

An Idea for the Future of Dental Research: A Cloud-based Clinical Network and Database

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Received: August 8, 2013

Accepted: October 22, 2013

Online Published: October 28, 2013

doi:10.5430/jct.v2n2p86

URL: <http://dx.doi.org/10.5430/jct.v2n2p86>

Abstract

Evidence-based dentistry (EBD) is an approach to oral healthcare requiring systematic assessment of relevant scientific evidence to clinical practice and patients' needs. EBD attempts to globally establish personalized dental care based upon the most recent and highest order scientific evidence. However, some times the EBD does not consider local clinical circumstances, which represents a practitioner's actual patient population and experiences.

The purpose of this study is to outline a design for a cloud-based clinical network/database model that is believed to be a valuable addition to the current clinical research models. This paper provides a rationale for the establishment of a network and makes recommendations as to how this format would bridge EBD and clinical practice. To do so would provide a significant advance for dental education, clinical research, and clinical practice.

Keywords: *evidence based dentistry (EBD); clinical research network; online networking; cloud-based clinical network/database*

1. Introduction

It is not surprising that many dental practitioners face major challenges to be current when one considers the immense body of products, procedures, and research published yearly. This is particularly true for a solo practitioner who often has limited professional interaction with other practitioners. Evidence-based dentistry (EBD) represents the averaged data gathered from particular experiments, which is not necessarily relevant to local circumstances. Clinical experience and local evidences, while often established in a less structured fashion, often represents a more accessible and meaningful dataset for use with local patient populations (Hay et al., 2008; Horn et al., 2010; Valdes, 2010).

A practical bridge between EBD and clinical practice would help practitioners incorporate the best scientific evidence into practice and can help researchers answer practical and clinical questions more efficiently (Charles et al., 2011; Horn et al., 2010; Valdes, 2010). The use of technological advances offers a key emerging tool for improving the quality of clinical care based upon solid scientific knowledge.

1.1 The Basis of the Concept

In most dental practices, the care provider gathers local clinical evidences, plans treatment based upon experience optimized for a particular patient and tracks outcomes, and makes adjustments as needed to provide optimal care. What if these activities were part of a searchable online database? What if a practitioner (or a participating group of practitioners) built a body of knowledge of what works or does not work with a particular population (or groups) or within different contexts? Conceptually, this model would enable member practitioners to contribute data to and/or participate in the analysis or retrieval of data, following the standards defined by the network (Hay et al., 2008).

New programs and consortia are emerging to encourage practitioners to be active practitioner-investigators in

generating new project ideas and participating in clinical-based studies. Practitioner-investigators operate in their practices and communities while serving patients. At present, however, not many practitioners see the value in these emerging opportunities (Hay et al., 2008). The goal of this work is to provide a rationale for the investment of resources in producing and reporting data to a central network in the context of a private dental practice and to describe the return on the investment. We believe this argument serves as a catalyst for private practitioners to participate and actively engage in scientific activities. This will only happen if practitioners see a financial or a practical return on their investment. We believe a well-designed and active cloud-based platform could bridge EBD and clinical practices.

In simplest terms, the network would be comprised of contributors, users, and a central organizing structure (COS) to facilitate the collection and compilation of data. The COS would allow for a prioritization of questions to address, as well as, the analysis and reporting of results. Contributors could share data and members could analyze it over time. With limited facilitation, any member could pose questions to the database, analyze datasets based on need or interest, and pose hypotheses or questions to the network for the benefit of all. The central networking/ database model would grow from data contributions generated from local solo or small groups of practitioners. The network would also be an online structured resource to answer clinicians' questions based on available evidence and members' clinical experience.

Clearly, the major barriers to the establishment of this consortium lie in the startup and maintenance costs and in soliciting members and talent (e.g. software design, employment of specialists dedicated to ensure that data is entered according to a protocol and importantly how/who would do the analysis). Keeping these issues in mind, it will require significant financial resources and time. The question therefore, becomes, "Why do it at all?"

From an academic stand point, the clear and most important benefits are derived from the promulgation of knowledge including the publication and evaluation of work in peer reviewed forums (Resnik et al., 2008). Further, the opportunity to change practice paradigms and serve as an educational resource are also clear benefits. However, a key point must be that the implementation of a system creates efficiencies for practices both in terms of time and finances and establishes guidelines for practice where little evidence exists beyond trial and error.

1.2 Foundations of Clinical Research and Practice

EBD is an approach to oral healthcare that requires the integration of a systematic assessment of relevant scientific evidence. What constitutes "clinically relevant" may be far reaching. It may include, but is not limited to, issues pertaining to a patient's oral and medical conditions, a dentist's expertise and a patient's treatment needs and preferences. In addition, EBD attempts to establish personalized dental care based upon the most recent and highest order scientific evidence. As a goal, EBD takes a patient-centered approach to arrive at the best treatment decisions (American Dental Association Center for Evidence-Based Dentistry, 2011). The four important domains of EBD are: (1) The best available scientific evidence; to inform dentists and patients, but never to mandate a specific course of treatment. (2) A dentist's clinical skill and judgment. (3) Each patient's needs and preferences. (4) Local data and information (Rycroft-Malone et al., 2004). EBD represents a centric focus that overlaps each of the four domains (Fig. 1).

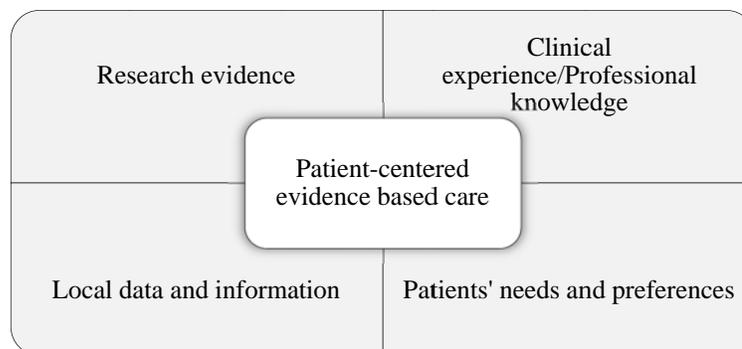


Figure 1: Sources of Evidence for a Patient-Centered, Evidence-Based Practice (Modified from Rycroft-Malone et al., 2004)

Along with evidence-based practice, it is important to systematically gather local evidence from the clinical experiences of practitioners to guide effective practice using a top-down approach and a broader interpretation of a clinician's role (Hay et al., 2008). Instead of "mining" the literature and guidelines, practitioners play an active role

in examining their practices (and other practices). Such an integrated investigator-practitioner role is recognized prominently in many disciplines such as education, agriculture, and engineering (Hay et al., 2008). The important distinction of a “top-down” model is that investigation addresses specific needs in an individual practice rather than producing universal knowledge or global evidence (Hay et al., 2008). Hay et al. 2008 reported that improvements in patient care outcomes might be gained by balancing the global data of evidence-based medicine with locally relevant data through scientifically harnessing clinical experience.

The suggested cloud-based clinical network and database are designed to use technological advances to merge these foundations in favor of more scientific dental practices.

1.3 Current Networking Models as They Relate to the Proposed Model

In the National Institute of Health News 2012, a dental practice-based research network is defined as an investigative union of practicing dentists and academic scientists (National Institute of Health News, 2012). Practitioners get an opportunity to propose, or participate in, research studies in this network. The studies address day-to-day issues in oral healthcare and are conducted in participating dental offices with consenting patients. This setting expands the profession’s base of evidence and further refines care. As part of the National Institute of Health-National Institute of Dental and Craniofacial Research (NIH-NIDCR) initiative to reduce disparities in oral health, a national research network was launched in April 2012 (National Institute of Health News, 2012). There are also regional nationwide networks (Denucci, 2009; National Institute of Dental and Craniofacial Research, 2012), such as Practitioners Engaged in Applied Research and Learning (PEARL), Dental Practice-Based Research Network Northwest (DPBRN) and Practice-based Research Collaborative in Evidence Based Dentistry (PRECEDENT).

There are also online resources and numerous study clubs, such as the ADA center for evidence-based dentistry TM, MDConsult.com, DentalTown.com, TripDatabase.com, and DrBicuspid.com. Each of these links scientific-purposed networks to social activities, continuing education, and marketing. Dental study clubs and groups are usually small dental networking groups, which regularly meet to discuss shared fields of interest.

