

**Introduction:** As medical care gets more and more complex and new information is already overwhelming physician's capacity to treat patients with the latest information, physicians need new technologies to help them cope. There is great need for a digital record to allow capture of patient data that can then be processed and mined for insights into better treatment for patients. The electronic medical record (EMR) is the tool that promises to provide the platform from which new functionality and new services can be provided for patients.

**History of Electronic Medical Records:** Physicians are expected to document encounters they have with patients to ensure crucial information for decision-making is recorded and actions taken are also recorded. Documentation is also required as an archival record of what happened in cases of dispute. To a great extent, physicians resent the task of documentation, as it detracts from their primary task: taking care of patients. Physicians also resent the duplication of effort required with documentation, as every medication that is written on a prescription pad, every lab test ordered, every x-ray ordered has to be re-written in the chart to maintain a good record. Communication between practitioners is difficult as in many cases the information collected is fragmented, frequently redundant and voluminous. Finally, physicians are constantly inundated with new information and have no tools to help them incorporate new techniques and treatments into their day-to-day activities, other than using their memories or having to lug around large textbooks.

The idea of recording patient information electronically instead of on paper –the Electronic Medical Record (EMR) –has been around since the late 1960's, when Larry Weed introduced the concept of the Problem Oriented Medical Record into medical practice.<sup>1</sup> Until then, doctor's usually recorded only their diagnoses and the treatment they provided. Weed's innovation was to generate a record that would allow a third party to independently verify the diagnosis. In 1972, the Regenstreif Institute developed the first medical records system. Although the concept was widely hailed as a major advance in medical practice, physicians did not flock to the technology.<sup>2</sup> In 1991, the Institute of Medicine, a highly respected think tank in the US recommended that by the year 2000, every physician should be using computers in their practice to improve patient care and made policy recommendations on how to achieve that goal.<sup>3</sup>

However, in spite of pockets of use of EMR since the 1970's, mostly in government hospitals and a few visionary health institutions, EMR use has not taken off. It is estimated that EMR use is about 20% in the hospital sector in the US (less in Canada) and about 5% in clinics (probably about the same in Canada). In Canada, many large clinics have already implemented these technologies. However, the vast majority of physicians work in 1-3 physician practices, where the costs of implementing technology are prohibitive.

**Performance criteria:** Physicians need to be able to document findings and look up information quickly and easily in their electronic medical record. Since most patient encounters last about 7-10 minutes and typically 25% of the time is spent in documentation, physicians need to be able to record an encounter in about 2 minutes. They need systems that are low in cost to purchase and to maintain; they need highly reliable systems which are always available, that are easy to support and protected from data loss. They need systems which are easy to use and which don't require long learning curves.<sup>4</sup> They also want systems which enable them to control where

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<sup>1</sup> <http://phcsg.ncl.ac.uk/conferences/camb96/mikey.htm>

<sup>2</sup> <http://www.medrecinst.com/uploadedFiles/MRILibrary/StatusReport.pdf>.

<sup>3</sup> <http://www.medinfo.ufl.edu/omi/docs/olmr/cpri.html>

<sup>4</sup> <http://www.compete-study.com/publications.htm>

and how the information they collect is used, as they need to promise confidentiality to their patients. In addition to the clinical requirements stated above, physicians also benefit from the following functionality for their office: reduction of storage space from paper charts onto hard drives (typically can expect decreases from 100-300 square feet down to 20 square feet), fewer charts lost (typically from around 11% down to less than 1%), retrieval time of charts (typically from 1 minute down to 2 seconds).<sup>5</sup>

In addition to physicians, *health care systems* (e.g., HMOs, Regional Health Authorities, Ministries of Health) also need information technology to meet their management and administration needs. Their performance criteria include timely reporting of data, reduction of duplicate tests, reduction of medical errors, improvement of care and cost management. There has been an on-going tension in the health care marketplace between the needs of physicians and healthcare systems –their needs have not always been aligned. Additional performance criteria include use of standards for data exchange, billing, diagnosis, medications and laboratory data. To distinguish technology that meets health system needs from technology that meets physician needs, we will introduce a new term: Electronic Health Record (EHR). The EHR is the system that attempts to meet health system needs.

Although many people in the industry claim that no new technology is required to make the EMR effective in clinical practice, the infrastructure for exchanging data between physicians and pharmacists or laboratory technicians (the EHR) is still not in place. Implementing an EMR in the physician office recreates the data island prevalent today in the paper world –although, it is possible now to print off prescriptions and lab requisitions, saving physicians some time, effort and frustration of duplicate data entry.

**Description of the technology:** Clearly, the EMR (used by physicians in their offices) and the EHR (used by health systems to transmit and manage health care data) are complementary technologies. One without the other doesn't provide much benefit. The modules required by an EMR include: scheduling, patient registration, documenting patient encounters, writing prescriptions, managing documents, requisitioning and receiving lab and diagnostic imaging reports, managing interoffice communications, clinical decision support and billing. The modules required by an EHR are: Authentication of patients and providers, laboratory results reporting, drug claims adjudication, diagnostic imaging reporting, hospital discharge summaries, secure messaging and clinical decision support.

