Review

Clinically Excellent Use of the Electronic Health Record: Review

Leah Wolfe[1], MD; Margaret Smith Chisolm[2], MD; Fuad Bohsali[3], MD

[1]Division of General Internal Medicine, Johns Hopkins Bayview Medical Center, Johns Hopkins University School of Medicine, Baltimore, MD, United States

[2]Department of Psychiatry and Behavioral Sciences, School of Medicine, Johns Hopkins University, Baltimore, MD, United States

[3]Department of Medicine, School of Medicine, Duke University, Durham, NC, United States

Corresponding Author:
Leah Wolfe, MD
Division of General Internal Medicine
Johns Hopkins Bayview Medical Center
Johns Hopkins University School of Medicine
5200 Eastern Avenue, Mason F Lord Building
Center Tower, Suite 2300
Baltimore, MD, 21224-2780
United States
Phone: 1 410 550 0512
Fax: 1 410 550 3403
Email: lewolfe@jhmi.edu

Abstract

Background: The transition to the electronic health record (EHR) has brought forth a rapid cultural shift in the world of medicine, presenting both new challenges as well as opportunities for improving health care. As clinicians work to adapt to the changes imposed by the EHR, identification of best practices around the clinically excellent use of the EHR is needed.

Objective: Using the domains of clinical excellence previously defined by the Johns Hopkins Miller Coulson Academy of Clinical Excellence, this review aims to identify best practices around the clinically excellent use of the EHR.

Methods: The authors searched the PubMed database, using keywords related to clinical excellence domains and the EHR, to capture the English-language, peer-reviewed literature published between January 1, 2000, and August 2, 2016. One author independently reviewed each article and extracted relevant data.

Results: The search identified 606 titles, with the majority (393/606, 64.9%) in the domain of communication and interpersonal skills. Twenty-eight of the 606 (4.6%) titles were excluded from full-text review, primarily due to lack of availability of the full-text article. The remaining 578 full-text articles reviewed were related to clinical excellence generally (3/578, 0.5%) or the specific domains of communication and interpersonal skills (380/578, 65.7%), diagnostic acumen (31/578, 5.4%), skillful negotiation of the health care system (4/578, 0.7%), scholarly approach to clinical practice (41/578, 7.1%), professionalism and humanism (2/578, 0.4%), knowledge (97/578, 16.8%), and passion for clinical medicine (20/578, 3.5%).

Conclusions: Results suggest that as familiarity and expertise are developed, clinicians are leveraging the EHR to provide clinically excellent care. Best practices identified included deliberate physical configuration of the clinical space to involve sharing the screen with patients and limiting EHR use during difficult and emotional topics. Promising horizons for the EHR include the ability to augment participation in pragmatic trials, identify adverse drug effects, correlate genomic data to clinical outcomes, and follow data-driven guidelines. Clinician and patient satisfaction with the EHR has generally improved with time, and hopefully continued clinician, and patient input will lead to a system that satisfies all.

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Introduction

Use of the electronic health record (EHR) during clinical encounters is now a standard part of contemporary medical practice. The EHR—like other medical technologies—is designed to optimize the efficiency and quality of health care delivery, and ultimately—one hopes—improve patient outcomes. However, as anyone who has ever used or seen his/her health care provider use the EHR during a clinic visit knows that use of the EHR in a way that preserves or enhances clinical excellence is challenging. The Johns Hopkins Miller-Coulson Academy of Clinical Excellence (MCACE) has previously identified the following domains of clinical excellence: (1) communication and interpersonal skills, (2) diagnostic acumen, (3) skillful negotiation of the health care system, (4) scholarly approach to clinical practice, (5) professionalism and humanism, (6) knowledge, and (7) passion for clinical medicine [1]. To identify best practices around the clinically excellent use of the EHR, the authors conducted a literature review of the MCACE domains and the EHR.

Methods

The concepts of the clinical excellence domains and the EHR were defined using a combination of controlled vocabulary terms applicable to PubMed and keyword terms and phrases to capture the English-language, peer-reviewed literature published between January 1, 2000, and August 2, 2016 (Multimedia Appendix 1). Citations were imported into a citation management system, and duplicates were removed. The authors ensured the search strategies captured a previously published review [2] on the topic. One author (LW, FB, or MSC) independently reviewed each article and extracted relevant data. The study was submitted to the institutional review board and deemed exempt from further review.

Results

Overview

The search identified 606 titles (Figure 1), the majority (393/606, 64.9%) were in the domain of communication and interpersonal skills. Twenty-eight of the 606 (4.6%) titles were excluded from full-text review, primarily due to lack of availability of the full-text article. The remaining 578 full-text articles reviewed were related to either clinical excellence generally (3/578, 0.5%) or to the specific domains of communication and interpersonal skills (380/578, 65.7%), diagnostic acumen (31/578, 5.4%), skillful negotiation of the health care system (4/578, 0.7%), scholarly approach to clinical practice (41/578, 7.1%), professionalism and humanism (2/578, 0.3%), knowledge (97/578, 16.8%), and passion for clinical medicine (20/578, 3.5%).

Figure 1. Flowchart for search strategy and review of English-language, peer-reviewed articles on clinical excellence and the electronic health record between January 1, 2000 and August 2, 2016.
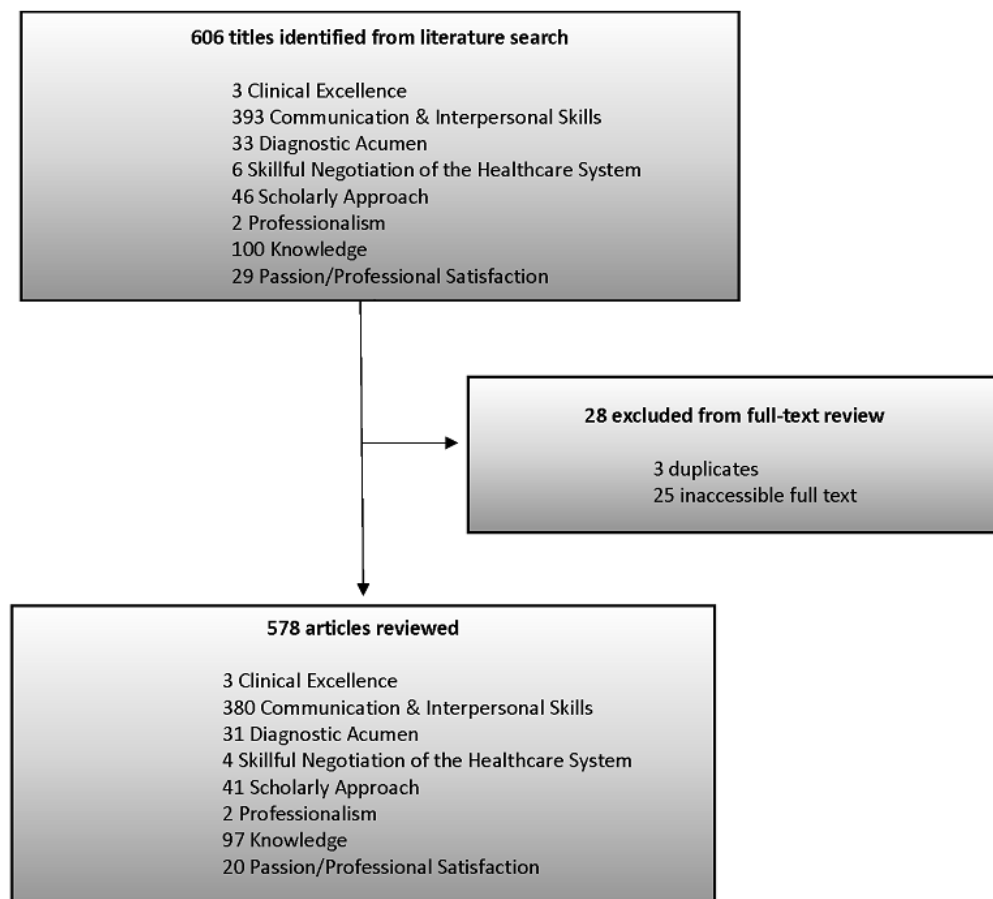
Communication and Interpersonal Skills

Within the communication and interpersonal skills domain, the following practice-based themes emerged from the literature, yielding the following clinical "pearls."

How Clinicians Practice

Clinicians' baseline communication styles are the main determinants of how we communicate in the presence of EHR implying that continuing education on the basic skills of clinician-patient communication is essential as we implement the EHR [3-5]. Clinician attitudes toward the EHR can affect the attitudes of patients and the quality of clinician-patient communication in its presence [6]. It can be useful for clinicians to learn to touch type and consider the use of scribes to help optimize face-to-face communication [7-12]. Quieter keyboards can also be less disruptive to the flow of communication [2]. It is helpful for clinicians to be more transparent about their use of the EHR and to address its presence in appreciative tones [13-16].

Impact on Patients

Generational, cultural, and socioeconomic differences can affect patients' attitudes toward and engagement with the EHR [17]. When working with patients who speak a different language, the EHR may be both an asset and a hindrance (translation capability within the EHR can potentially mitigate this, but can be tricky) [18,19]. For example, Ratanawongsa and colleagues [19] found that increased EHR use by clinicians was associated with more biomedical statements and less positive effect from patients with low English proficiency and low health literacy. This group advocated for further research on whether the increased use of technologies like the EHR are reducing or increasing the confusion of patients with language and health literacy barriers. Studies of patient attitudes toward the EHR generally show more favorable attitudes than clinicians or researchers anticipate [5,20-23].

How to Prepare for a Visit

It is helpful for clinicians to review the record ahead of time to identify interval events and data, and to review the patient's social history so that communication during the patient visit is more valuable, personalized, and less superfluous [10,12,24,25]. Clinicians can use the EHR to remind them of current life events of patients, to help personalize the visit and couch discussion of health care issues in the context of their lives [26]. Clinician-patient communication through patient portals can enhance both inter-visit and in-visit communication [27-29].

How to Organize the Room

Screen sharing is a significant theme in the existing literature, for the promotion of patient engagement, facilitation of communication during the visit, transparency, and patient empowerment and education. It is helpful if clinicians ensure the screen is visible to both the clinician and patient so that they share a "joint focus of attention" [2,13,25,30-36]. It is imperative that the display be large enough for the patient to view. Optimally, the room should be organized to allow eye contact between the clinician and patient at all phases of the visit [24,32,33,37-39].

How to Engage Patients with the Electronic Health Record in the Room

Multiple strategies can be used to improve patient engagement in visits through conscientious use of the EHR. One of these is the use of "transition phrases" or "signposting" when moving from the patient to the EHR and back [2,12,16,30,31,40-42]. It is also wise to use a language of collaboration when discussing the EHR and to address openly any issues of confidentiality [23]. It can be helpful for both patient and clinician if clinicians repeat what they write in the EHR verbally while typing—to emphasize information and messages, and to maintain a shared focus on the topic [2,40,41]. Sharing the screen with patients can facilitate communication as well—through review and verification of content, as well as through visual display of information (eg, graphics) to educate and empower [2,4,13,16,31,41,43-47]. It can even be valuable to have patients input information [12,13,48].