The intent of the proposed model is to establish a cloud-based platform on which practitioners and researchers can interact, adhering to certain organizational and scientific principles. Ideally, practitioners would not simply function in the network as data collectors but would serve as investigators. Members should have a sense of ownership in the network, believing it belongs to them as a tool to benefit patients and the profession (Hay et al., 2008). Creating a cloud-based network/database system may be a promising venue for clinical dentistry and dental research because other social and clinical experience networks have been successful to some degree at communicating information to target communities, (Denucci, 2009; Gordan et al., 2011). It is important to consider that local experience does not equate with the high-level evidence obtained through randomized clinical trials, meta-analysis, or systematic reviews, but incorporating a peer review system in the cloud-based platform will significantly increase the quality of the evidence gathered from endogenous sources.

2. The Cloud-Based Clinical Network and Database Model

A central network/database model worth considering would be a cloud-based network shared by practitioners, researchers, and academicians. Conceptually, individuals or organizations with the scientific/educational/research prowess and experience would organize it. An organized system is necessary to manage vast sums of information that would be necessary to create a vital network (e.g. NIH, NIDCR, ADA, ADEA). Ideally, the model could be designed in a way to systematically gather practitioners’ experiences and data through a user-friendly interface with little or no training required by members. In addition, the network would need to provide an environment for clinicians to share experiences. Shared materials would need to follow a set of pre-established criteria and peer review prior to submission for publication should that be desirable.

2.1 Implications of the Model

The National Institute of Standards and Technology (Mell & Grance, 2011) defines cloud computing as a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) (Mell & Grance, 2011). The NIST adds that cloud computing can be rapidly provisioned and released with minimal management effort or service provider interaction (Mell & Grance, 2011). Cloud computing is a readily available, shared, customizable, and fast resource. The cloud-based model is inspired by existing networking and database models in medicine, dentistry, and other scientific and social fields. It is a service model, a platform as a service (PaaS), overseen by an organizational infrastructure and shared by clinicians, researchers and academicians (Mell & Grance, 2011).

The suggested network model organizes data using records and sets as fundamental constructs. Records contain fields, and sets define one-to-many relationships between records: one owner, many members. As a hierarchical model, data are organized into tree-like structures (Len Silverston, 2009).

2.2 An Overview of the Platform

A foundational structure of the cloud-based clinical research network/database model is summarized in Table 1.

Features of the model are:

- A user-friendly central library browser to search for evidence-based dentistry research, particularly systematic reviews containing active links to references, (Cochrane Library, 2012).
- Should encourage practical and clinically oriented questions: What can I do? How can I do it?
- Should provide practical, scientifically sound answers, supported by published evidence or properly documented personal experience.
- Peer-reviewed member-written case reports on clinical cases and their treatments.
- Submission forms and templates available on the platform.
- Advanced search capabilities to quickly review relevant research based on keywords and category.
- Ability to record member feedback and short critical appraisals discussing evidence and reports; There must be a place for inputs, organizational questions, and comments from members.
- Critical appraisal of the submitted clinical data should be completed before it is posted on the website by a scientific committee, chosen and invited by the central authority.
- Online professional networking options will be incorporated in the software.
- Calendar will be available for scheduling meeting panels on popular topics.

A cloud-computing platform works best when a multidisciplinary team that comprehends the variety of technical and legal issues involved designs it. To optimize the platform, there needs to be evaluations, discussion, prototyping, and pilot studies.

2.3 Elements, Roles and Interactions

In designing a network/database system, a group of foundational elements and resources need to be organized and managed properly. Two major elements worth considered in designing the current model are organizational infrastructure and contributors and users.

The potential organizational infrastructure of a professional, cloud-based dental network is likely to require an organizing and scientific committee, information technology (IT) professionals, legal advisers, and community representatives. The central organization infrastructure may be comprised of individuals with scientific/educational/research/clinical expertise. Depending on the size and scope of the network, the organizational infrastructure could require a scientific committee with multi-disciplinary backgrounds to ensure consideration of multiple perspectives to appraise the validity of practitioners' clinical findings. Because the entire project would be heavily dependent on IT, IT professionals and statisticians would best be engaged in the design acquisition, processing, storage and dissemination of data (Longley and Shain, 1986; Longley et al., 1989), in addition to people who can provide legal counsel at all levels. An attorney would not be able to directly address the issue of how these queries skirt issues associated with the patients' consents in the database, particularly because it will need to deal with protected health information. Therefore, the clinicians, scientists and the attorneys will establish the legal guidelines together.

A number of professionals representing the participants' various geographic regions, different clinical experiences, research needs, and academic interests would be of great value in the design phase and implementation and operational phase of the project. Particularly speaking, most of the contributors and users of this model are likely to be practitioners, scientists and academicians in the field of dentistry and dental specialties, but they might also include students and dental specialty residents. Therefore, this cloud-based network/database is a platform for scientific clinical interaction between dental professionals. Conceptually, each could share their knowledge and experiences through this system at the national and ultimately on a global level. Particular attention should be paid to calibrating the data entered into the database from members, to prevent the risk of the "junk in- junk out." Hence, members should be trained by the central organization to follow the platforms rules and principals. They should know how to formulate an appropriate question to be answered from the database (e.g. how to formulate an

appropriate PICO question -population, intervention, comparison, and outcome).

Critical components in the development of an efficient model are data collection, managing procedures and network interactions, and quality control and quality assurance. Contributors can submit questions following the outline described in Table 1. To be successful and for members to gain value from participating in the network, considerable emphasis must be placed on the responsiveness of the network to the needs of the members. Hence, the ability to acquire quality input in terms of data and the ability to address clinically pertinent questions will depend on the responsiveness of the network to participants needs. This means refinement of input data will be critical (Table 1) while the software incorporated in the cloud platform will determine the success of information extraction.

Table 1: Cloud Computing - Sharing Evidences and Experiences Through a Cloud-based Clinical Network/Database

Features	Main headings and criteria		
	Question:	Answer:	Case report:
Input: Clinical issues	Clinical/Practical	Clinical/Practical/Evidences	Clinical 600-800 words
	20-30 words	600-800 words	5 pictures/graphs
	2 pictures	5 pictures/graphs 5 references	5 references
Process: Scientific evaluations and peer reviews	<ul style="list-style-type: none"> • Quality control and quality assurance • Statistical analysis and statistical process control • Comparing the inputs to each other and to available scientific evidences 		
Outcome	A peer reviewed online resource on practical and clinical issues, including an organized summary of the relevant evidences and properly documented clinical experiences		

For quality control and assurance, two aspects of the model should be evaluated: quality of the materials submitted to the platform and its subsequent output (e.g. reports or articles) and the intrinsic quality of the platform performance itself. Both are essential to the success of the networking/database model. Trained reviewers must assess the quality of the submitted material by the contributors. Likewise, a critical component is challenge the evidence, synthesis, and efficacy of the clinical recommendations. The governing board is a group of clinician/scientists with the skill, knowledge, and experience to critically review the submitted material, and forward it for a peer review process.

2.4 Developmental Strategies

After the initial design, the model needs to be prototyped and formatted in small scale (e.g. sharing data between few professionals) (Fig. 2). This will simulate the model and test the practicality and accuracy of templates and structures. The next step is making modifications and changes. This process needs to be performed on a larger scale in the form of a pilot study until it reaches a satisfactory level of practicality. A survey form can be used to facilitate studies to determine if the model is ready to be launched. The developmental strategy will require a continuous process after the system is launched to improve the quality of the service.

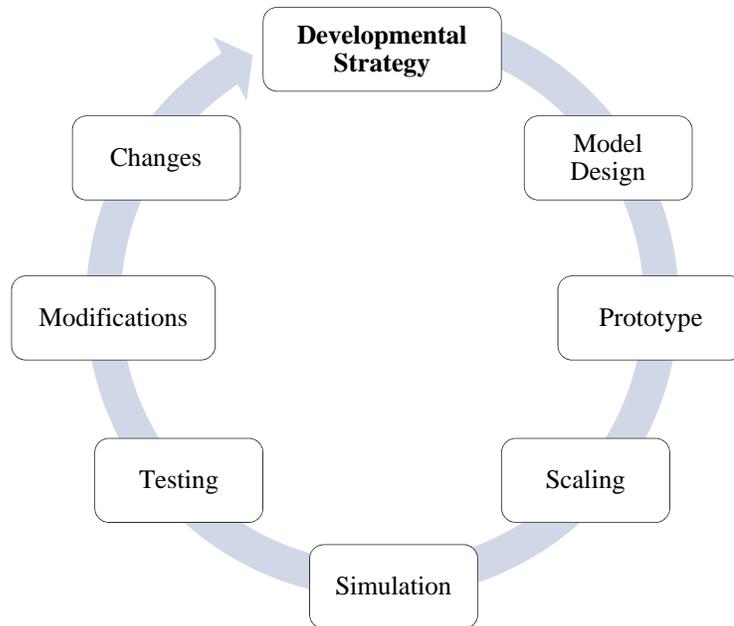


Figure 2: Developmental Strategies. The diagram shows the developmental strategies in the cloud-based clinical research network/database model

2.5 Limitations and Challenges

To create a clinical network and database model, certain questions logically arise: Why would dentists be motivated to participate? Why would dentists be willing to track and share treatment outcomes? Can dentists be objective about their treatment results? Who will manage and pay the costs of such a database?