**The key platforms that have had some success** are the VistA program developed by/for the Veteran's Affairs Hospital system in the US. The Regenstreif Institute in Idaho also has developed a platform that appears to work for them, but has not been transferable to other places. Both systems are open-source software and are freely available for download. EpicCare Inc, a vendor that is using an old software platform called MUMPS, also seems to be taking off (**Exhibit 1**). Interestingly, EpicCare provides both the EHR and EMR component in its offering: HMOs in the US have flocked to it. Over time we see that these systems have moved from integrated, highly coupled systems to more modular, interoperable components. The first EMRs were large repositories with different views for different clinicians. Increasingly, new EMRs are being defined as modular components: the Good Electronic Health Record project<sup>6</sup>, the OpenEHR project<sup>7</sup> and the Canada Health Infoway EHR Blueprint<sup>8</sup> are all very modular in

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<sup>5</sup> [http://www.compete-study.com/Successful\\_Computerization\\_in\\_Small\\_Primary\\_Care\\_Practises.pdf](http://www.compete-study.com/Successful_Computerization_in_Small_Primary_Care_Practises.pdf)

<sup>6</sup> <http://www.chime.ucl.ac.uk/work-areas/ehrs/GEHR/>

<sup>7</sup> <http://www.openehr.org/>

<sup>8</sup> <http://www.infoway-inforoute.ca/>

their approach (**Exhibit 2**). All of these initiatives have taken the perspective of the health care system rather than that of physicians, mostly because the funders of health care tend to be the health systems themselves. In most cases, we have not seen large scale physician uptake of these products as they rarely meet physician's performance criteria.

In the last few years, governments around the world and health maintenance organizations (HMOs) in the US are increasingly encouraging the implementation of EMRs. Many western European countries have subsidized the cost of EMR so that physicians can afford them. In some European countries as many as 80-90% of physicians use an EMR in their practice. In these countries, governments have realized that EHRs cannot work if physicians are not using EMRs, since a crucial component of data is not available.

The major barriers to widespread EMR implementation are cost (both direct and indirect) and time required for documentation –current methods of data input are slow and tedious.<sup>2</sup> If discontinuities are going to make a difference to EMR uptake, it will have to be in these two areas. A data input breakthrough in the computer area in general could make a huge impact in this arena.

**Technology Cycle of Electronic Medical Records.** Our initial approach was to analyze this technology using Anderson and Tushman's model of technology cycles (characterized by the appearance of an initial technological discontinuity, followed by a period of 'ferment' (which includes a period of substitution and a period of design competition), which leads to the development of a dominant design and culminates in a period of incremental improvement). However, having gone through the process of gathering data for this paper, it has become more and more clear that this model is inadequate to describe this technology. Although the dominant design (DD) model can be applied to EMR technology, the technologies which end up being described are more generic and apply to many other industries, not just the EMR/EHR industry; for example, hardware, data input technologies, the Internet, database technologies and electronic data interchange (EDI), to name just a few. None of these technologies is unique to the EMR and EHR space.

When we start to describe the modules required to make the EMR and EHR work (**Exhibit 3**), we began to realize that perhaps the Modularization of Design theories described by Christensen<sup>9</sup> would more appropriately describe this industry and its development. Christensen explains that most complex technologies consist of components and subassemblies, which themselves are made up of yet smaller components, in a nested fashion. When technologies are first developed, products must often be built in an integrated way, because what the various components are and how they fit together is not well understood. Making changes to these systems can be quite costly as making changes in one area will inevitably cause changes in another area. Over time, people learn how to modularize the technology so that changes made to one module do not cause problems with another. Typically, they have to develop the standards for how various components should interface and how they will work together. As the technology matures, new modules can become "plug and play". Modularization has many advantages, including the ability to make changes and add new functionality quickly, easily and inexpensively. There are two factors which seem to point to modularization as the major technological paradigm for EMR and EHR technologies: First, the major players who are defining EHRs are defining them in a modular way. These, usually, governmental, quasi-governmental and consensus bodies are quite powerful and have significant backing behind

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<sup>9</sup> Christensen, Clayton M (2000). The evolution of innovation. In: Strategic Management of Technology and Innovation. Pp 3.2-3.10.

them. The second factor, discussed below in the standards section is that the EMR and EHR industries are too important as public goods to have standards be at the mercy of proprietary interests. So the modules and their interfaces are being developed by quasi-regulatory bodies. Christensen<sup>9</sup> goes on to point out that in industries that modularize, those who have proprietary advantages can easily lose their leads as their technology diffuses into the industry as component standards. This is congruent with our upcoming observation that there are no proprietary advantages to be had in developing standards in the health care sector. