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REVIEW ARTICLE/BRIEF REVIEW

Brief review: Adoption of electronic medical records to enhance acute pain management

Article de synthèse court : L'adoption du dossier médical informatisé pour améliorer la prise en charge de la douleur aiguë

David H. Goldstein, MD · Rachel Phelan, MSc · Rosemary Wilson, PhD · Amanda Ross-White, MLIS · Elizabeth G. VanDenKerkhof, DrPH · John P. Penning, MD · Melanie Jaeger, MD

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Abstract

Purpose *The purpose of this paper is to examine physician barriers to adopting electronic medical records (EMRs) as well as anesthesiologists' experiences with the EMRs used by the acute pain management service at two tertiary care centres in Canada.*

Source *We first review the recent literature to determine if physician barriers to adoption are changing given the exponential growth of information technology and the evolving healthcare environment. We next report on institutional experience from two academic health sciences centres regarding the challenges they encountered over the past ten years in developing and implementing an electronic medical record system for acute pain management.*

Principal findings *The key identified barriers to adoption of EMRs are financial, technological, and time constraints. These barriers are identical to those reported in a systematic review performed prior to 2009 and remain significant factors challenging implementation. These challenges were encountered during our institution's process of adopting EMRs specific to acute pain management. In addition, our findings emphasize the importance of physician participation in the development and implementation stages of EMRs in order to incorporate their feedback and ensure the EMR system is in keeping with their workflow.*

Conclusions *Use of EMRs will inevitably become the standard of care; however, many barriers persist to impede their implementation and adoption. These challenges to implementation can be facilitated by a corporate strategy for change that acknowledges the barriers and provides the resources for implementation. Adoption will facilitate benefits in communication, patient management, research, and improved patient safety.*

Author contributions *David Goldstein* was involved in study conception. *David Goldstein, Rachel Phelan, Rosemary Wilson, Elizabeth G. VanDenKerkhof*, and *Amanda Ross-White* participated in the study design. *Melanie Jaeger* organized the literature review process. *David Goldstein, Rachel Phelan, Rosemary Wilson, Elizabeth G. VanDenKerkhof, Amanda Ross-White,* and *Melanie Jaeger* participated in the literature review process and were involved in manuscript composition and revision. *Amanda Ross-White* conducted the literature search. *John Penning* participated in manuscript composition with regard to electronic medical record implementation within The Ottawa Hospital (second centre). All authors made intellectual contributions to this work.

D. H. Goldstein, MD · R. Phelan, MSc · R. Wilson, PhD · E. G. VanDenKerkhof, DrPH · M. Jaeger, MD
Department of Anesthesiology & Perioperative Medicine, Queen's University, Kingston, ON, Canada

R. Wilson, PhD · E. G. VanDenKerkhof, DrPH
School of Nursing, Queen's University, Kingston, ON, Canada

A. Ross-White, MLIS
Bracken Health Sciences Library, Queen's University, Kingston, ON, Canada

J. P. Penning, MD
Department of Anesthesiology, The Ottawa Hospital, Ottawa, ON, Canada

M. Jaeger, MD (✉)
Department of Anesthesiology & Perioperative Medicine, Victory 2, Kingston General Hospital, Queen's University, 76 Stuart Street, Kingston, ON K7L 2V7, Canada
e-mail: jaegerm@kgh.kari.net

Résumé

Objectif *L'objectif de cet article est d'examiner les réticences des médecins à l'adoption du dossier médical informatisé (DMI) ainsi que l'expérience des anesthésiologistes avec les DMI utilisés au service de prise en charge de la douleur aiguë de deux centres tertiaires canadiens.*

Source *Nous passons tout d'abord en revue la littérature récente afin de déterminer si les réticences des médecins à l'adoption évoluent étant donné la croissance exponentielle des technologies de l'information et l'évolution de l'environnement des soins de santé. Par la suite, nous rapportons l'expérience institutionnelle de deux centres universitaires des sciences de la santé et les défis qu'ils ont rencontrés au cours des dix dernières années en matière de mise au point et de mise en œuvre d'un système de dossier médical informatisé pour la prise en charge de la douleur aiguë.*

Constatations principales *Les principaux obstacles à l'adoption du DMI que nous avons identifiés sont liés à des contraintes financières, technologiques et de temps. Ces obstacles sont identiques à ceux rapportés dans une revue méthodique réalisée avant 2009 et demeurent d'importants facteurs rendant difficiles la mise en œuvre d'un tel système. Nous avons rencontré ces difficultés pendant le processus d'adoption de DMI spécifiques à la prise en charge de la douleur aiguë dans notre institution. En outre, nos résultats soulignent l'importance de la participation des médecins dans les étapes de mise au point et de mise en œuvre du DMI afin d'intégrer leurs commentaires et de garantir que le système de DMI s'intègre dans leur flux de travail.*

Conclusion *L'utilisation du DMI deviendra inévitablement la norme de soins; toutefois, de nombreux obstacles persistent et freinent sa mise en œuvre et son adoption. Ces défis à la mise en œuvre peuvent être résolus en utilisant une stratégie institutionnelle de changement qui tient compte de ces obstacles et fournit les ressources nécessaires à la mise en œuvre. En adoptant le DMI, la communication, la prise en charge des patients, la recherche et la sécurité des patients seront toutes améliorées.*

Effective management of acute post-surgical and post-traumatic pain is a priority in the Canadian healthcare system, and the importance of pain is highlighted in the recommendation that it be recognized as the fifth vital sign.[1] Yet, in spite of significant advances in pain research and management, studies cite that 50-80% of patients report moderate to severe pain in the early postoperative period.[2,3] The International Association for the Study of Pain issued a call to action in the 2010-2011 Global Year Against Acute Pain to address improvements in the treatment of postoperative pain – organizational factors included.[4]

In Canada, approximately 1.8 million adults undergo elective surgical procedures annually.[5] Growing numbers of patients with multiple comorbidities[6] in an aging population[7,8] combine to create complicated issues when addressing a patient's acute pain. The result is the requirement for more sophisticated and personalized management strategies.[9-12] By incorporating multimodal analgesia therapies, utilizing combinations of systemic and regional analgesia techniques, and working within a multidisciplinary team, clinicians strive to manage acute pain and minimize associated side effects. Formalized Acute Pain Management Services (APMS) have helped meet this demand in many hospitals,[13-16] yet the performance of this expanded team depends on effective and efficient communication to ensure the safest care possible.[17,18]

An electronic medical record (EMR) system has the potential to be an effective tool to facilitate the communication needs of APMS. In the first section of this paper we systematically review the recent literature on barriers to the adoption of EMR systems. In the second section, we describe a case study in the development of an EMR system for an Acute Pain Management Service and our experience with implementation. We then summarize the lessons learned and identify future directions.

