

Refereed papers

Barriers to proliferation of electronic medical records

Ignacio Valdes MD MS
MIRECC Fellow, Houston Center for Quality of Care and Utilization Studies, Health Services Research and Development Service, Department of Veterans Affairs Medical Center, and Department of Psychiatry and Behavioral Sciences, Baylor College of Medicine, Houston, Texas, USA

David C Kibbe MD
Director of the Center for Health Information Technology

Greg Tolleson MS
Manager of Data Analysis and Collection

American Academy of Family Physicians

Mark E Kunik MD MPH
Senior Scientist and Associate Director, Houston Center for Quality of Care and Utilization Studies, Health Services Research and Development Service, Department of Veterans Affairs Medical Center, and Department of Psychiatry and Behavioral Sciences, Baylor College of Medicine, Houston, Texas, USA

Laura A Petersen MD MPH
Robert Wood Johnson Foundation Generalist Physician Faculty Scholar, Houston Center for Quality of Care and Utilization Studies, Health Services Research and Development Service, Department of Veterans Affairs Medical Center, and Department of Medicine, Baylor College of Medicine, Houston, Texas, USA

ABSTRACT

Background Error reduction, quality improvement and lowering of cost can all be achieved through electronic integration of healthcare providers. Proliferation of standard electronic health records/electronic medical records (EHR/EMR) software is an essential precursor of this integration. Proliferation of EHR/EMR software has not occurred in the United States.

Objective To characterise users and non-users of EHR/EMR software, identify potential barriers to proliferation, examine the extent of standardisation across reported EHR/EMR and suggest possible solutions to identified barriers.

Methods We performed a secondary analysis of member survey data collected by the American Academy of Family Physicians (AAFP) in January 2003. The purpose of the survey was to measure interest in an AAFP-sponsored EHR/EMR service. We examined demographic and purchasing data from the survey by gender, population density, region and age. We also counted the number of different software vendors reported by users of an EHR/EMR to assess the number of users with unique software.

Results Of the 35 554 members contacted, 5517 (15.5%) responded. Of those responding, 1297 (23.5%) reported use of an EHR/EMR. Of the members responding, 81% reported interest in EHR/EMR software and 61% reported cost as a major reason for not purchasing it. At least 264 different EHR/EMR software programs are currently in use. On average, the percentage of respondents with the same EHR/EMR software is 0.4%.

Discussion The number of AAFP members with unique EHR/EMR software is very large. Fragmentation, caused by the use of hundreds of unique systems, is a major barrier to proliferation of these systems. Many of the barriers to proliferation could be mitigated through the tools and techniques available through Free and Open Source Software (FOSS).

Keywords: access and evaluation, computerised, healthcare quality, medical informatics, medical records systems

Introduction

Fewer than 10% of all healthcare systems in the United States use significant computerisation, despite the fact that healthcare delivery through integrated computer systems yields reduced medical errors and lowered medical costs.[1–5] While many have attempted to implement healthcare information technology solutions, costly failure has been the rule, not the exception.[6,7] Substantial literature exists regarding the barriers to the implementation of electronic health records/electronic medical records (EHR/EMR) in medicine.[1,3,8–14] Identified barriers include lack of ability to exchange data, high cost, lack of standardisation and multiple organisational issues. Despite the identification of these barriers and attempts at solutions, such as medical record data exchange standards like HL7, the proliferation of these technologies in medicine has not proceeded to the extent that it has in other industries.[15] Even the 'successes' have major ethical, training, disaster preparedness and sustainability problems.[12,14,16,17] Under the present circumstances, a patient is likely to have a longer life than the software on which their medical record is stored, making access to these vital data difficult or impossible.[18]

A systematic examination of reasons for the failure of widespread use of clinical computing software in medicine is an important step in improving the penetration of these vital technologies.[2] We examined American Academy of Family Physicians (AAFP) member survey data to achieve the following goals:

- to characterise users and non-users of EHRs/EMRs
- to examine the number of unique EHR/EMR software packages in use among AAFP members
- to identify potential barriers to their use
- to suggest possible solutions to identified barriers.