Limitations with respect to running such a model include funding, promoting the network, time and human resources, the quality of assurance and standardization, and participation of general practitioners and researchers as contributors/users. Kay et al. (2003) highlighted the intrinsic motivation and personal desire of practitioners to be part of a research network. The responses collected included the importance of being part of a group, the educational aspects of a research network, enjoyment and alleviation of boredom, potential advantages of research networks to patients, and the sense that a network contributes to improvements in oral care, even if only locally. (Kay et al., 2003). Thus, establishing a database network self-promotes itself. Monetary incentives along with the offering of CE credits and some financial imbursements could be built in the networking model to provide extrinsic motivation (Basch, 2005; Goldman, 2011). To insure the sustainability and growth of the network, full-time commitment and human resources are a necessity.

A major challenge in establishing a cloud-based network relates to work force. Incentives must be established so local practitioners see clear benefits from their participation both in terms of time and resource allotment. Conceptually, the computing and the data management could be managed either by standardizing data inputs or linking to data already been collected and added to by practitioners as part of their electronic health records. For this sort of network to work, the private sector would need to play a major role.

To establish a financial model where participation in the data management becomes cost-effective for practitioners, before they receive any benefit from the network, the engagement of entrepreneurs or private sector organizations would be beneficial. For example, if data gathered were part of the cloud-based electronic record derived from the day-to-day practice activities, the ability to attract buy in from dentists would less of a barrier. For such a system to be viable, access to the data entered by local dentists would need to be able to accessible at little or no cost to their practices in at least the initial stages while value was being established. Organizing the data, the sort of queries that could be answered by the network and the utilization of the information in the system would be a major organizational challenge that could only be addressed by the groups that stand to gain financially from an investment.

It is clear that the available high quality peer reviewed scientific publications would not be possible without the dedications of devoted scientists and clinicians, each willing to contribute to clinical practice by sharing knowledge.

Similarly, a cloud-based system would rely significantly on the contributions of committed scientists and practitioners. We believe that in the near future, the use of online models will play a significant role in clinical practices and research, so current limitations will be overcome. This will be made feasible by increasing the number of practitioners using online resources, and on advancements in cloud-based systems and health information technology. Even so, certain challenges will only be resolved by organizational investment and support.

3. Conclusions

While barriers exist to establish a cloud-based clinical network and database model, current private and commercial entities suggest that practitioners see value in online communications. A clinical research network could contribute to the ability of professionals in the field to rapidly evaluate practice outcomes in a scientific manner bridging evidence-based dentistry and clinical practice. Therefore, dental research could significantly benefit from using the potential of the cloud computing and networking in promoting clinical research, practice, and evidence-based dentistry.

The role of policy actors is to build the infrastructures in the form of a central organizing structure (COS) and provide facilities for the development of a clinical cloud based network and database. In addition, the role of the clinicians, scientists, researchers and teachers is to systematically gather local clinical data and participate in the network by sharing their clinical research experiences, knowledge, and data through the network. This model would enable members to participate in the analysis or retrieval of data, following the standards defined by the network. We believe that over time the information gathered on this database will serve as a valuable resource for clinicians to find practical answers to some of their clinical question.

Acknowledgements

We wish to acknowledge and thank the students and faculty associated with the University of Michigan Scholars Program in Dental Leadership, Dr. William V. Giannobile, Dr. Carol A. Murdoch-Kinch, Dr. Sean Edwards, Ms. Charlene S. Erickson, Dr. Josef N. Kolling, Dr. Scott Smith, and Dr. Ralph Bozell for their help, support and contributions to this article and Mr. Pedram Owtdad for his contributions towards the initiation and development of the idea of cloud based clinical network and database.

The authors have no proprietary, financial, professional or other interest of any nature or kind in any product, service and/or company that could be construed as influencing the position presented in, or the review of, this manuscript.

