer had clearly been desirable to those unwilling to identify themselves in PubMed Commons. PubPeer has since taken even stronger measures to ensure privacy by not caching any IP addresses from the

⁷⁶ Teixeira da Silva, "The Opacity of the PubPeer Foundation"; Blatt, "Vigilante Science."

⁷⁷ Eidelman, "ACLU Wins Case Protecting Identity Of Anonymous Online Critics."

originating networks connecting reviewers to the PubPeer servers. This technique ensured that PubPeer would not have any identifiable data about its anonymous users for which some future litigant might try to subpoena for their own personal legal objectives. The ruling in favor of PubPeer to protect anonymity now ensured a safer space for those reviewers who felt compelled to remain anonymous before posting any controversial comments against another author's published research.

In contrast, PubMed Commons by design did not allow any form of anonymity. It may be that, in the aftermath of PubPeer's victory in *Sakar vs. Doe*, many would-be contributors to PubMed Commons felt a chilling effect before attaching their name to an overly critical post-publication review. As PubPeer's position on anonymity was strengthened and affirmed after the 2016 ruling, and their volume of activity continued to increase, rates of participation in PubMed Commons, by comparison, remained much lower. Placing one's name next to a post-publication review carried an element of risk that further diluted any potential incentive the task may have had. In spite of this, PubMed Commons continued to have a steady flow of participants albeit not on the scale of PubPeer. What motivated contributors to remain with PubMed Commons?

Participant Perspectives: Reflections from PubMed Commons Members

Brief interviews were conducted with 5 former members of the PubMed Commons community. During separate 20-30 minute interviews, each participant was asked to talk about their experiences with and assessment of the PubMed Commons approach to post-publication peer-review. The interviewees were asked with 4 questions to guide the conversation towards sharing observations about the strengths and weakness of the system and discussing the motivations and incentives that prompted their participation in the online forum.

Each interviewee recognized that there were no significant incentives that played a role in their participation, but rather attributed their motivation to contribute to a sense of responsibility to the profession. The common theme that each reviewer noted was that the desire to participate was akin to a moral obligation to respond to the scientific record when new information can be shared and important questions must be asked. One reviewer mentioned that there is no immediate personal incentive to be had from potentially angering an author by pointing out flaws and weaknesses in their work. However, in each case, reviewers indicated that one of the great strengths of the PubMed Commons system was in its design that placed comments where they can be seen on the citation record within the PubMed database. If indeed problems or concerns were pointed out in a paper, the citation record was the most logical location to communicate this information to future readers who might encounter the abstract or citation.

Three reviewers also noted the value of a comment as a tool by which to contact the author and receive an important response in the threaded comments. One of the respondents (Respondent #2) was active in PubMed Commons by directing attention to readers (and authors) of older publications that had used problematic cell-lines in their experiments. For her, this potential use of PubMed Commons demonstrated a much more efficient way to communicate this important fact to readers rather than having a separate editorial or article published in a journal. The misidentification of cell-lines in the earlier articles was not an error of such importance as to require a retraction, and an editorial or separate article discussing the problem in a current journal would be divorced from the earlier abstract in the PubMed database. Yet, those who happened upon the earlier paper and would try to reproduce the experiment would need to know that this discrepancy in the labeling of cell-lines was discovered years later. The PubMed Commons feature allowed these important post-publication updates to be posted

directly on the citation within the database and alert potential readers at the point of citation discovery.

Respondent #4 mentioned a similar point in his assessment of one of the strengths in PubMed Commons, as it allowed researchers the ability to look both forward and back in the published record. As articles may become out of date and new updates and discoveries are made, the PubMed Commons commentary combined with the PubMed record permitted this interlinking between older citations and more recent publications. In this context, a reviewer could use the commenting feature on the PubMed record to offer opinion about the publication and also provide links and citations within their review that lead the reader to more current research on the same topic. This benefit is greater than using a citation index to simply follow the citation trail of the article under review. Using a citation index to determine which current articles have cited articles from the past is an important way to track a publication's impact into the future. However, many articles may never become cited in future journals, or if they do, it may not be recorded in the citation indexes for many years. However, a post-publication reviewer can record directly on the PubMed record where a reader will find more current articles on the same topic. As a method of linking the past research with future advances, the post-publication reviewer can make that bridge where the citation index cannot.

Several reviewers acknowledged that other social media platforms may have very active communities that comment on recent publications, but these are dispersed across the web and less likely to be discovered by the majority of researchers at the point of research need. Three of the interviewees mentioned that they have participated in online journal clubs facilitated on Twitter, Facebook or independent blogs, but the ideal benefit with PubMed Commons was that a bridge could be made between the PubMed record and the external location of the discussion that

may have been captured on a blog, video or Twitter feed. The immediacy, comprehensiveness, and community engagement that occurred in the PubMed Commons system was seen as much more beneficial to researchers than attempting to submit the same commentary to a journal for publication.

While the incentives may have been minimal, the motivation to regularly contribute and participate in PubMed Commons was consistent with each interviewee. The lack of anonymity was not perceived as a deterrent, and several respondents mentioned that this policy may have played a role in the substantiality and thoughtfulness that was crafted into many of the contributions. However, it was also recognized that the policy on anonymity most likely caused many potential participants to shy away. Respondent #1 mentioned that the implementation of journal clubs in PubMed Commons provided a mechanism to allow one facilitator to post a review on behalf of the group. This provided a convenient way to include many voices that may have had their own reasons for remaining anonymous. The practice of having a journal club post a comment was initiated by the PubMed Commons team in late 2014.⁷⁸ Respondent #1 initiated a journal club with his students focusing on nephrology. His group also maintained an active Twitter space which could then bridge the connections between the article under review on PubMed Commons and additional information and commentary by the whole team on their external site. The discoverability of one endpoint to the other was an essential feature that was unmatched in any other medical literature database or post-publication peer-review system.

For the interviewees, participating in PubMed Commons and post-publication peer-review in general was driven by altruism rather than any professional incentive. It was clear from each conversation that the participants were disappointed that PubMed Commons was abruptly

⁷⁸ “Introducing PubMed Commons Journal Clubs | PubMed Commons Blog.”

shutdown in March 2018. While the participation seemed low in comparison to PubPeer, the fact that the comments were threaded within the PubMed database was seen as a major benefit and motivating factor for these participants to contribute to PubMed Commons. However, it is important to note, that in the random selection of reviewers who agreed to be interviewed for this study, each participated with some regularity to PubMed Commons. Several invitations were extended to reviewers with whom posted only one review into PubMed Commons but those users unfortunately declined. Frequent participants in PubMed Commons were unlikely to be as dissatisfied with the system as those who tried it only once or twice and then abandoned the community. Whatever the reasons for not participating in PubMed Commons, it remains true that it offered a central repository for the collection of post-publication peer reviews, each of which was indexed in combination with the literature under discussion, and supplemented by external resources and commentary by experts in the field. Participants were motivated by a sense of fostering the greater good of the community by contributing to the published scientific record and fostering scholarly communication and open science.

Epilogue

For some researchers, challenging the claims of another scholar and pointing out shortcomings in their publication is an intimidating process. It is understandable why many voices would choose to remain silent rather than publicly express concern and risk confrontation or stigma. Asking hard questions and pointing out potential problems is ultimately more beneficial to the scientific record, but with professional egos and power dynamics always involved on one side of the equation, speaking anonymously is better than remaining silent.

Given the circumstances, anonymity will always have its place in academic review and online discourse. The culture of anonymity in the pre-publication phase is accepted as part of traditional publishing norms, although it is true that more examples of open peer-review systems are becoming common, and this is encouraging for open science and academic research transparency. Post-publication peer-review also benefits from a mix of both onymity and anonymity, as the former yields some connection and credentials to the known reviewer and the latter may allow a voice to speak when otherwise they might not share their knowledge.

The anonymity issue seemed more detrimental to PubMed Commons than the restriction on membership criteria. The technical constraints that slowed the process of gaining an account in the system could be overcome by requesting an invitation. The desire to remain anonymous, especially after witnessing the potential liability concerns that surfaced during the PubPeer lawsuit may have had a chilling effect on PubMed Commons users who were required to sign their name next to any comment. The ruling in the case had indirectly shown that anonymity was the safest way to avoid risk when engaging in online debate. Otherwise, potential retaliation by a disgruntled author might find the named reviewer on the defense over what began as an online academic debate. If the goal is to have more voices contribute to the forum, especially if they

have discovered something that should be exposed, anonymity must be managed rather than completely disallowed. The risks of harassment or trolling behaviors from the anonymous participant can be managed in a multitude of ways without compromising the greater good of inviting all voices to speak.

As the data showed, PubMed Commons was not devoid of constructive and impactful scholarly exchange, but many voices in the community remained silent. Although the participation was lower than the NIH had hoped, the consistent rate of PubMed Commons participation demonstrated that was never dwindling significantly. In October 2016, it was reported that PubMed Commons had over 10,632 registered members.⁷⁹ The data shows that roughly 2000 members had posted 1 or more reviews. Efforts should have been made at that time to revisit the policy on anonymity and see if lifting that restriction would result in participation among the other 8000 members.

One significant loss with the demise of PubMed Commons was in the benefit that it provided to users of the PubMed database; including medical researchers, students, consumer health advocates and patients. There are essentially three primary roles and relationships in the post-publication peer-review cycle; the author/journal, the post-pub reviewer/online review community, and the researcher/database

The first role in this cycle is that of the author, without whom there would be no scholarship to review. The author publishes a paper with a journal, and once the journal places the article online, a commenting feature might be available within the publisher's page. The second role is the post-publication reviewer, who upon locating and reading the article on the publisher's site, or by some other means, the post-publication reviewer leaves commentary on

⁷⁹ "PubMed Commons Blog | Keeping You up to Date about PubMed Commons."

the journal's dedicated site. The post-publication reviewer might login to PubPeer, and copy their comments into the record that PubPeer maintains. The third role is someone who is researching a particular topic, perhaps a medical student. In this role, the student does not have a particular article in mind, but hopes to find the most relevant batch of articles on some research topic. The student does not begin searching for a range of articles by going to a single journal title's web page. The student does not begin to search for an array of recent articles on a specific topic using the PubPeer tool. The medical student will search for academic literature within PubMed. (If Google was the search engine used, then results in the list would likely lead to PubMed all the same). Unfortunately, this is where the lost opportunities begin. Within PubMed, the student researcher will not discover any of the post-publication peer-review warnings or questionable flaws that might be expressed on that publication elsewhere. The external links that the post-publication reviewer posted in PubPeer are not replicated in PubMed at the point of discovery for the student. Any related external datasets, software, corrections that were exclusively on the PubMed Commons comments in 2017, are now lost to the end-user. The contributions to PubMed Commons were deemed to be too small in number, and as a result, the voices of over 2000 participants with over 7000 comments and suggestion on over 6000 PubMed medical citations were removed in 2018.

The impact and necessity of post-publication peer-review and the need for prompt evaluation of scientific literature today cannot be overestimated. This is even more essential during times of international health crises where advances in medical research, vaccine development, and combatting a deadly pathogen is most urgent. Added to that challenge is the disturbing trend, albeit not new, of political leaders and fringe medical professionals who perpetuate misinformation, conspiracy theories, and create barriers to trust between the public

and the health science community. When large portions of a major political party adopt an anti-science posture and promote a misleading narrative to the public by contradicting medical truths,⁸⁰ scientists must find additional venues to make their voices heard.

The timing of the abrupt shutdown of PubMed Commons seems curious given that the Trump administration installed its Health and Human Services (HHS) secretary Alex Azar one month before silencing the PubMed Commons forum. As the HHS leadership is soon to change, and a respect for “truth in science” returns to the highest level of the executive branch, perhaps an NIH sponsored post-publication peer-review system can be revisited and seen in a new light. The objectives of PubMed Commons and post-publication peer review align directly with federal open access policies and the drive to ensure collaborative open science initiatives continue to advance biomedical and health science research around the world.

⁸⁰ “What Caused the U.S.’ Anti-Science Trend?”

Appendix 1

Example Data from PubMed Commons Dataset

ArticlePMID	DATE PUB	DateCreated	FirstName	LastName	Respondent	Found_Helpful	Content
4426613	1974	6/1/15 21:46	thomas	samaras	thomas samaras	0 of 1 people found this helpful	Additional information on height, CHD, and longevity is available from these
10737948	2000 May 15	12/13/13 20:30	Rafael	Najmanovich	Najmanovich Rafael Najmanovich	1 of 1 people found this helpful	A more in-depth analysis appears in <PMID:22962462>.
16356178	2005 Dec 15	2/20/14 23:09	Tom	Kindlon	Tom Kindlon	2 of 3 people found this helpful	Data from another population study found scores on the RE subscale are si
23532053	2013 May	6/13/13 21:04	Sebastian	Schneeweiss	Sebastian Schneeweiss	0 of 1 people found this helpful	Nice summary of assumptions and the issues arising when doing 1:1:1 match
25790980	2015 May	4/19/15 23:18	Lei	Zhao	Lei Zhao	0	excellent
26195734	2015 Aug 4	9/28/15 8:57	George	McNamara	George McNamara	1 of 1 people found this helpful	I posted this on PubPeer:https://pubpeer.com/publications/25CC01C368B9
26208718	2015 Jul 25	7/29/15 16:22	Benoit	Bruneau	Benoit Bruneau	6 of 7 people found this helpful	The paper by Polk et al purports to demonstrate a genetic interaction betw
26519325	2016 Mar	11/3/15 13:45	Richard	Kellermayer	Richard Kellermayer	0	I greatly appreciate the responses by Alessandro Borghi and colleagues to c
27071381	2016 Jun	4/19/16 20:47	Anderson	Santos	Anderson Santos	0	Dear users of the MED pipeline, The MED web server address has been mig
27779132	2016 Nov	8/15/17 7:05	Victoria	MacBean	Victoria MacBean	2 of 2 people found this helpful	**Plain English summary**Parasternal intercostal electromyography (EMG
27868194	2018 Jan	7/31/17 12:10	Robin P	Clarke	Robin P Clarke	2 of 2 people found this helpful	Nutrient deficiencies being factors in autism causation was predicted by the
28499169	2017 Aug 18	5/21/17 19:24	Amanda	Capes-Davis	Amanda Capes-Davis	3 of 3 people found this helpful	The authors tested against "two different cancer cell lines", HeLa and KB. U
12049239	2002 Jun	9/4/15 4:40	Lydia	Maniatis	Lydia Maniatis	0	Lower region was not a new cue in 2002. Rubin discussed it in his article "V
18222422	2008 Feb	10/28/13 13:39	DAVID	SANDERS	DAVID SANDERS	1 of 3 people found this helpful	Identical Env deletions to those described in this article ("The Env truncate
18313567	2008 Apr	12/10/14 6:44	Kath	Wright	Kath Wright	0	Other search filters are available from the InterTASC Information Specialists
20572635	2010 Jul 26	5/2/16 22:31	Suresh	Panneerselv	Suresh Panneerselvam	0	This is very informative article. I enjoyed reading this. Thank you.
24136252	2014 Jan	11/1/13 13:10	Allison	Stelling	Allison Stelling	0	The FTIR ATR instrument highlighted in the infrared section of this interest
24382836	2014 Sep	2/1/14 6:47	Jan	Tunv@r	Jan Tunv@r	0	In the paper, the parameters are described: According to the acknowledged
24733905	2014 Apr 22	5/6/14 19:44	Melissa	Vaught	Melissa Vaught	11 of 11 people found this helpful	In this perspective, Alberts _et al_ reference a white paper published by th
25337188	2014	10/24/14 10:35	Gwinyai	Masukume	Gwinyai Masukume	1 of 1 people found this helpful	The authors write, "Only two cases of an abdominal pregnancy combined w
26668206	2015 Dec 14	3/25/16 10:01	Egon	Willighagen	Egon Willighagen	0	I was wondering earlier today if a possible cause if this could be a change in
26933091	2016 Mar	3/8/16 7:24	Lydia	Maniatis	Lydia Maniatis	2 of 3 people found this helpful	I would like for the moment to single out the following argument/countera
27520920	2016 Aug	9/14/16 20:50	Lily	Chu	Lily Chu	5 of 5 people found this helpful	As a member of the Institute of Medicine Committee, I talked to multiple p
29165424	2018 Mar	1/17/18 15:56	Ivan	Shatsky	Ivan Shatsky	1 of 1 people found this helpful	The review contains an extensive bibliography and in general could be usef
387102	1979	12/10/15 15:59	S A	Ostroumov	S A Ostroumov	0	Abstract is available, as well as the list of cited publications: https://www.r
17955130	2008 Jan 15	8/24/14 14:53	Ivan	Oransky	Ivan Oransky	5 of 5 people found this helpful	This study has been retracted: http://retractionwatch.com/2014/07/25/pap
20032487	2010 Feb	11/1/13 12:26	Darren L	Dahly	Darren L Dahly	0	I am currently drafting a paper following from this work that uses mixture r
22127832	2012 Jun	10/31/13 15:19	John	Cannell	John Cannell	0	The authors found markers oxidative stress is present in autism spectrum d
22754943	2011 Jan	3/7/15 9:16	Prof.Dr.Joge	Pramanik	Prof.Dr.Jogenananda P	0	Prof.Dr.Jogenananda Pramanik and Zury Azreen,Research Intellect organiza
24265184	2014 Jan-Feb	9/23/16 8:28	Israel	Hanukoglu	Israel Hanukoglu	0	The link to the Proteopedia page with animations and examples:http://ww
24442642	2014 Feb	2/1/14 19:16	Susan	Love	Susan Love	2 of 2 people found this helpful	While this is an interesting contribution to the field it is limited in that only

Appendix 2
Journals Most Discussed in PubMed Commons (2017)
Sorted by Frequency In the Forum; Impact Factor and Total Number of Articles Published

PMC List	Journal Title
1	PLoS One
2	NEW ENGLAND JOURNAL OF MEDICINE
3	NATURE
4	PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES
5	JAMA-JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION
6	SCIENCE
7	LANCET
8	JOURNAL OF VISION
9	NUCLEIC ACIDS RESEARCH
10	BMJ-British Medical Journal
11	JAMA Internal Medicine
12	CELL
13	Scientific Reports
14	Cochrane Database of Systematic Reviews
15	JOURNAL OF BIOLOGICAL CHEMISTRY
16	Nature Communications
17	BIOINFORMATICS
18	ANNALS OF INTERNAL MEDICINE
19	PEDIATRICS
20	JOURNAL OF NEUROSCIENCE

Articles in 2017	Journal Title
17,879	PLoS One
17,152	Scientific Reports
5,058	Nature Communications
3,269	PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES
1,579	JOURNAL OF BIOLOGICAL CHEMISTRY
1,279	NUCLEIC ACIDS RESEARCH
904	NATURE
861	BIOINFORMATICS
799	SCIENCE
777	JOURNAL OF NEUROSCIENCE
644	Cochrane Database of Systematic Reviews
558	PEDIATRICS
454	CELL
321	NEW ENGLAND JOURNAL OF MEDICINE
264	LANCET
212	JAMA-JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION
204	JOURNAL OF VISION
167	BMJ-British Medical Journal
128	ANNALS OF INTERNAL MEDICINE
124	JAMA Internal Medicine

Impact Factor	Journal Title
70.67	NEW ENGLAND JOURNAL OF MEDICINE
59.102	LANCET
51.273	JAMA-JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION
43.07	NATURE
41.063	SCIENCE
36.216	CELL
27.604	BMJ-British Medical Journal
20.768	JAMA Internal Medicine
19.315	ANNALS OF INTERNAL MEDICINE
11.878	Nature Communications
11.147	NUCLEIC ACIDS RESEARCH
9.58	PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES
7.755	Cochrane Database of Systematic Reviews
6.074	JOURNAL OF NEUROSCIENCE
5.401	PEDIATRICS
4.531	BIOINFORMATICS
4.106	JOURNAL OF BIOLOGICAL CHEMISTRY
4.011	Scientific Reports
2.776	PLoS One
2.089	JOURNAL OF VISION

Appendix 3

Interview Questions and Selection Process

Objective: Conduct 30 minute interviews with former members of the PubMed Commons

Selection: Random selection of names from a list of contributors. Final slate of interviewees was determined by the first 5 respondents to accept the interview offer after 12 invitations were emailed.

Potential Confounder: Two invitees declined the interview because they felt that they did not use the system “that much”. A potential bias might be that persons who were not very interested in the PubMed Commons system may have been less willing to participate. Of the 5 interviews who did respond, each person was eager to talk about what they enjoyed about the PubMed Commons. Those with negative experiences or indifferent feelings may have been less motivated to share their impressions of PubMed Commons.

Questions to Former PubMed Commons Members:

1. As a contributor to a post-publication peer review forum, what do you feel were some of the strengths and weaknesses of this activity?
2. What were some of the incentives that you felt were important in motivating you to devote the time and effort to contribute to the online forum?
3. Did you also offer post-publication feedback/commentary in other venues and formats (letters to editor; follow-up publication; critique in conference presentation etc.)? What are some of the pros/cons of these alternatives?
4. Have the reviews within some post-publication peer review forum prompted your own research (or understanding) to evolve in ways that might not have been possible without having access to that reviewer’s comments? If so, please tell us how?

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