Our hypothesis is that the lack of standard software is a major barrier to proliferation of EHR/EMR software. Proliferation of standard EMR software is an essential condition for healthcare delivery through integrated computer systems.[2]

Methods

The AAFP collected member survey data in January 2003 to measure interest in an AAFP-sponsored EHR/EMR service. The study population consisted of active members of the AAFP (n=55 400) with email addresses (n=35 554; 64%). We performed a secondary analysis of these data using an electronic spreadsheet and SAS™ statistical software. The survey consisted of seven questions on the following topics: current use of EHR/EMR, name of currently used EHR/EMR, gender, age, region, reasonable amount to pay per month for constant EHR/EMR service, and reasons why EHR/EMR software has not been purchased.

Statistical analysis was done on the demographic data in order to identify possible trends in the use and non-use of EHR/EMR, interest in purchasing EHR/EMR software and the amount willing to pay per month for constant EHR/EMR service. Chi-square (χ^2) tests and t-tests were used to examine differences between the two groups for discrete-valued and continuous-valued variables, respectively. We performed univariate analyses using the χ^2 test to examine differences in interest (yes/no) across region, age and gender. We performed univariate analyses using the t-test to examine the differences in amount willing to pay across region, age and gender. Finally, we utilised two regression models to analyse variance in (1) interest in an EHR/EMR and (2) amount willing to pay. To examine the variance explained by region, age and gender on interest (yes/no) in EHR/EMR, a logistic regression was performed. A linear regression was done to examine the variance explained by age, region and gender on the amount willing to pay for EHR/EMR.

Examination of the extent of unique software systems across reported EHR/EMR software was done by sorting the EHR/EMR programs in our dataset by name and then counting the number of unique EHR/EMR programs listed, as well as the number of users for each unique EHR/EMR program. Uniformity of the data was achieved by changing inexact but obvious matches, such as misspellings or a company name versus the name of the product the company sells. All locally developed software was categorised as 'in-house'. In-house software was counted as a single vendor or group, despite the high likelihood of non-standardisation. This assumption would tend to underestimate the effect we were assessing. Standardisation is an important contributor to the ability of these systems to be used.[19]

Results

Of the AAFP members with email addresses, 5517 responded to the survey, producing a response rate of 15.5%. The average age of respondents was 46 years (SD ± 9 years, range 24–80), non-respondents' average age was 44.6 (SD ± 9.5 years, range 25–91), and 4348 (78.8%) of respondents were men versus 68.3% of non-respondents. The average age of an EHR/EMR user was 45 (SD ± 8, range 26–80) and 1044 (80.5%)

were men. Of those responding, 1297 (23.5% of respondents) reported use of an EHR/EMR, 4211 (76.3% of respondents, 7.6% of all AAFP members) reported no use of an EHR/EMR, and 9 (0.2%) made no response.

No difference existed in current use of EHR/EMR across demographic groups. Table 1 displays the differences in current use, interest and amount willing to pay per month for EHR/EMR service across gender, population density (urban/rural), region and age group.

Males and those in younger age groups (82.0%, P=0.003 and 83.7%, P=0.01, respectively) had increased interest in purchasing EHR/EMR. There was little difference in interest for urban versus rural groups (80.6% vs 82.7%, P=0.29). Subjects under 40 years old reported the highest rate of interest in EHR/EMR use at 83.7%, with those aged 40–65 reporting 80.4% interest, and those over 65 (n=114) reporting 75.3% interest (P=0.01). Regional differences existed, indicating more interest in the South (P=0.004). Within the logistic regression model, we examined odds of use of EHR/EMR, controlling for region, age and gender. After adjustment for age and gender, those in the South were significantly more likely to be interested in EHR (OR: 1.4, CI: 1.2–1.7, $P<0.0001$). Each ten-year increase in age resulted in a significant decrease in interest in EHR/EMR (OR: 0.8, CI: 0.7–0.9, $P<0.0001$), after being adjusted for gender and region within the logistic regression. After adjusting for age and region, females were significantly less likely to be interested in EHR/EMR (OR: 0.7, CI: 0.6–0.9, $P<0.0001$).

The average member would be willing to pay $152 per month (SD ± $414, range 0–20 000) for an AAFP-sponsored EHR/EMR service. Males would be willing to pay on average $156/month versus $126/month for females ($P<0.003$). There was no difference among age groups for the amount physicians would be willing to pay (P=0.52). The average clinician in the Northeast region would be willing to pay $127; the West, $145; the South, $146 and the Midwest, $182 ($P<0.04$). Linear regression examining the variance in the amount those surveyed were willing to pay by region, age and gender showed no significance for any of the variables.

Table 2 shows the reasons respondents gave for not purchasing EHR/EMR software. Cost concerns (n=2548, 60.5%), work slow-down (n=2282, 54.2%), concern that the company may go out of business (n=1629, 38.7%) and security/privacy issues (n=998, 23.7%) were the most common reasons given. More than one answer could be given, resulting in percentages

Table 1 Demographic comparison of EHR/EMR use, interest and reasonable amount users are willing to pay per month for the service by gender, population density, region and age*

	Current use of EHR/EMR %	P-value (group difference)	Interest in EHR/EMR %	P-value (group difference)	Reasonable amount/month mean ± SD ($)	Confidence interval for mean	P-value (group difference)
Gender							
Male	21.7	0.10	82.0	0.003	$156 ± $447	141–172	0.003
Female	24.1		78.1		$126 ± $177	113–139	
Density							
Urban	23.5	0.90	80.6	0.29	$155 ± $479	137–173	0.58
Rural	23.7		82.7		$146 ± $231	133–159	
Region							
South	24.1	0.96	83.9	0.0004	$146 ± $214	135–157	0.04
M-west	23.4		78.8		$182 ± $746	136–229	
N-east	23.3		81.5		$127 ± $161	114–140	
West	23.5		79.3		$145 ± $194	132–158	
Age group							
<40	23.5	0.60	83.7	0.01	$158 ± $398	133–183	0.52
40–65	23.7		80.4		$148 ± $421	133–164	
>65	19.1		75.3		$205 ± $325	116–294	

*Missing data rates were gender (n=2, 0.04%), density (n=337, 6.11%), region (n=70, 1.27%), current use (n=9, 0.16%), interest (n=9, 0.16%), age (n=27, 0.49%), reasonable amount (n=1576, 28.57%)

Table 2 Reasons EHR/EMR has not been purchased*

Respondents *n*	Respondents %	Response
2548	60.5	I can't afford an EHR/EMR
2282	54.2	I am worried that the currently available products will slow down my workflow and decrease productivity in the office
1629	38.7	I am worried that companies that sell this software may go out of business
998	23.7	I am concerned about security and privacy issues
846	20.1	I am worried that my partners won't accept an EHR/EMR
348	8.3	I don't type
1628	38.7	Other reason

*Respondent allowed to choose more than one response. 22 respondents, 0.5%, did not provide this information

adding up to greater than 100. Of all of those currently using EHR/EMR software, 86% (1119) used proprietary software.

Table 3 shows that there were four medical software vendors that accounted for the four most frequently reported installations – Centricity/Logician/Medicalogic/GE, Physician Micro Systems/Practice Partner, Epic/EpicCare/Epic Systems and Docs, Inc/Soapware (*n*=148, 138, 108 and 90, respectively) – accounting for 37% of the total number of users of EHR/EMR software in this sample and 0.9% of all 55 400 AAFP members. The fifth largest group reported was 'unknown' (*n*=62). The sixth largest group consisted of those who used locally developed, 'in-house' software (*n*=60). The seventh largest category (*n*=56), 'Government', used CHCS/VistA software, which is available in the public domain. The remainder of the EHR/EMR software users were placed in an arbitrary 'Other' category of EHR/EMR users and consisted of groups with less than 56 users (*n*=635). The largest group of EHR/EMR users using the same software in this sample was 2.6% of the respondents. At least 264 different EHR/EMR programs were currently being used among the family physicians that responded to the survey, which averages to 1297/264 = 4.9 or 0.4% of respondents who use the same EHR/EMR.

Discussion

Our results show that among this small sample of AAFP members, there were a large (*n*=264) number of unique medical record software systems in use. We believe the likelihood is low that standardisation is occurring among these unique medical records

Table 3 Frequency of EHR/EMR by vendor

Group	Total users *n*	Total users %
Centricity/Logician/Medicalogic/GE	148	11.4
Physician Micro Systems/Practice Partner	138	10.6
Epic/EpicCare/Epic Systems	108	8.3 Docs,
Inc/Soapware	90	6.9
Unknown	62	4.8
In-house developed	60	4.6
Government (CHCS/VistA)	56	4.3
Other, less than 56 users	635	49.0
Total	1297	99.9

software systems. Like other studies, we conclude that there is a low rate of standardisation among current EHR/EMR software users in this sample. Respondents also identified cost, work slow-down, business failure and security concerns as the top four barriers to purchasing EHR/EMR software.

Our findings of low usage of EHR/EMR are consistent with the low rate of computer usage in medicine.[2] The demographic data revealed little difference in current use of EHR/EMR software by gender, population density, region or age group. This indicates a stable equilibrium of low usage across groups and the presence of an insurmountable barrier. Males and younger age groups seemed to be somewhat more interested in EHR/EMR software, perhaps due to greater exposure to computers among these populations. Our findings that those in the South had the most interest and that those in the North had the least interest confirmed the findings of Lenhart *et al*.[20]

The $152 that the average AAFP member is willing to pay suggests the possibility that a transition from a proprietary licence-based industry to a service-oriented one could be viable. Males appeared to be willing to pay more for the software than females. Concerns about decreased productivity, that partners won't accept the software, about cost and that the company selling the software may go out of business are likely to be legitimate reflections of the commonplace expensive failures that medicine has experienced.[6,7] The low percentage (8.3%) of clinicians reporting concern about inadequate typing skills is similar to the results of Rind and Safran, who also found this to be much less of a problem than expected.[13]

The strongest findings are that greater than 264 unique types of EHR/EMR software implementations are in current use among respondents, resulting in only 0.4% of respondents using the same software. The actual rate of unique software systems is likely to be much higher, based on the assumptions inherent in treating 'in-house' and 'unknown' software groups as only one unique EHR/EMR each. Our findings illustrate the magnitude of the problem and are consistent with previous studies that found standardisation to be a major barrier to proliferation.[14,21] Such widespread non-standardisation results in a great devaluation of existing implementations.

The devaluation due to non-standardisation can be measured through the application of Metcalfe's Law. Metcalfe's Law states that 'the value of a network grows as the square of its number of users'.[22] The definition of 'value' in this law is a broad one, and it can include but is not limited to the following: computing, economic, social, political and communication values. In short, to get the maximum value, one must connect with everyone else and be like everyone else.[23] A concrete example of the law is that a one-node network, such as a single telephone, has the power to communicate only with itself, and therefore has a utility of 1^2 or 1. A usable two-node telephone network has a much greater utility than just double that of a one-node network, when taking into consideration its possibilities for economic, social and political activity. It therefore has a power of 2^2 or 4, with each added user increasing power, going to 3^2 and so on. When a 'critical mass' of standard users is reached, the value increases dramatically as well. Adoption of the technology accelerates and becomes ubiquitous once that mass has been achieved. This has occurred in other industries, yet medicine remains one of the few in which this necessary change has not occurred.[15] If all 55 400 AAFP members were using standard software, the network would have an arbitrary value of $55\,400^2$ or 3 069 160 000. Currently, the largest group of users with the same software is only 148, yielding an actual network value of just $148^2 = 21\,904$.

A potential solution to the barriers of standardisation, cost and business failure, identified in our study is Free and Open Source Software (FOSS) EHR/EMR.[24,25] FOSS is not a particular piece of software; rather, it is a software engineering method or a software agreement that results in alternatives to proprietary software. 'Free' refers to the safeguarding of software freedoms, not price.[26] It is not free of costs associated with installation, maintenance, support and training.[27] FOSS software is characterised by licences which guarantee access rights to program software, such as rights to 'run, copy, distribute, study, change and improve the software'.[26] One of the most highly regarded free licences is called the GNU General Public License, or GNU GPL for short.[28] These rights are not guaranteed with proprietary software and in fact are rarely available for it. Our data show that proprietary software dominates clinical computing in this sample.

Interconnectivity problems have been solved in the past using FOSS techniques.[29,30] This is best demonstrated by the internet, which owes much of its universal nature to software developed in a free manner.[30–32] While FOSS is not a universal solution to interconnectivity (and other) problems, data exchange and standardisation problems are more easily solved using FOSS licences since no technical information can be hidden.[33] FOSS software can be incorporated without charge into a different product if it adheres to the terms of the licence. Permission to incorporate parts of FOSS software in whole or in part is explicitly granted in advance by the licence. The only real barriers to standardisation are technical, but not legal or political. FOSS may be effective in addressing the identified concerns of clinicians found in Table 2 of the survey, particularly those of cost and companies going out of business. FOSS systems can remove the cost and necessity of duplicate engineering, as well as removing disincentives to standardisation of both data and user interface.[31] Furthermore, the ability to

test standardisation among multiple systems does not require purchasing each unique product. Currently, the likelihood that a vendor has the financial and technical means of buying all or even some proprietary competitors' products to do standardisation testing is exceedingly low, given the high cost of EHR/EMR software.[34] One study has shown that the FOSS-based Veterans Administration physician order entry system was preferred over a proprietary one.[35] The AAFP is actively developing a software service using FOSS techniques.

Our analysis has some limitations. First, the overall response rate of the survey was only 15.5%, which was lower than the 25–32% rates published in other online survey studies.[36] This may have biased our results by the exclusion of significant populations of EHR/EMR users. Second, self-selection bias may have occurred in the form of (a) having an email address, (b) responding to the survey and (c) being a member of AAFP. However, we believe that because those with the greatest interest in this topic are the most likely to respond, our findings are an underestimate of the true extent of the problem of non-standardisation of EHR/EMR software. Third, our age findings may be biased due to the smaller number of respondents over the age of 65. Fourth, our assumption of standardisation among unique EHR/EMR may be flawed. Alternatively, it may also be true that 'standard' software cannot exchange records with itself easily. Despite the desirability and economic benefits of an integrated clinical software infrastructure, the near-term prospects for widespread use of standard EHR/EMR software appear poor. This is due to the devaluation of EHR/EMR software through hundreds of unique systems. Fundamental change through the use of EHR/EMR software is widely recognised as necessary, but a specific mechanism for such change is lacking. Free and Open Source Software shows promise as a means to achieving the true potential of EMR software in improving health care.

ACKNOWLEDGEMENTS

The authors of the paper would like to thank Brenda Schubert, Peter Richardson PhD and Laura Krishnan for their invaluable assistance in the preparation of this manuscript.

This material is based upon work supported (or supported in part) by the Health Services Research and Development Service, Office of Research and Development, Department of Veterans Affairs; and by the Office of Academic Affiliations, VA Special MIRECC Fellowship Program in Advanced Psychiatry and Psychology, Department of Veterans Affairs and the American Academy of Family Physicians.

REFERENCES

1 Agrawal A. Return on investment analysis for a computer-based patient record in the outpatient clinic setting. *Journal of the Association for Academic Minority Physicians* 2002;13(3):61–5.
2 Institute of Medicine. *Crossing the Quality Chasm: a new health system for the 21st century*. Washington DC: IOM, 2001.
3 Institute of Medicine. *The Future of the Public's Health in the 21st Century*. Washington DC: IOM, 2002.
4 Bates DW, Leape LL, Cullen DJ *et al*. Effect of computerized physician order entry and a team intervention on prevention of serious medication errors. *Journal of the American Medical Association* 1998;280(15):1311–16.
5 Petersen LA, Orav EJ, Teich JM, O'Neil AC and Brennan TA. Using a computerized sign-out program to improve continuity of inpatient care and prevent adverse events. *Joint Commission Journal on Quality Improvement* 1998;24(2):77–87.
6 Dorenfest S. The Decade of the '90s. *Healthcare Informatics* 2000;Aug:64–8.
7 Littlejohns P, Wyatt JC and Garvican L. Evaluating computerised health information systems: hard lessons still to be learnt. *British Medical Journal* 2003;326:860–3.
8 Ash JS. Factors affecting the diffusion of the computer-based patient record. *Journal of the American Medical Informatics Association Supplement, AMIA Proceedings* 1997;682–6.
9 Berkowitz LL. Breaking down the barriers: improving physician buy-in of CPR systems. *Healthcare Informatics* 1997;14(10):73–6.
10 Chessare JB and Torok KE. Implementation of COSTAR in an academic group practice of general pediatrics. *MD Computing* 1993;10(1):23–7.
11 Dansky KH, Gamm LD, Vasey JJ and Barsukiewicz CK. Electronic medical records: are physicians ready? *Journal of Healthcare Management* 1999;44(6):440–54.
12 Pare G. Implementing clinical information systems: a multiple-case study within a US hospital. *Health Service Management Research* 2002;15(2):71–92.
13 Rind DM and Safran C. Real and imagined barriers to an electronic medical record. Proceedings of the Annual Symposium of Computing Applications in Medical Care 1993;74–8.
14 Retchin SM and Wenzel RP. Electronic medical record systems at academic health centers: advantages and implementation issues. *Academic Medicine* 1999;74(5):493–8.
15 Katz L. *Technological Change, Computerization and the Wage Structure*. Cambridge, MA: MIT Press, 1999.
16 Herb H. *The GNUmed Project Current State*. Proceedings of the Open Source Healthcare Alliance 2002 Conference, Los Angeles, November 2002. www.gnumed.org
17 Layman E. Health informatics: ethical issues. *Health Care Manager* 2003;22(1):2–15.
18 DeBry PW. Considerations for choosing an electronic medical record for an ophthalmology practice. *Archives of Ophthalmology* 2001;119(4):590–6.
19 Nielsen J. *Usability Engineering* (1e). San Francisco: Morgan Kaufmann, 1994.

20 Lenhart JG, Honess K, Covington D and Johnson KE. An analysis of trends, perceptions, and use patterns of electronic medical records among US family practice residency programs. *Family Medicine* 2000;32(2):109–14.
21 Gleiner JA. Paving the way for electronic medical records. *Physician Executive* 2000;26(1):32–6.
22 Metcalfe RM. Metcalfe's Law: a network becomes more valuable as it reaches more users. *InfoWorld* 10-2-1995:65. San Francisco, CA: InfoWorld Media Group, 1995.
23 Lucky W. Who runs the Internet? *IEEE Spectrum* 2002; 39(3):80.
24 Benson T. Medical software's free future: all software developed at the public's expense should be licensed as open source. *British Medical Journal* 2001;322:863.
25 Yackel TR. How the open-source development model can improve medical software. *Medinfo* 2001;10(Pt. 1):68–72.
26 Free Software Foundation. *The Free Software Definition*. Boston: Free Software Foundation, 2003.
27 Fink M. *The Business and Economics of Linux and Open Source*. Upper Saddle River, NJ: Pearson Education, Inc., 2003.
28 Stallman R. The GNU operating system and the Free Software Movement. In: DiBona C, Stone M and Ockman S (eds). *Open Sources: voices from the Open Source Revolution*. Sebastopol, CA: O'Reilly, 1999.
29 The MITRE Corporation. *Use of Free and Open-Source Software (FOSS) in the US Department of Defense*. Bedford, MA: The MITRE Corporation 2002.
30 Raymond ES. *The Cathedral and the Bazaar.* Sebastopol, CA: O'Reilly, 2001.
31 Cuffel BJ and McCarter L. Managed care: toward open-source practices in managed behavioral health. *Psychiatric Services* 2001;52(7):897–9.
32 Goldstein D. Open source powers the medical Internet today and tomorrow. *Managed Care Interface* 2002;15(2): 52–4.
33 Kantor GS, Wilson WD and Midgley A. Open source software and the primary care EMR. *Journal of the American Medical Informatics Association* 2003;10:616.
34 DeBry PW. Considerations for choosing an electronic medical record for an ophthalmology practice. *Archives of Ophthalmology* 2001;119(4):590–6.
35 Murff HJ and Kannry J. Physician satisfaction with two order entry systems. *Journal of the American Medical Informatics Association* 2001;8(5):499–509.
36 Cook C, Heath F and Thompson R. A meta-analysis of response rates in web- or internet-based surveys. *Educational and Psychological Measurement* 2000;60: 821–36.

CONFLICTS OF INTEREST

None.

ADDRESS FOR CORRESPONDENCE

Ignacio H Valdes MD MS
3519 Blue Bonnet
Houston, TX 77025
USA
Tel: +1 713 661 1887
Fax: +1 713 661 1887
Email: ivaldes@hal-pc.org

Accepted November 2003