Literature review

In 2010, Boonstra and Broekhuis[19] conducted a systematic review (1998-2009) of barriers physicians identified as impeding adoption of generic EMRs. They identified the major barriers as 1) financial, 2) technical, 3) time, 4) psychological, 5) social, 6) legal, 7) organizational, and 8) change management. In the intervening years, exponential technological advances have occurred simultaneously with an increasing demand for fiscal accountability. Therefore, we considered it important to reassess whether these documented barriers persist or whether they are also changing in this climate. By performing an updated review (2009-May 2013) using the same search strategy used by Boonstra and Broekhuis, we were able to assess whether the challenges in adopting EMRs have been altered given the ubiquitous nature of computer technology today. In addition, we used the Joanna Briggs Institute approach, which provides a systematic approach to reviewing literature that falls outside of Cochrane style reviews of randomized controlled trials.[20]

Based on our original question, we performed a MEDLINE® search to scan the literature on adoption of mobile devices by physicians to facilitate control and management of pain. Using both available subject headings— which are slow to catch up on current definitions— and keywords for multiple brand names of smart phones and tablets (e.g., iPad, iPhone, Android, Blackberry®, etc.), we did not find sufficient research published to date. Articles focused on either older technologies, such as portable computers, or the use of the devices by patients (e.g., to distract pediatric patients during procedures) or by physicians for purposes other than to control and manage pain. These results led us to realign the question so that the issue of barriers to adoption of EMRs could be better addressed.

Consistent with Boonstra and Broekhuis, we employed medical subject headings of exp "Computerized Medical Records Systems" and exp "Physicians" combined with a keyword search for "barrier". Being cognizant of the changing nature of MeSH following our search in MEDLINE, we replicated the search in Web of Science® and EMBASE™ and removed duplicates and "off-topic" articles to arrive at a final set of 84 results (Fig. 1). A complete set of searches conducted is available upon request.

Two authors independently reviewed the abstracts of the 84 potentially relevant articles and categorized them as "Yes", "No", or "Need more information" according to whether they met the following four criteria as outlined by Boonstra and Broekhuis:[19] 1) the article was written in English; 2) the focus of the article was solely on electronic medical/ electronic health records (EMR/EHRs); 3) the article focused on barriers to adoption of EMRs from the physicians' perspective; and 4) the articles were empirical studies rather than reviews of empirical studies. Following the initial independent reviews, all papers categorized as "Need more information" were sent to a third author for independent review. Seventeen full articles were initially retrieved, and five additional articles were identified from the reference sections to provide 22 articles for full review. Each full article was independently reviewed by two authors and the results were compared. Differences in opinion were resolved by discussions between all authors until consensus was met. This process is consistent with the systematic review methodology of the Joanna Briggs Institute.[20]

Following the review process, 14 full articles remained eligible for independent review; however, three articles were based on the same data set, and as such, they were treated as one (see Holden *et al.*).[21-23] Consequently, twelve articles are reported, nine quantitative[24-32] and three qualitative[21-23,33,34] (Table 1A, B). Eight papers were from the USA, and the remaining papers were from Austria,[34] Brazil,[25] Canada,[33] and Switzerland.[29] The studies were highly variable, both in the types of physicians surveyed (general practitioners, specialists)[27,32] and in the practice environment (ambulatory clinics/care centres[24,25,29] or inpatient hospitals). The ranges of sample size and response rates were 99[25] - 1,888[31] and 12.3%[32] - 89%,[25] respectively. The focus of the articles varied from