References

- American Dental Association Center for Evidence-Based Dentistry (2011). ADA Clinical Recommendations Handbook. American Dental Association© Website, pp. 39.
- American Dental Education Association Leadership Institute. (2009). ADEA Leadership Institute Position Paper. ADEA Library, pp. 11.
- Basch P. (2005). Electronic health records and the national health information network: affordable, adoptable, and ready for prime time? *Ann Intern Med*, 143(3), 227-228. <http://dx.doi.org/10.7326/0003-4819-143-3-200508020-00009>
- Charles C, Gafni A., & Freeman E. (2011). The evidence-based medicine model of clinical practice: scientific teaching or belief-based preaching? *J Eval Clin Pract*, 17(4), 597-605. <http://dx.doi.org/10.1111/j.1365-2753.2010.01562.x>
- Cochrane Library. (2012). *The Cochrane library; independent high-quality evidence for health care decision making*. John Wiley & Sons, Ltd.
- Dental Tribune Study Club (2012). DT Study Club; becoming the standard practice for dentists worldwide, not only in continued education, but in communications of all kinds.
- Denucci DJ. (2009). Historical overview of models of practice based research; NIDCR DPBRN grant initiative. *J Dent Hyg*, 83(4), 165.
- Goldman D. (2011). *National electronic health records network gets closer*. CNN Money Tech.
- Gordan VV., Riley JL, 3rd, Carvalho RM, Snyder J, Sanderson JL, & Anderson M et al. (2011). Methods used by

- Dental Practice-based Research Network (DPBRN) dentists to diagnose dental caries. *Oper Dent*, 36(1), 2-11. <http://dx.doi.org/10.2341/10-137-CR>
- Hay MC., Weisner TS., Subramanian S., Duan N, Niedzinski EJ., & Kravitz RL. (2008). Harnessing experience: exploring the gap between evidence-based medicine and clinical practice. *J Eval Clin Pract*, 14(5), 707-713. <http://dx.doi.org/10.1111/j.1365-2753.2008.01009.x>
- Horn SD., Gassaway J., Pentz L., & James R. (2010). Practice-based evidence for clinical practice improvement: an alternative study design for evidence-based medicine. *Stud Health Technol Inform*, 151, 446-460.
- Kay EJ., Ward N., & Locker D. (2003). A general dental practice research network--philosophy, activities and participant views. *Br Dent J*, 194(10), 545-549. <http://dx.doi.org/10.1038/sj.bdj.4810198>
- Len Silverston PA. (2009). *The Data Model Resource Book, Vol. 3: Universal Patterns for Data Modeling*. Wiley publishing, Inc.
- Longley D., & Shain M. (1986). *Dictionary of information technology*(2nd ed.). New York: Oxford University Press.
- Longley D., Shain M., & Longley D. (1989). *Van Nostrand Reinhold dictionary of information technology*(3rd ed.). New York: Van Nostrand Reinhold.
- Mell P., & Grance T. (2011). US standards body publishes definition of cloud computing, The NIST Definition of Cloud Computing. IM@TOnline:8.
- Nash M. (2002). The Jackson Dental Study Group. *J Am Coll Dent*, 69(4), 29-31.
- National Institute of Dental and Craniofacial Research NIH (2012). *Dental Practice-Based Research Networks*. NIDCR Website: NIDCR-NIH.
- National Institute of Helath News (2012). NIDCR establishes National Dental Practice-Based Research Network; Seven-year grant continues to build the evidence base in dentistry. nih.gov: U.S. Department of Health and Human Services, NIH news.
- Ozar DT. (2001). A position paper: six lessons about managed care in dentistry. *J Am Coll Dent*, 68(1), 30-35.
- Resnik DB, Gutierrez-Ford C., & Peddada S. (2008). Perceptions of ethical problems with scientific journal peer review: an exploratory study. *Sci Eng Ethics*, 14(3), 305-310. <http://dx.doi.org/10.1007/s11948-008-9059-4>
- Rycroft-Malone J., Seers K., Titchen A., Harvey G., Kitson A., & McCormack B. (2004). What counts as evidence in evidence-based practice? *J Adv Nurs*, 47(1), 81-90. <http://dx.doi.org/10.1111/j.1365-2648.2004.03068.x>
- Taichman RS., Green TG., & Polverini PJ. (2009). Creation of a scholars program in dental leadership (SPDL) for dental and dental hygiene students. *J Dent Edu*, 73(10), 1139-1143.
- Valdes K. (2010). Overcoming the challenges to incorporate evidence-based medicine into clinical practice. *J Hand Ther*, 23(3), 239-240. <http://dx.doi.org/10.1016/j.jht.2010.05.004>