Clinicians should limit the use of the EHR during difficult and emotional topics [4,12,49,50], and try to maximize eye contact to avoid missing nonverbal cues and to enhance the relationship [2,4,24,25,41,51-53]. Clinicians do not want to lose the narrative and patients must have time to express their concerns, and tell their story [42,53-57]. Several studies have highlighted ways in which EHR use can facilitate provider-patient dialogue and partnership strategies, even in the context of conversations around difficult topics [2,58,50].

How to Use the Electronic Health Record to Enhance Intervisit Communication

Patient portals for email communication are an opportunity to enhance the flow of information and to build relationships [26,27,39,59-62]. Multiple studies exist on the use of the EHR for patient self-management of chronic disease and health behaviors [39,61,63-65]. Tasks that took time during traditional office visits can be accomplished through intervisit use of the EHR, freeing up more time for meaningful communication in the office. Direct access to test results by patients can enhance the quality and safety of care [39,61,62,66,67]. It is important to remember, however, that not all patients will have access to or identify the means of bridging that gap. The EHR has significantly increased opportunities for interprovider communication and has demonstrated benefit in transitions of care, and in the coordination of care, especially for patients with complex health needs [68-71].

Diagnostic Acumen

Review of the literature revealed several ways in which the EHR can assist a clinician's diagnostic acumen, such as instant access to historical records, and automation of risk score algorithms. The EHR makes access to past medical history automatic within the sphere in which the EHR operates. Retrieving outside data are the slowest area of progress, but is still improving with the EHR. The EHR's ability to provide interconnected and immediate point-of-care access adds a new dynamic to the health care system, expanding the background of clinical knowledge and enhancing diagnostic acumen and speed of diagnosis [72].

The EHR also brings the potential to use calculated risk scores to the user's fingertips. Physicians admitting a patient with non-ST-elevation myocardial infarction can have immediate access to the thrombolysis in myocardial infarction score. An outpatient provider can have an automated atherosclerotic cardiovascular disease risk score calculated as soon as vital signs are measured. While debate exists around the utility of these scores [73,74], they have and will continue to be ever-present in our understanding of disease. The EHR gives clinicians the added functionality of automatically calculating and providing this data as an added input to the clinician, another tool in the toolbox.

Skillful Negotiation of the Health Care System

The EHR can help clinicians more deftly navigate the health care system to provide high-quality, cost-conscious care. One way the EHR helps clinicians improve care is by promoting adherence to guidelines. Despite knowing that guideline-directed care improves outcomes, chronic and acute-care patients receive guideline-directed care only about 50% of the time [75], and one-third of health care expenditure is wasteful [76]. Clinical decision support (CDS) is the set of prompts that highlight information that could change clinical care and is the answer to the gap in guideline-based care. CDS relies heavily on input from clinical staff who are up-to-date with guidelines. However, when done correctly, CDS has the potential to facilitate the delivery of high-quality care, improving the health of patients and avoiding unnecessary care [77,78].

Further, the Office of the National Coordinator for health care information technology is moving toward national knowledge-sharing for CDS prompts with the intent of eventually standardizing and classifying the importance of CDS. Together, these represent methods for ensuring that we are navigating our health care environment to provide succinct and concise care.

As the use of the EHR grows, data-sharing is being enhanced across networks in regional data exchange systems called health information exchanges (HIEs). With these, clinicians can share pertinent patient information, labs, and notes, as well as communicate directly about essential details. HIEs are the vehicle for creating seamless and secure data-sharing between networks.

Scholarly Approach to Clinical Practice

Use of the EHR facilitates the creation of patient databases and undertaking of pragmatic trials [79]. Through automation of the processes of patient screening, patients can be assessed for participation in pragmatic trials directly through diagnostic codes and demographic information, and messaged at home or asked in the office if they would consent to a study. For patients with the ability to access a computer, investigators have provided informed consent via online videos which can be viewed in the comfort of the patient's own home. Further, the addition of the computer to the clinical setting means that the networks for starting a pragmatic clinical trial are primed and ready. The data are already being collected in the system, and need only to be consented to appropriately and shared.

Professionalism and Humanism

The human price of the EHR is the distraction. CDS popups alert clinicians to a clinical need, an incorrect allergy warning may alarm while entering a prescription, and vital signs may flag a sepsis warning inappropriately. In the rapidly advancing world of the EHR with its increased distractions, it is imperative that clinicians maintain strong bonds with patients and stop the intrusion into clinician-patient relationships [25]. Best practices described in the Communication and interpersonal skills domain can support humanistic attitudes and professional behaviors in the face of the EHR.

The electronic interface of collection is transforming the field of Patient Reported Outcomes (PROs). Many patient portals are set up to ask and record PROs, which can seamlessly integrate into the patient's record. These PROs provide the ability to compare treatments and add patient-centered outcomes to the research. These data are being mobilized for use in decision making by groups like the Patient-Centered Outcomes Research Institute, the National Institutes of Health Collaboratory, and the American Society of Clinical Oncology.

Knowledge

The EHR brings a new way to interface with the knowledge that clinicians generate. Two of the most exciting changes to knowledge will be the discovery of new patterns and the incorporation of genetic data to patient records via "big data" methodology. In computing, big data refers to the use of extensive datasets that are analyzed computationally to reveal previously unknown trends and associations. With enough data points, data scientists suspect that computers will eventually be able to generate prediction models for individual cases based on repositories of old case data [80]. For example, a computerized model of hyponatremia correction in newborns has been created based on large numbers of observations by computers [81].

On the forefront, data scientists and geneticists hope to incorporate patient genomic information into the EHR to help identify patterns and uncover new genetic connections. Once genetic data has been added to a patient's profile, the EHR could theoretically learn what gene loci predispose a patient to angioedema, interstitial lung disease, or any number of previously poorly understood disease states [82,83].

In a similar vein, the EHR can automate the reporting of adverse drug reactions to newly prescribed drugs. By reporting early trends in side effects from a new agent, EHRs might accelerate the detection of untoward side effects—like myocardial infarction associated with cyclooxygenase enzyme inhibitors (ie, COX-2) [84].

Passion and Professional Satisfaction

The introduction of the EHR was fraught with underprepared EHR platforms and unrealistic expectations. Clinicians were initially confronted with decreased efficiency, increased burnout, and high turnover. Early on, physicians using computerized order entry and electronic documentation were 30% more likely to report burnout after controlling for other variables [85]. The only intervention that routinely improved satisfaction was

employing scribes, which suggests that the only positive experience associated with the EHR was minimizing its use [85]. Further analysis into trends of physician satisfaction reveals that a more robust platform is more correlated with satisfaction. Clinical notes, diagnosis function, and off-site capability were all associated with higher satisfaction. There was a trend that younger physicians were more likely to be satisfied than their elder peers [85]. Finally, and most promising of all, physicians who had access to their EHR for at least two years were 2.78 times more likely to be satisfied with their EHR compared to those with less than two years' experience [86].

Much of the literature in other domains touched on the EHR's potential to improve the interface with clinicians. Tools are being introduced to provide the clinician with medical references on demand for reading about developing medical data [87-89]. Finally, natural language processing is another advancing technology in which the computer attempts to interpret the clinician's intention when writing. As an example, when a clinician diagnoses a patient with pneumonia, the EHR could ask if it should open the pneumonia order set [34,90,91]. This technology is still in its infancy and will likely require years to be ready for implementation. That said, it is one of the exciting transformations of the EHR that would produce a more fluent interface between the clinician and computer, allowing clinicians to focus back on the priority—patients.

Discussion

Many articles published after our literature review cite the EHR as a significant factor in clinician burnout. For example, in their 2017 commentary, Shanafelt and colleagues [92] discuss clinician burnout in the era of the EHR and its attendant clerical, regulatory, and workload implications. They outline the potential broader impacts of clinician burnout for the quality of care and the health care system at large. They also emphasize the importance of measures to address the increasing documentation burden especially performance and documentation of components of care that are justifiable for billing purposes alone and do not contribute meaningfully to the episode of care. A recent systematic review by West and colleagues [93] highlights the evidence supporting both organizational and individual interventions to address burnout. Though beyond the scope of our review, clinician burnout is critical among factors that should be considered in the design, implementation, and use of the EHR going forward.

The EHR has completely transformed the clinical landscape. Its arrival and integration have been fraught with challenges, including having noticeably altered clinicians' communication with patients. That said, clinicians are gradually transforming their approach to, and interaction with, the EHR in a way that attempts to minimize distraction and enhance the quality of the clinician-patient connection again. Computerizing this work has effectively put clinicians "on the grid" and hopefully will continue to bring positive changes to the way that clinicians gather and interact with patient data to further enhance diagnostic acumen, scholarly approach to medicine, professionalism, knowledge, passion for clinical medicine, and the ability to negotiate the health care system to provide clinically excellent care for patients.

Conflicts of Interest

None declared.

Multimedia Appendix 1

PubMed search terms and process for literature review for clinically excellent use of the electronic health record.

[PDF File (Adobe PDF File), 46KB-Multimedia Appendix 1]

References

1. Christmas C, Kravet SJ, Durso SC, Wright SM. Clinical excellence in academia: perspectives from masterful academic clinicians. Mayo Clin Proc 2008 Sep;83(9):989-994. [doi: 10.4065/83.9.989] [Medline: 18775198]
2. Alkureishi MA, Lee WW, Lyons M, Press VG, Imam S, Nkansah-Amankra A, et al. Impact of Electronic Medical Record Use on the Patient-Doctor Relationship and Communication: A Systematic Review. J Gen Intern Med 2016 May;31(5):548-560 [FREE Full text] [doi: 10.1007/s11606-015-3582-1] [Medline: 26786877]
3. Taft T, Lenert L, Sakaguchi F, Stoddard G, Milne C. Effects of electronic health record use on the exam room communication skills of resident physicians: a randomized within-subjects study. J Am Med Inform Assoc 2015 Jan;22(1):192-198 [FREE Full text] [doi: 10.1136/amiajnl-2014-002871] [Medline: 25336596]
4. Kazmi Z. Effects of exam room EHR use on doctor-patient communication: a systematic literature review. Inform Prim Care 2013;21(1):30-39 [FREE Full text] [doi: 10.14236/jhi.v21i1.37] [Medline: 24629654]
5. Montague E, Asan O. Considering social ergonomics: the effects of HIT on interpersonal relationships between patients and clinicians. Work 2012;41 Suppl 1:4479-4483. [doi: 10.3233/WOR-2012-0748-4479] [Medline: 22317411]

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6.   Kanter MH. Capsule Commentary on Alkureishi et al., Impact of Electronic Medical Record Use on the Patient-Doctor Relationship and Communication: A Systematic Review. J Gen Intern Med 2016 May;31(5):538 [FREE Full text] [doi: 10.1007/s11606-016-3626-1] [Medline: 26902240]

7.   Menon SP. Maximizing Time with the Patient: the Creative Concept of a Physician Scribe. Curr Oncol Rep 2015 Dec;17(12):59. [doi: 10.1007/s11912-015-0484-7] [Medline: 26475774]