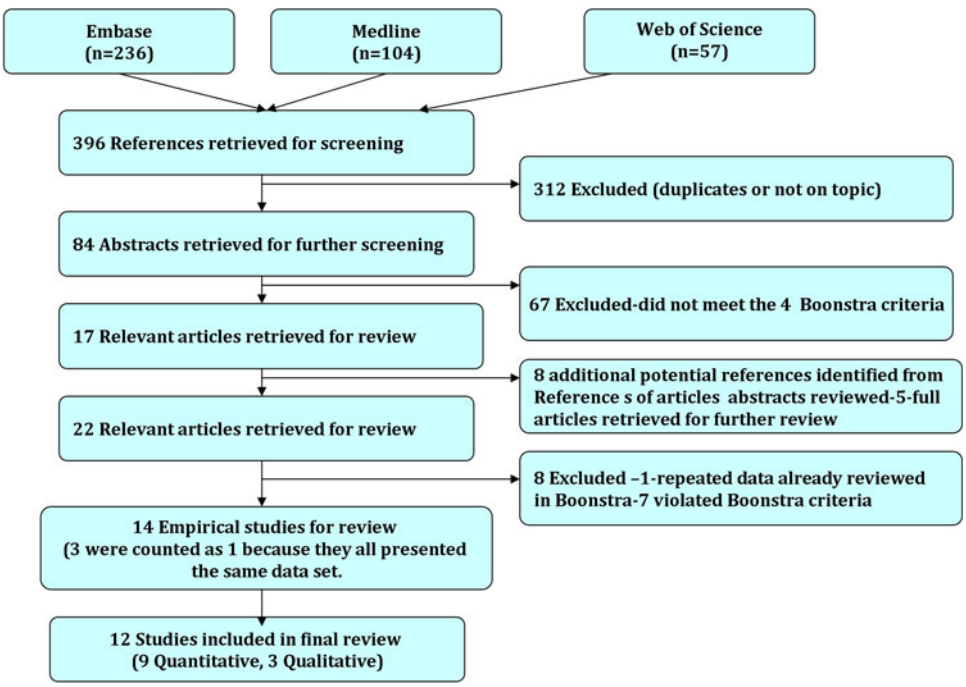

Fig. 1 Flow chart for search and independent review process

Table 1 A overview of included quantitative studies

Article	Country	Clinical area	Barriers (experienced or expected)	Sample size/ RR/ sampling method	Data collection method	Focus	Limitations	Additional factors for consideration
A								
Bramble *et al.*[24]	Nebr., S.D. US	All office-based physicians-ambulatory practice	1. Lack of internal IT support 2. Small centres 3. Older physicians 4. more years in practice	$n = 955$ RR = 17.2%	• Cross-sectional E-mail survey of all office physicians in ambulatory care based on state licensing databases • Used Dillman method	• Whether physicians use EHRs, are planning to use EHRs, or are not planning to use EHRs • Used logistic regression to look at associated factors	• Low RR not focused on "barriers to" but rather "factors associated with" adoption	• Age of practitioner and length of time in practice were found to be "factors" associated with whether or not EMRs would be used
Holanda *et al.*[25]	6th District, Fortazela Brazil	Primary care physicians from ≈ 20 community health centres with previous history of using EMRs	1. Lack of support 2. Being out of service 3. Difficulty with use 4. System is slow 5. System breaks down 6. Structural issues were major barriers 7. not easy to use	$n = 99$ RR = 89% • Intended to be census of primary care physicians in 6th district-not sample • Non-participants claimed "lack of time" to participate	• Cross-sectional survey with open-ended questions	• Whether used EMRs • Satisfaction of EMR use • Knowledge of function	• Narrow focus of questions asked limited the barriers identified	• Identified factors associated with usage: sex, young, still "in training", and seeing fewer than 16 patients per half day were all associated with increased likelihood of using EMRs • Eluded to the fact that doctors and patients should be involved in the planning phase
Kaushal *et al.*[26]	Mass., USA	Primary care physicians	1. Start-up costs-90% 2. Ongoing costs-86% 3. Time loss due to training & productivity-86% 4. Technical limitations of system-83% 5. Lack uniform standards-81% 6. Lack of time to acquire knowledge-80% 7. Dissatisfaction with practice situation-71% 8. Lack of IT support-69% 9. Physician/staff lack computer skills-61% 10. Physician skepticism-60% 11. Privacy/security-53% 12. loss of efficiency-21%	$n = 1,345$ RR = 71.4% • Random sample("users" data not included) • Also excluded 94 physicians for ineligibility (i.e., retired, relocated)	• Mailed survey	• All barriers	• The "users" data were reviewed previously in Boonstra & Broekhuis[19]	• Data expressed as weighted averages of imminent adopters and non-users: • Non-users (56.8%), imminent adopters (10.6%), users (35.6%) • Users' data excluded • Overall (and consistent with other reports) barriers were perceived as being greater in non-users than users • Financial barriers are the most easily modified with incentives • Age of physician, practice size, and ownership status of practice were all significantly different ($P < 0.001$) between users, non-users, and imminent adopters

Table 1 continued

Article	Country	Clinical area	Barriers (experienced or expected)	Sample size/ RR/ sampling method	Data collection method	Focus	Limitations	Additional factors for consideration
Leu *et al.*[27]	USA	pediatricians	1. Financial-56% 2. Finding system that meets requirements-40% 3. Concern for productivity-36%	$n = 646$ RR = 57.2% • Random sample	• Mailed survey • American Academy of Pediatrics	• All barriers & features of adoptedEMRs		• Those in hospitals more likely to use EMRs • Only(3%) use fully functional pediatric-supportive systems
Peterson *et al.*[28]	Texas, USA	All	1. Financial 2. inefficiency	$n = 1,772$ RR = 17.7%	• Mailed survey- Texas Medical Association	• Map the EHR value streams that define the return on investment (ROI) calculation • Compares value streams of current users with intended adopters	• Low RR • Focused on "factors that improved adoption" • Framework surrounded efficiency and effectiveness of practice, therefore, other potential barriers not considered	• 27 % of respondents-current users, 46% intended to adopt, 27% had no intention to adopt • Intended adopters very different than users in terms of perceived ROI, structure of values streams (qualitatively & quantitatively), outcomes associated with realized *vs* anticipated outcomes also differed. The value stream is far more complex for intended adopters than for users.
Rosemann *et al.*[29]	Switzerland	All physicians working in independent practice	1. Use of computers in consult room-57%2. Too time-consuming-53% 3. Impact on physician-patient relationship-47% 4. Data security & legal issues-35% 5. Change not worthwhile-32% 6. Questionable cost-benefit ratio-31% 7. Dependency on external IT company-28% 8. Irritates me-27% 9. irritates patients-19%	$n = 719$ RR = 59.5% • Random sample (with those missing data excluded)	• Mailed survey-Swiss Medical Association -to be returned by fax.	• All barriers	• To return by fax-may have biased who responded • Only surveyed independent practices, which are smaller and less likely to use EMRs • Barriers perceived as greater than those of users • Inconsistent results	• Found underuse of EMRs compared with Europe • This system is pay for service • No compensation for good quality so not worth the effort • Smaller practices, older physicians, and particularly primary care physicians were less likely to use EMRs • What they called "most important barriers" were not the ones most frequently reported • Data were broken down by specialty - we report only totals.

Table 1 continued

Article	Country	Clinical area	Barriers (experienced or expected)	Sample size/ RR/ sampling method	Data collection method	Focus	Limitations	Additional factors for consideration
Stream[30]	Washington., USA	Family physicians-sizes ranged from solo to 187 physicians in network	1. Startup costs-60% 2. Ongoing costs-39% 3. Training & productivity loss-36% 4. Lack of uniform standards-29%5. Lack of time to acquire knowledge-29% 6. Lack of computer/IT support-24% 7. Physician skepticism-21% 8. Technical limitations of system-19% 9. Lack of computer skills of staff/provider-16% 10. privacy/security concerns-7%	464 practices (1,961 FP) $n = 120$ Overall RR = 43.8% E-mail-166 RR = 47% Mail-125 RR = 38.9%	• Mailed/ E-mailed survey via SurveyMonkey® • Washington Association of Family Physicians • For 464 practices, an E-mail address was available for at least one member in 166 cases • A mailing address was available for 125 of the 298 with no E-mail address • No E-mail or mailing address available for the remaining 173	• Asked to rate 10 potential barriers on 3-point Likert scale.	• Asked to rate10 barriers; therefore, any other barriers not considered • Findings may be limited to only family physicians in Washington • Limited by availability of contact information • The fact that E-mail or mailing addresses could not be located for so many practices is troublesome • The opinions of those without E-mail addresses may differ • RRs not equal for mail/E-mail	• Those in networks were treated as a single practice since decision to use or not to use EMRs would be made at the network level • Adoption of EMRs as high as 57 %; little variability between practices • EMR adoption strongly associated with practice size.
Trentman *et al.*[32]	USA	Anesthesiologists	-Only 290 (who had installed, were installing, selected or were searching for AIMS) reported on barriers: 1. Startup costs-52% 2. Lack of system integration with institutional EMRs-43% 3. lack of IT support for AIMS-42% 4. fear of inaccurate records/ legal-40% 5. Lack of system to meet anesthesiologist requirements-36% 6. anesthesiologists resistance-36% 7. ongoing IT costs-33% 8. lack of expertise among anesthesiologists-33% 9. competition with other IT projects for funding-29% 10. poor return on investment-21% 11. lack of support from hospital administration-15% 12. no benefit over paper-12%	$n = 615$ RR = 12.3%	• E-mailed survey-through American Anesthesiologists' Society	• All barriers to AIMS	• Low RR • Only 290/5,000 responded (re: barriers) 5.8% of total or 290/615 = 47% of respondents	• Larger groups with higher case loads affiliated with academic government centres were more likely to have AIMS • 24% had installed AIMS • 13% had installed or selected an AIMS system • 13% were searching for AIMS

Table 1 continued

Article	Country	Clinical area	Barriers (experienced or expected)	Sample size/ RR/ sampling method	Data collection method	Focus	Limitations	Additional factors for consideration
Yan *et al.*[31]	R.I, Conn., Mass. USA	All licensed physicians	1. Training/productivity-77% 2. Technical limitations of system-76% 3. Ongoing financial-76% 4. Startup costs-75% 5. Lack uniform standards-74% 6. Lack of interoperability-73% 7. Impact physician-patient relation-59% 8. access to technical support-59% 9. Privacy/security-55% 10. Availability of computers-44% 11. lack of computer skills-34%	$n = 1{,}888$ RR = 58.1%	• Survey information was taken from the 2009 R.I. Department of Health • Mandatory Health Information Technology (HIT) survey *via* E-mail or letter-with link to electronic survey	• Compared all perceived barriers in users *vs* non-users	• Not-anonymous, reporting bias likely • Respondents may be more likely to have EMRs and have stronger opinions • Physicians were told that lack of responsiveness would be considered an indication of non-use of EMRs; therefore, may have reduced likelihood of non-users responding	• perceived barriers for users vs non-users • 79% of those without EMRs perceived startup financial costs as a major barrier *vs* 46% of those who use EMRs • respondents with EMRs consistently perceived fewer barriers compared with those without EMRs • users/non-users- differed in types and magnitude of barriers ($P < 0.0001$), e.g., financial, time, and technical limitations • younger, hospital-based, in larger practices, physicians in Anesthesia, Emergency, and Radiology (unlike Internal Medicine, Dermatology, Cardiology, Neurology, Ophthalmology, and Psychiatry) were more likely to use EMRs

Author	Region	Clinical Area	Result-Barriers/Experienced/Expected	Cases	Methodology	Focus of Study	Limitations of Study	Overall comments
B								
Greiver *et al.*[33]	Toronto, Canada	Community-based family physicians	EMR systems: 1. Complicated/inflexible 2. Low compatibility with physicians' needs 3. Difficulty adapting EMR to organization and vice versa 4. Lack of relative advantage 5. Amount of time required for data entry 6. Long lag between effort and reward-disappointment 7. Unexpected costs 8. Reduced efficiency reported by some-especially with specialists, hospitals, diagnostics etc., coming from outside (lack of system interoperability) 9. IT structure failures/breakdown, no backup 10. Lack of knowledge for computer operations 11. Lack of tech support-no way to manage small problems so became large and took physicians' time 12. Training offered before implementation 13. Need ongoing support & training	$n = 12$	• Two focus groups & semi-structured interviews-18 months after implementation of EMR.	• Applies diffusion of innovations theory to examine factors perceived by family physicians to influence adoption of EMRs.	• Small sample with limited experience • Focus groups 18 months post-implementation- attitudes & opinions may be very specific to this static time point and different from non-users • Financial start-up costs would no longer be a barrier • Focused on small offices-would differ from large • Results may be limited by the theoretical framework used.	

Table 1 continued

Author	Region	Clinical Area	Result-Barriers/ Experienced/ Expected	Cases	Methodology	Focus of Study	Limitations of Study	Overall comments
Hackl *et al.*[34]	Innsbruck &	surrounding district-Austria	General practitioners and specialists in private practice	Identified 18 categories of negative emotions (ranked in terms of frequency mentioned-most to least)-times mentioned: 1. Unsettled due to missing, insufficient or negative information about EMR-43 2. Data privacy/security-41 3. Additional workload, time-loss-36 4. Unauthorized 3rd parties will access-35 5. Physicians will be "other-directed" due to EMRs-21 6. EMRs lead to controllable, transparent physician-19 7. Accustomed workflows need to be changed because of EMRs 8. Costs of EMRs will be downloaded to physician -18 9. Benefits unknown-17 10. EMRs lead to controllable, transparent patient 11. Usability of EMRs insufficient-12 12. Data from EMRs will be used against physicians-11 13. Time not ripe for EMRs-11 14. EMRs lead to 2 class medicine-9 15. EMRs will be implemented imperfectly-7 16. EMRs will fail due to the scarce cooperation of physicians (i.e., resistance)-6 17. Too much information narrows and blurs vision-4 18. A system change always causes loss of information-1	• 8 final interviews with 60 physicians • 11 participated RR = 13%	• Problem-centred interviews	• To gain insight into negative emotions associated with implementation of mandatory EMRs.	• Low RR • Small sample

Table 1 continued

Author	Region	Clinical Area	Result-Barriers/ Experienced/ Expected	Cases	Methodology	Focus of Study	Limitations of Study	Overall comments
Holden *et al.*[21-23] (Based on same data)	Midwest, USA	General practitioners and specialists in community hospitals & outpatient facilities	1. Limited number of work stations 2. Limited space at work stations 3. Slow processors 4. Limited training 5. Digital chart incomplete 6. Awkward to find data 7. Added time required for data entry and retrieval 8. EMRs disrupt workflow 9. Hidden costs to physicians' time 10. Limited IT support 11. Separate logon for disparate systems	$n = 20$(9 from one hospital, 11 from another)	• Semi-structured interviews	• 2010: investigated physicians' beliefs about using EMRs and computerized provider order entry (CPOE)—very theoretical-beliefs elicitation approach • 2011: All facilitators and barriers to physicians use of EMRs • 2012- social and personal normative forces that influence technology use and performance	• Small sample• Limited generalizability • 2010: were asked specific questions to elicit beliefs; did not specifically look into barriers • 2011-subjective in terms of how responses were classified.	• Counted all three papers as one because they were all based on same data

IT = information technology; RR = response rate; EMR = electronic medical record; AIMS = Anesthesia Information Management Systems

identifying all possible barriers to adoption of EMRs to specific barriers (such as current or planned use of EMRs) to knowledge or satisfaction with EMRs. Only one study focused on barriers to anesthesia information management systems (AIMS).[32]

In spite of the differences in methodology and measures we discerned in our review, the key findings, i.e., barriers to adoption, were similar to those identified by Boonstra and Broekhuis:[19] a) financial, b) technical, c) time, d) psychological, e) social, f) legal, g) organizational, and h) change process. All studies cited some level of technical limitations or concern as a barrier to adoption. Specific barriers included lack of training,[25] lack of computer skills,[26] lack of technical support (internal or external),[24-26,32] systems that are complex and difficult to use,[25] breakdown of hardware/software,[25] and lack of wireless connectivity.[22] Many feared that an EMR system would not be suitable for their needs or would be incompatible with other systems, and they cited the lack of uniform standards as being highly problematic. Six papers cited financial costs (startup and/or ongoing) as a major barrier.[26-28,30-32] Time was a major issue cited in six papers, either a perceived lack of time or a fear of reduced productivity.[26,27,29-32] Issues such as the effect of computers on the clinical relationship,[22,29] skepticism/resistance,[26,32] normative and personal pressures from both physicians and patients,[23] fear of loss of productivity/efficiency,[25-27] and fear of inaccuracies in data and privacy/security/legal implications[22,26,29,32] were also reported. Other less frequently cited factors associated with barriers to adoption of an EMR system were age of clinician,[24,29] workload,[25] time since medical training,[24,25] and type (i.e., government or academic) and size of practice/facility (independent, hospital networks).[27,29,30]

Principal findings from the literature

Boonstra and Broekhuis identified financial, technical, and time-related factors as being the most common barriers to adoption of EMRs.[19] Our updated review of the literature reinforces these three major factors as the most frequently identified barriers to the adoption of EMRs despite the rapidly evolving climate in technology and healthcare.

The fact that *financial* barriers are still most frequently cited as determinants affecting physician's adoption of EMRs suggests that capital investment should result in greater adoption. From 2006 to 2012, adoption of EMRs by Canadian primary care physicians doubled from 23-56% following provincial and territorial EMR investment programs.[35] Similarly, Australia, New Zealand, and the United Kingdom have adoption rates of greater than 90% among primary care physicians.[36] Incentive payments from the American Recovery and Reinvestment Act of 2009 (*aka*. stimulus package) for EMR implementation, interoperability, and training within the USA are also having a major impact on adoption rates. Within the USA, usage of EMRs for office-based physicians, small practices, and hospitals at least doubled from 2008 to 2011.[37]

Technical issues remain a major barrier to adoption[26,31,32] and were second only to financial barriers. In order to address these barriers, it must be recognized that some specialized groups require specialized software (e.g., AIMS for anesthesiologists), which must interface seamlessly with the enterprise system. Often, these specialty systems require a great deal of customization, including building in particular workflows and user capabilities.[38] This software must be designed and implemented with an understanding of the demands on clinicians while attending to patients with different needs. Stakeholders should be involved in both the selection and implementation processes[39] and must also be part of the design and development processes. The more clinicians are able to express their needs and see real-time alterations to suit their workflow, the better technology will be for meeting clinical needs and thereby increase adoption rates. This approach will increase confidence in the system, and users will be more likely to persevere through the adoption process.[15A] In addition, real-time 24/7 technical support is required for the development, implementation, and maintenance of EMRs. Regardless of the organizational framework, it is imperative that Information Technology personnel have excellent technical and interpersonal skills to bridge the gap between users and the technology to support adoption.[40]

Time is the third area that was repeatedly found to affect adoption of EMRs.[26,28-30] Time spent on an EMR is often cited as time away from patient care, and this is particularly salient in this age of overworked and underresourced clinicians. In addition, these three barriers, financial, technical, and time constraints, are interdependent and cannot be considered in isolation, e.g., physician fee structures where "time is money". Time required to research, purchase, and implement an EMR system, i.e., time devoted to EMRs, is time away from patient care that translates into loss of income and represents a financial barrier.[29] Likewise, time devoted to "computer literacy" indirectly becomes a financial barrier.

A growing number of publications describe barriers and driving forces for adopting electronic record systems, but anesthesiologists have written relatively little about this process[32,39,41] as it pertains to EMRs designed specifically

[A] *Goldstein DH.* How can corporate change facilitate evidence based practice? A description of the adoption barriers, removal strategies and lessons learned from a hospital wireless computer implementation at Kingston General Hospital. Ottawa, Ontario: Canadian Health Services Research Foundation, EXTRA; 2005.

for the management of acute pain. In general, anesthesiologists are slower to adopt AIMS than other clinicians using generic EMRs.[39,41,42] Nevertheless, AIMS implementation is gaining momentum,[43] in part because of government incentives that encourage reporting of timely use of antibiotics, prevention of central line sepsis, and other indicators of quality of care.[44] Consistent with the adoption of generic EMRs, anesthesiologists have cited financial constraints as one of the main barriers to adoption.[41] Another major factor may be the level of customization required following selection of an AIMS (e.g., interfacing with each institutions' enterprise computer network, various anesthetic machines, and stand-alone equipment). Without customization, commercially available systems are inadequate for individual user/institutional needs and practices[43] and the specific interoperability required.[45] Some have also suggested that anesthesiologists, in particular, have competing priorities as a result of contracting/employment arrangements and scheduling at multiple sites.[39] A more global barrier, not specific to anesthesiologists, may be physician resistance due to concerns that electronic documentation will alter the workflow in their daily practice. Involving stakeholders in the selection and implementation of the systems may help overcome this barrier.[39]

One of the strengths of this review is that it updates previously published work. In spite of the varied nature of the literature, we identified themes consistent with the previous review[19] and with our own experience. A further strength of this review is our use of the systematic review methodology of the Joanna Briggs Institute, which provided a recognized template for the review process.[20] Each paper was independently reviewed by two reviewers, and any disagreement on inclusion and interpretation required consensus from all authors.

A limitation of this review is that most papers originated in the USA. Consequently, the take-home messages should be interpreted with caution, given the international variation in healthcare systems as well as the potential differences in general belief systems and safety climates. In some studies, the primary focus was not on identification of barriers to the adoption of EMRs, while in others, only a narrow range of barriers were considered[25] or the authors did not indicate reporting frequency or rank the importance of the barriers.[34] Comparisons between papers were hampered by the use of different analytic methods and/or theoretical frameworks in which the barriers were considered.[21,28,33] In some instances, barriers were only loosely identified in terms of "factors associated with adoption"[24] or "facilitations with respect to efficiency and efficacy",[28] in which case, we interpreted the absence of factors as a barrier. Hackl considered barriers to adoption of mandatory EMRs rather than EMRs selected by the institution/physician as in the other articles reviewed.[34] All these factors make it difficult to formulate collective summary statements about the studies.

Institutional experiences in adopting an EMR system

An EMR system was developed in our institution by acute pain clinicians in concert with a research-based software development team. The system was specific to the needs and workflow of the Acute Pain Management Service. An EMR system for acute pain could 1) enable clear documentation of care for perioperative pain and make it available in real time to any clinician; 2) allow for analysis of data with respect to management strategies and patient outcomes; and 3) facilitate the formulation and testing of hypotheses for further augmentation of accountability, quality of patient care, and translational research. Nevertheless, the adoption of this EMR system was a distinct challenge with periods of success and regression over a five-year span.[15,46-52] The process included participation of several academic pain teams who came together to develop a national strategy for acute pain management.[47]

Before the introduction of this EMR system, we relied on a paper-based system for identifying and tracking those patients on the APMS system. Incomplete or missing papers resulted in patients being potentially lost to follow-up, which could deleteriously affect patient safety. In addition, the handwritten assessments were rarely standardized and often illegible, and this hindered successful handover of management plans. The new system (ACUPAM) was designed to improve communication and patient safety in the context of acute pain management, to provide support for decisions to improve patient care and facilitate teaching, and to contribute to research in pain management.

Process and implementation

The ACUPAM system enables computer charting for patient interactions and retrieval of historical information. Initially, this was a rudimentary patient list stored locally on a personal digital assistant (PDA) that quickly evolved into a Web-based system supporting both wireless and local area network (LAN) data entry and retrieval. The system remains partially integrated into the hospital enterprise patient care system. Access has always been secured by a username and password logon requirement (two-factor authentication), which is consistent with the evolving hospital EMR system. An interface with the hospital operating room software affords a pre-populated screen for scheduled elective surgical procedures, while

free-text ability enables emergency procedures to be entered manually. Surgical subspecialty is recorded to facilitate information retrieval and analysis. Free text is also available for further rundown of pertinent details relevant to the patient's pain management, supporting communication between those involved in management decisions at the bedside. The treatment modality panel provides a dropdown list of a variety of treatment options, including regional techniques, intravenous patient-controlled analgesia, and other options for co-analgesia. Built-in billing software for these procedures streamlines the process from an administration point of view. Operators can extract variables of their choosing over a specified time period to generate reports for clinical, research, and administrative purposes. Several features address common patient safety issues, such as handover between members of the pain management team and rapid access to laboratory results. Key patient history features, such as chronic opioid use, are flagged. A link with the hospital laboratory system provides users the ability to review recent lab results, and a flag system is in place to identify those patients with pre-identified laboratory values outside of a user-defined safe range. An active patient list can be accessed from any workstation/mobile device, or essential information can be printed, including patient name, location, surgical procedure, management modality, and postoperative day number. Regular updates from the registration, admission, and triage software of the hospital enterprise computer system accurately identify a patient's location in the hospital at any time.

A combination of free text and predefined checkbox variables facilitate documenting assessments. The variables, which are modelled on the data set recommended by the Canadian Collaborative Acute Pain Initiative,[47] help clinicians complete a comprehensive assessment. Assessment variables are unique to the type of modality chosen (e.g., sensory and motor assessment for regional techniques, opioid consumption for intravenous patient-controlled analgesia). The assessment items can be seen on a summary page, which allows the clinician to view the previous four assessments at a glance and observe trends over time (Fig. 2). Important and/or rare events, such as respiratory depression or neurologic dysfunction, are documented on a "notable events" tab. From a quality improvement perspective, the ability to search the database over time to determine the incidence of such notable events has been valuable in safety reporting.