8.   Mettner J. Noteworthy addition. Minn Med 2015 Feb;98(2):10-12. [Medline: 25771641]

9.   Hertz BT. Ways to stay focused on your patients, not your EHR. Med Econ 2014 Apr 10;91(7):44-47. [Medline: 25233768]

10.   Gallegos A. Are you satisfied? What drives physician professional satisfaction in a time of dwindling face-time with patients? Mich Med 2014;113(2):10-14. [Medline: 25154275]

11.   Day TA. The ultimate constant of head and neck oncology—the physician-patient relationship. JAMA Otolaryngol Head Neck Surg 2014 Dec;140(12):1218-1224. [doi: 10.1001/jamaoto.2014.1567] [Medline: 25068431]

12.   Shachak A, Reis S. The impact of electronic medical records on patient-doctor communication during consultation: a narrative literature review. J Eval Clin Pract 2009 Aug;15(4):641-649. [doi: 10.1111/j.1365-2753.2008.01065.x] [Medline: 19522722]

13.   Peck AD. Making the EHR your partner in patient care. Med Econ 2013 Sep 25;90(18):50-53. [Medline: 25509656]

14.   Strum S. Inviting patients to read doctors' notes. Ann Intern Med 2012 Apr 17;156(8):608. [doi: 10.7326/0003-4819-156-8-201204170-00016] [Medline: 22508741]

15.   Wolf DM, Hartman LM, Larue EM, Arndt I. Patient first: a patient sensitivity tool for an electronic health record implementation. Comput Inform Nurs 2007;25(2):112-117. [doi: 10.1097/01.NCN.0000263976.08307.56] [Medline: 17356333]

16.   Ventres W, Kooienga S, Vuckovic N, Marlin R, Nygren P, Stewart V. Physicians, patients, and the electronic health record: an ethnographic analysis. Ann Fam Med 2006;4(2):124-131 [FREE Full text] [doi: 10.1370/afm.425] [Medline: 16569715]

17.   Shachak A, Reis S, Pearce C. Patient-physician interactions and electronic health records. JAMA 2013 Nov 06;310(17):1857-1858. [doi: 10.1001/jama.2013.277969] [Medline: 24193087]

18.   Ratanawongsa N, Barton JL, Schillinger D, Yelin EH, Hettema JE, Lum PJ. Ethnically diverse patients' perceptions of clinician computer use in a safety-net clinic. J Health Care Poor Underserved 2013 Nov;24(4):1542-1551 [FREE Full text] [doi: 10.1353/hpu.2013.0188] [Medline: 24185151]

19.   Ratanawongsa N, Barton JL, Lyles CR, Wu M, Yelin EH, Martinez D, et al. Computer use, language, and literacy in safety net clinic communication. J Am Med Inform Assoc 2017 Jan;24(1):106-112 [FREE Full text] [doi: 10.1093/jamia/ocw062] [Medline: 27274017]

20.   Farber NJ, Liu L, Chen Y, Calvitti A, Street RL, Zuest D, et al. EHR use and patient satisfaction: What we learned. J Fam Pract 2015 Nov;64(11):687-696. [Medline: 26697540]

21.   Migdal CW, Namavar AA, Mosley VN, Afsar-manesh N. Impact of electronic health records on the patient experience in a hospital setting. J Hosp Med 2014 Oct;9(10):627-633. [doi: 10.1002/jhm.2240] [Medline: 25052463]

22.   Pandit RR, Boland MV. The impact of an electronic health record transition on a glaucoma subspecialty practice. Ophthalmology 2013 Apr;120(4):753-760. [doi: 10.1016/j.ophtha.2012.10.002] [Medline: 23352195]

23.   Gadd CS, Penrod LE. Dichotomy between physicians' and patients' attitudes regarding EMR use during outpatient encounters. Proc AMIA Symp 2000:275-279 [FREE Full text] [Medline: 11079888]

24.   Wise J. More computer use during consultations is linked to lower patient satisfaction. BMJ 2015 Nov 30;351:h6395. [Medline: 26628480]

25.   Dalla CG, Maida S, Sorrentino P, Braunstein M, Comi G, Martinelli V. Opinion & special articles: professionalism in neurology. Maintaining patient rapport in a world of EMR. Neurology 2014 Jul 08;83(2):e12-e15. [doi: 10.1212/WNL.0000000000000569] [Medline: 25002570]

26.   Chunchu K, Mauksch L, Charles C, Ross V, Pauwels J. A patient centered care plan in the EHR: improving collaboration and engagement. Fam Syst Health 2012 Sep;30(3):199-209. [doi: 10.1037/a0029100] [Medline: 22866953]

27.   Fernandez L. The essence of morning. J Gen Intern Med 2013 Apr;28(4):598-599 [FREE Full text] [doi: 10.1007/s11606-012-2196-0] [Medline: 22948930]

28.   Ward ME. A cautionary tale of technology: not a substitute for careful collaboration and effective communication. JONAS Healthc Law Ethics Regul 2012;14(3):77-80. [doi: 10.1097/NHL.0b013e318263eb0e] [Medline: 22914453]

29.   Feeley TW, Shine KI. Access to the medical record for patients and involved providers: transparency through electronic tools. Ann Intern Med 2011 Dec 20;155(12):853-854. [doi: 10.7326/0003-4819-155-12-201112200-00010] [Medline: 22184694]

30.   Hickner J. Seeing eye to eye. J Fam Pract 2015 Nov;64(11):685. [Medline: 26697543]

31.   Frankel RM. Computers in the Examination Room. JAMA Intern Med 2016 Jan;176(1):128-129. [doi: 10.1001/jamainternmed.2015.6559] [Medline: 26619228]

32.   LeBlanc TW, Back AL, Danis M, Abernethy AP. Electronic Health Records (EHRs) in the oncology clinic: how clinician interaction with EHRs can improve communication with the patient. J Oncol Pract 2014 Sep;10(5):317-321 [FREE Full text] [doi: 10.1200/JOP.2014.001385] [Medline: 25027025]

33. Street RL, Liu L, Farber NJ, Chen Y, Calvitti A, Zuest D, et al. Provider interaction with the electronic health record: the effects on patient-centered communication in medical encounters. Patient Educ Couns 2014 Sep;96(3):315-319 [FREE Full text] [doi: 10.1016/j.pec.2014.05.004] [Medline: 24882086]

34. Patrick JD, Nguyen DHM, Wang Y, Li M. A knowledge discovery and reuse pipeline for information extraction in clinical notes. J Am Med Inform Assoc 2011;18(5):574-579 [FREE Full text] [doi: 10.1136/amiajnl-2011-000302] [Medline: 21737844]

35. Atkinson L. Integrating the EHR into the patient relationship. Iowa Med 2011;101(2):21. [Medline: 21667843]

36. Asan O, Young HN, Chewning B, Montague E. How physician electronic health record screen sharing affects patient and doctor non-verbal communication in primary care. Patient Educ Couns 2015 Mar;98(3):310-316 [FREE Full text] [doi: 10.1016/j.pec.2014.11.024] [Medline: 25534022]

37. Toll E. A piece of my mind. The cost of technology. JAMA 2012 Jun 20;307(23):2497-2498. [doi: 10.1001/jama.2012.4946] [Medline: 22797449]

38. Margalit RS, Roter D, Dunevant MA, Larson S, Reis S. Electronic medical record use and physician-patient communication: an observational study of Israeli primary care encounters. Patient Educ Couns 2006 Apr;61(1):134-141. [doi: 10.1016/j.pec.2005.03.004] [Medline: 16533682]

39. Rathert C, Mittler JN, Banerjee S, McDaniel J. Patient-centered communication in the era of electronic health records: What does the evidence say? Patient Educ Couns 2017 Jan;100(1):50-64. [doi: 10.1016/j.pec.2016.07.031] [Medline: 27477917]

40. Dowell A, Stubbe M, Scott-Dowell K, Macdonald L, Dew K. Talking with the alien: interaction with computers in the GP consultation. Aust J Prim Health 2013;19(4):275-282. [doi: 10.1071/PY13036] [Medline: 24070141]

41. Shield RR, Goldman RE, Anthony DA, Wang N, Doyle RJ, Borkan J. Gradual electronic health record implementation: new insights on physician and patient adaptation. Ann Fam Med 2010;8(4):316-326 [FREE Full text] [doi: 10.1370/afm.1136] [Medline: 20644186]

42. Quan SF. The electronic health record: the train is coming. J Clin Sleep Med 2009 Apr 15;5(2):101 [FREE Full text] [Medline: 19968039]

43. Asan O, Carayon P, Beasley JW, Montague E. Work system factors influencing physicians' screen sharing behaviors in primary care encounters. Int J Med Inform 2015 Oct;84(10):791-798. [doi: 10.1016/j.ijmedinf.2015.05.006] [Medline: 26049312]

44. Cook JE. The HITECH Act and electronic health records' limitation in coordinating care for children with complex chronic conditions. J Allied Health 2014;43(2):117-120. [Medline: 24925039]

45. White A, Danis M. Enhancing patient-centered communication and collaboration by using the electronic health record in the examination room. JAMA 2013 Jun 12;309(22):2327-2328 [FREE Full text] [doi: 10.1001/jama.2013.6030] [Medline: 23757080]

46. Elwood TW. Viewing health care through a semiotic veil of signs. J Allied Health 2012;41(1):3-13. [Medline: 22544402]

47. Almquist JR, Kelly C, Bromberg J, Bryant SC, Christianson THJ, Montori VM. Consultation room design and the clinical encounter: the space and interaction randomized trial. HERD 2009;3(1):41-78. [Medline: 21165880]

48. Feldman E. A piece of my mind. The day the computer tried to eat my alligator. JAMA 2010 Dec 22;304(24):2679. [doi: 10.1001/jama.2010.1805] [Medline: 21177498]

49. Mehta V. Reflections on Physician-Patient Interactions in the EHR Era. Otolaryngol Head Neck Surg 2015 Dec;153(6):905-906. [doi: 10.1177/0194599815607214] [Medline: 26408560]

50. Rasminsky S, Berman R, Burt VK. Are We Turning Our Backs on Our Patients? Training Psychiatrists in the Era of the Electronic Health Record. Am J Psychiatry 2015 Aug 01;172(8):708-709. [doi: 10.1176/appi.ajp.2015.15030333] [Medline: 26234594]

51. Ratanawongsa N, Barton JL, Lyles CR, Wu M, Yelin EH, Martinez D, et al. Association Between Clinician Computer Use and Communication With Patients in Safety-Net Clinics. JAMA Intern Med 2016 Jan;176(1):125-128 [FREE Full text] [doi: 10.1001/jamainternmed.2015.6186] [Medline: 26619393]

52. Gupta A, Harris S, Naina HV. The impact of physician posture during oncology patient encounters. J Cancer Educ 2015 Jun;30(2):395-397. [doi: 10.1007/s13187-015-0807-2] [Medline: 25757904]

53. Makoul G, Curry RH, Tang PC. The use of electronic medical records: communication patterns in outpatient encounters. J Am Med Inform Assoc 2001;8(6):610-615 [FREE Full text] [Medline: 11687567]

54. Strowd RE. Right brain: the e-lephant in the room: one resident's challenge in transitioning to modern electronic medicine. Neurology 2015 Mar 31;84(13):1387. [Medline: 25992400]

55. Stein HF. Interfaces between electronic medical record (EMR/EHR) technology and people in American medicine: insight. imagination, and relationships in clinical practice. J Okla State Med Assoc 2012 Aug;105(8):316-319. [Medline: 23091977]

56. Lown BA, Rodriguez D. Commentary: Lost in translation? How electronic health records structure communication, relationships, and meaning. Acad Med 2012 Apr;87(4):392-394. [doi: 10.1097/ACM.0b013e318248e5ae] [Medline: 22452913]

57. Patel VL, Arocha JF, Kushniruk AW. Patients' and physicians' understanding of health and biomedical concepts: relationship to the design of EMR systems. J Biomed Inform 2002 Feb;35(1):8-16. [Medline: 12415722]

58. Bernacki R, Hutchings M, Vick J, Smith G, Paladino J, Lipsitz S, et al. Development of the Serious Illness Care Program: a randomised controlled trial of a palliative care communication intervention. BMJ Open 2015 Oct 06;5(10):e009032 [FREE Full text] [doi: 10.1136/bmjopen-2015-009032] [Medline: 26443662]

59. Bernacki RE, Block SD, American College of Physicians High Value Care Task Force. Communication about serious illness care goals: a review and synthesis of best practices. JAMA Intern Med 2014 Dec;174(12):1994-2003. [doi: 10.1001/jamainternmed.2014.5271] [Medline: 25330167]

60. Little V. Transdisciplinary care: opportunities and challenges for behavioral health providers. J Health Care Poor Underserved 2010 Nov;21(4):1103-1107. [doi: 10.1353/hpu.2010.0930] [Medline: 21099063]

61. Zhou YY, Kanter MH, Wang JJ, Garrido T. Improved quality at Kaiser Permanente through e-mail between physicians and patients. Health Aff (Millwood) 2010 Jul;29(7):1370-1375 [FREE Full text] [doi: 10.1377/hlthaff.2010.0048] [Medline: 20606190]

62. Matheny ME, Gandhi TK, Orav EJ, Ladak-Merchant Z, Bates DW, Kuperman GJ, et al. Impact of an automated test results management system on patients' satisfaction about test result communication. Arch Intern Med 2007 Nov 12;167(20):2233-2239. [doi: 10.1001/archinte.167.20.2233] [Medline: 17998497]

63. Tenforde M, Jain A, Hickner J. The value of personal health records for chronic disease management: what do we know? Fam Med 2011 May;43(5):351-354 [FREE Full text] [Medline: 21557106]

64. Moore BJ, Wright JA, Watson B, Friedman RH, Adams WG. Usability testing of an electronic health record form to support physician-based counseling and self-management of overweight children. AMIA Annu Symp Proc 2008 Nov 06:1061. [Medline: 18999039]

65. Reis S, Visser A, Frankel R. Health information and communication technology in healthcare communication: the good, the bad, and the transformative. Patient Educ Couns 2013 Dec;93(3):359-362. [doi: 10.1016/j.pec.2013.10.007] [Medline: 24295793]

66. Martin DB. "Write it down like you told me": Transparent records and my oncology practice. J Oncol Pract 2015 Jul;11(4):285-286. [doi: 10.1200/JOP.2014.003095] [Medline: 25804986]

67. Sittig DF, Singh H. Improving test result follow-up through electronic health records requires more than just an alert. J Gen Intern Med 2012 Oct;27(10):1235-1237 [FREE Full text] [doi: 10.1007/s11606-012-2161-y] [Medline: 22790618]

68. Hoppszallern S. MOST WIRED. Becoming partners with the patient and family in their care. Hosp Health Netw 2015 Dec;89(12):18. [Medline: 26837128]

69. Calman N, Little V, Garozzo S. Electronic Health Records: Optimizing Communication to Support the Nonverbal Medical Patient With Developmental Disabilities. Prog Community Health Partnersh 2015;9(4):591-594. [doi: 10.1353/cpr.2015.0070] [Medline: 26639385]

70. Kantor MA, Evans KH, Shieh L. Pending studies at hospital discharge: a pre-post analysis of an electronic medical record tool to improve communication at hospital discharge. J Gen Intern Med 2015 Mar;30(3):312-318 [FREE Full text] [doi: 10.1007/s11606-014-3064-x] [Medline: 25416599]

71. Ahluwalia SC, Bekelman DB, Huynh AK, Prendergast TJ, Shreve S, Lorenz KA. Barriers and strategies to an iterative model of advance care planning communication. Am J Hosp Palliat Care 2015 Dec;32(8):817-823. [doi: 10.1177/1049909114541513] [Medline: 24988894]

72. Ben-Assuli O, Sagi D, Leshno M, Ironi A, Ziv A. Improving diagnostic accuracy using EHR in emergency departments: A simulation-based study. J Biomed Inform 2015 Jun;55:31-40 [FREE Full text] [doi: 10.1016/j.jbi.2015.03.004] [Medline: 25817921]

73. Sweney JS, Poss WB, Grissom CK, Keenan HT. Comparison of severity of illness scores to physician clinical judgment for potential use in pediatric critical care triage. Disaster Med Public Health Prep 2012 Jun;6(2):126-130. [doi: 10.1001/dmp.2012.17] [Medline: 22700020]