Results

The number of patient records managed on the APMS system has consistently increased over the decade since introduction (Table 2). This project originated as a research program funded by peer-reviewed grants, and subsequently, these funds were supplemented by additional industry support. Multiple research efforts associated with this research program have cost in excess of a million dollars. The annual $10,000 maintenance contract is built into the hospital budget, as it is a tool for patient care; however, the costs for upgrades are financed from our department (e.g., one major upgrade in 2006 to improve the interface, one minor upgrade to facilitate adding billing logic, and other minor upgrades).

We faced many challenges when adopting our system for implementation. As the system was initially developed as a research tool, many clinicians viewed the information required on each assessment as excessive, and therefore compliance was minimal. Engagement of all clinicians led to modifications of the software that satisfied the group and maintained efficiency and workflow. The other major challenges were determining the best hardware to use and the method by which to use it. Trial periods were conducted with PDAs, tablet computers, laptop computers on carts,[46,48,50] and kiosk desktop computers. Attempting to use a wireless infrastructure in its early stages of development was a frustrating experience for clinicians. Dropped signals, poor signal strength, and the resultant difficulty navigating through the patient files often led to our colleagues abandoning the technology. The current wireless system is appropriately robust and can be used easily by clinicians using an iPad or tablet computer; however, most clinicians use kiosk desktops, which are plentiful in our institution. The flexibility of system access to the LAN at kiosks has been an important feature in our adoption process.

The system allows data retrieval. We can extract a number of quality indicators in any given patient group and over any specified time period (Table 3). "Notable event" review is important for patient safety and quality assurance. For example, modifiable outcomes, such as respiratory depression, the prevalence of nausea and vomiting, and potentially catastrophic epidural catheter issues, can be monitored and practice changes can be made. The ability to retrieve data in real time to support clinical research hypotheses is a powerful tool for practice improvement. Additionally, providing statistics on clinical activity is essential to support resource allocation.

In our view, the key features of the APMS system that improve patient care and workflow are: 1) an up-to-date list of patients on the service, their latest locations, and whether or not they have been assessed on a given day; 2) clear, concise, and legible documentation of assessments and management plans; 3) a flag system for abnormal laboratory results; and 4) a searchable database for important quality indicators for patient care.

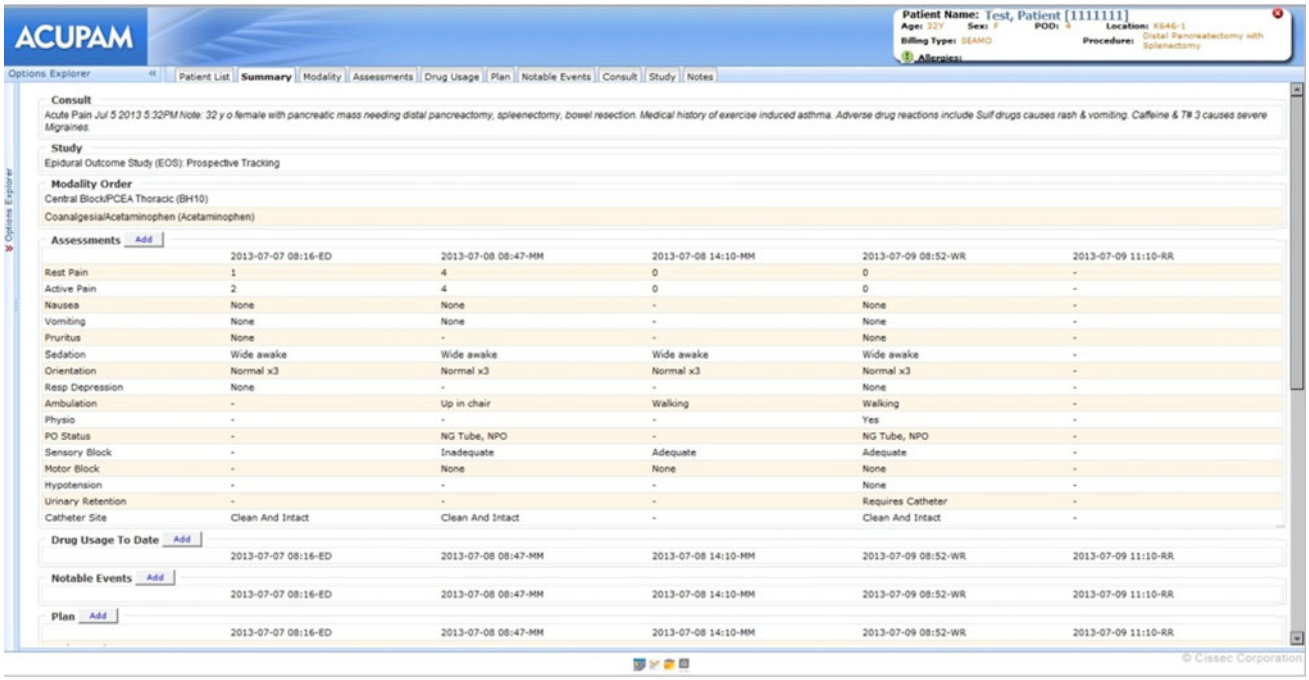

Fig. 2 Representative screen shot from ACUPAM, the acute pain management electronic medical record system used at our institution

Table 2 Management of patient records on the APMS system: comparison between 2006 and 2012

	Patient Census	Patient Visits	Average Daily Patient Census	Average Patient Visits/Week	Average New Patients/Week
2006	2,947	10,399	31	158	56
2012	3,488	13,616	30	219	66

APMS = Acute Pain Management Services

Discussion

While it would appear reasonable (in terms of both economics and patient safety) to implement EMRs, the process is far from straightforward. While some of the most commonly cited barriers, as confirmed in our review, were part of our implementation experience, other barriers were less obvious and even unforeseen. The benefits of ACUPAM were expected to be support for clinical and administrative management of acute pain while facilitating use of data for research. Nevertheless, the efficiency desired to document patient assessments, i.e., clinical needs, did not fully align with the need for extensive variable data for research. As a result, implementation of the initial version of the software was hampered by extensive data collection as well as by the abovementioned barriers to adoption. Clinicians reported that it interfered with their workflow and efficiency.[50] To overcome these challenges, we designed a revised version of the software using an iterative approach to development[15,46,48,51] and improved efficiency of data entry using portable devices.[48] There was a formal evaluation of documentation on an acute pain service using handheld computers *vs* pen and paper[48] as well as a review of social norms and peer pressure as they related to adoption.[52] In short, we addressed the users' concerns and thereby encouraged adoption.

Anecdotal evidence on the implementation of ACUPAM in The Ottawa Hospital a decade later identified similar barriers to the initial implementation, but distinct differences were also recognized. Financial challenges were perceived to be significant, as unforeseen costs continued to increase. The introduction was initially funded with a grant of $10,000; however, modifications of the software to fit the workflow in the centre turned out to be a larger project than anticipated, requiring close to $90,000 of additional departmental funds over the ensuing six years. Information technology and infrastructure requirements were also underestimated. The need for security, privacy, seamless wireless navigation, and

Table 3 Sample variables available for quality analyses*

Subgroups	Variables
Gender	Pain scores
Surgery type/Surgical category	Side effects
Modality type/combination	Notable events
Age group	Opioid use
Nursing unit	Activity level
Opioid tolerance	Diet
Time period	Length of stay on APMS

*Any subgroup or variable can be combined and/or compared. APMS = Acute Pain Management Services

appropriate server space complicated the project. Interestingly, physician resistance to using the system was not encountered. As this implementation was a decade later, most physicians were already computer literate and welcomed an electronic record that was much more efficient than the previous paper system. The version of ACUPAM implemented had been designed and tested for use on an iPad; moreover, the hospital provided additional support by issuing iPads for communal use, which further enhanced adoption. In addition, the environment at the time of implementation involved widespread computer technology enhancements and EMR developments in other areas, so the physicians were quite accepting of this "new reality". The physicians found that the use of ACUPAM saved a significant amount of time during patient care. The clear communication, ease of finding patients within the hospital, and ability to look up patient charts from remote locations were extremely helpful to the workflow. The seamless integration of the billing software has significantly increased billing capture.

The similarities and differences in ACUPAM adoption between two different centres at two different time frames help underscore the common themes that may be generalizable elsewhere. It is common to underestimate the enormity of challenges when implementing an EMR, particularly in terms of financial resources, Information Technology involvement, and time required. The success in the second centre was the result of continued support from the department chair as well as a dedicated group of physician users. Although implementation had its challenges, not a single user would want to go back to the paper system. Another major factor in the success of the second centre was the substantial improvement of wireless infrastructures over the previous decade. As shown in the introduction of ACUPAM in the second centre, the use of up-to-date hardware (tablet computers or iPads) and a stable wireless infrastructure have solved the majority of concerns regarding interference with workflow. Giving clinicians the ability to access the ACUPAM on the LAN has been a very useful strategy for us, as it provides them with the flexibility to use the device of their choosing. The widespread availability of kiosk computers on the LAN makes accessing patient information easy and efficient even when working in the operating room.

Anesthesiologists are, by nature or necessity, independent individuals each with their own unique characteristics, and as such, they are not always fond of what they perceive as interference from administration or management suggesting changes to their practice environment. Consequently, our colleagues were initially skeptical of ACUPAM. In hindsight, anesthesiology staff would have benefited from an adoption strategy that was individualized, effectively communicated, and formulated with a corporately supported framework in mind. Lessons can be learned from the corporate world with regard to improving this process. Kotter describes an eight-stage process to enable successful corporate change.[53] He explains the necessity for establishing a sense of urgency; creating a team of like-minded early adopters; developing an EMR vision, tactical strategy, and communication methodology; incentivizing physicians; establishing short-term wins to sustain the effort of adoption; leveraging the wins and reinforcing the argument for change; and finally, nudging the corporate and physician cultures to sustain the adoption of EMRs.

Conclusions

The barriers affecting anesthesiologists when adopting the EMR system for acute pain management were similar to those described in our review of adopting a general EMR system. Moreover, the interrelationship between each barrier makes explication difficult. Yet despite these issues, use of the ACUPAM system is now the standard of care in our institution. Computer technology is becoming omnipresent; the average physician is more computer savvy, and the new technology is no longer as daunting to accept and adopt. The eventual success of our adoption process was due to the perseverance of clinician leadership. Physician and nurse practitioners addressed issues as they arose and incorporated user feedback for translation into software improvements.

Financial cost, technical issues, and potential loss of time or efficiency continue to be major barriers to adoption of electronic medical records. These issues have not changed in the last five years despite the exponential adoption and incorporation of information technology into every other aspect of life. As was shown in both institutions, implementation of an EMR system requires an understanding of these barriers and a formulated strategy for change in order to achieve successful

adoption. There must be an intimate understanding of the technology and its application to clinician workflow and needs. Institutions may face additional barriers depending on the type of EMR system they implement (a general EMR system or an EMR system for a specific specialty) and whether they plan to incorporate mobile devices. Regardless, the fundamental principles remain; the system must fit the task at hand and meet the needs and capabilities of the users.[37]

Overall, adopting an EMR system will be successful once physicians' expectations are clarified regarding medical records in general and electronic versions in particular and lay the groundwork for implementation. Before a new EMR is considered, there must be corporate endorsement, hospital and department support, physician support (in time and education), information technology prioritization, and a well-communicated implementation strategy. Characteristics of the EMR and related systems must include an interface with existing electronic charts, intuitive technology, a stable wireless infrastructure, and 24/7 technical support. In short, the EMR system must help clinicians produce the desired end result, i.e., safe patient care. With "multidirectional accountability" (corporation to patient, clinician to patient, clinician to corporation, and corporation to clinician), the initiative can be successful.

Key points

- Today's healthcare environment requires clear effective communication and data collection as can be provided by an EMR system.
- The main barriers to physicians adopting an EMR system are time, technical issues, and cost, and these stumbling blocks have not changed over the past decade.
- Physician involvement is crucial in ALL phases of development and implementation, and the EMR system must be tailored to fit into the physician's workflow.
- Information Technology must offer ongoing 24/7 support and involvement.
- In order for successful adoption of the EMR system, management must engage the users and provide the resources to endorse a corporate strategy for change.

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