74. Fenix JB, Gillespie CW, Levin A, Dean N. Comparison of Pediatric Early Warning Score to Physician Opinion for Deteriorating Patients. Hosp Pediatr 2015 Sep;5(9):474-479 [FREE Full text] [doi: 10.1542/hpeds.2014-0199] [Medline: 26330246]

75. McGlynn EA, Asch SM, Adams J, Keesey J, Hicks J, DeCristofaro A, et al. The quality of health care delivered to adults in the United States. N Engl J Med 2003 Jun 26;348(26):2635-2645. [doi: 10.1056/NEJMsa022615] [Medline: 12826639]

76. Berwick DM, Hackbarth AD. Eliminating waste in US health care. JAMA 2012 Apr 11;307(14):1513-1516. [doi: 10.1001/jama.2012.362] [Medline: 22419800]

77. Kawamoto K, Houlihan CA, Balas EA, Lobach DF. Improving clinical practice using clinical decision support systems: a systematic review of trials to identify features critical to success. BMJ 2005 Apr 2;330(7494):765 [FREE Full text] [doi: 10.1136/bmj.38398.500764.8F] [Medline: 15767266]

78. Bloomrosen M, Detmer DE. Informatics, evidence-based care, and research; implications for national policy: a report of an American Medical Informatics Association health policy conference. J Am Med Inform Assoc 2010;17(2):115-123 [FREE Full text] [doi: 10.1136/jamia.2009.001370] [Medline: 20190052]

79. Rosenthal GE. The role of pragmatic clinical trials in the evolution of learning health systems. Trans Am Clin Climatol Assoc 2014;125:204-16; discussion 217 [FREE Full text] [Medline: 25125735]

80. Abidi SSR, Manickam S. Leveraging XML-based electronic medical records to extract experiential clinical knowledge. An automated approach to generate cases for medical case-based reasoning systems. Int J Med Inform 2002 Dec 18;68(1-3):187-203. [Medline: 12467802]

81. Pham SL, Bickel JP, Moritz ML, Levin JE. Discovering knowledge on pediatric fluid therapy and dysnatremias from quantitative data found in electronic medical records. AMIA Annu Symp Proc 2010 Nov 13;2010:652-656 [FREE Full text] [Medline: 21347059]

82. Bean LJH, Tinker SW, da SC, Hegde MR. Free the data: one laboratory's approach to knowledge-based genomic variant classification and preparation for EMR integration of genomic data. Hum Mutat 2013 Sep;34(9):1183-1188. [doi: 10.1002/humu.22364] [Medline: 23757202]

83. Slonim N, Carmeli B, Goldsteen A, Keller O, Kent C, Rinott R. Knowledge-analytics synergy in Clinical Decision Support. Stud Health Technol Inform 2012;180:703-707. [Medline: 22874282]

84. Shang N, Xu H, Rindflesch TC, Cohen T. Identifying plausible adverse drug reactions using knowledge extracted from the literature. J Biomed Inform 2014 Dec;52:293-310 [FREE Full text] [doi: 10.1016/j.jbi.2014.07.011] [Medline: 25046831]

85. Shanafelt TD, Dyrbye LN, Sinsky C, Hasan O, Satele D, Sloan J, et al. Relationship Between Clerical Burden and Characteristics of the Electronic Environment With Physician Burnout and Professional Satisfaction. Mayo Clin Proc 2016 Jul;91(7):836-848. [doi: 10.1016/j.mayocp.2016.05.007] [Medline: 27313121]

86. Menachemi N, Powers T, Au DW, Brooks RG. Predictors of physician satisfaction among electronic health record system users. J Healthc Qual 2010;32(1):35-41. [doi: 10.1111/j.1945-1474.2009.00062.x] [Medline: 20151590]

87. Albert KM. Integrating knowledge-based resources into the electronic health record: history, current status, and role of librarians. Med Ref Serv Q 2007;26(3):1-19. [doi: 10.1300/J115v26n03_01] [Medline: 17915628]

88. Reichert JC, Glasgow M, Narus SP, Clayton PD. Using LOINC to link an EMR to the pertinent paragraph in a structured reference knowledge base. Proc AMIA Symp 2002:652-656 [FREE Full text] [Medline: 12463904]

89. Price SL, Hersh WR, Olson DD, Embi PJ. SmartQuery: context-sensitive links to medical knowledge sources from the electronic patient record. Proc AMIA Symp 2002:627-631 [FREE Full text] [Medline: 12463899]

90. Farkash A, Neuvirth H, Goldschmidt Y, Conti C, Rizzi F, Bianchi S, et al. A standard based approach for biomedical knowledge representation. Stud Health Technol Inform 2011;169:689-693. [Medline: 21893835]

91. Jing X, Kay S, Hardiker N, Marley T. Ontology-based knowledge base model construction-OntoKBCF. Stud Health Technol Inform 2007;129(Pt 1):785-790. [Medline: 17911824]

92. Shanafelt TD, Dyrbye LN, West CP. Addressing Physician Burnout: The Way Forward. JAMA 2017 Dec 07;317(9):901-902. [doi: 10.1001/jama.2017.0076] [Medline: 28196201]

93. West CP, Dyrbye LN, Erwin PJ, Shanafelt TD. Interventions to prevent and reduce physician burnout: a systematic review and meta-analysis. Lancet 2016 Dec 05;388(10057):2272-2281. [doi: 10.1016/S0140-6736(16)31279-X] [Medline: 27692469]

Abbreviations

CDS: clinical decision support
EHR: electronic health record
HIE: health information exchange
MCACE: Johns Hopkins Miller-Coulson Academy of Clinical Excellence
PROs: patient reported outcomes

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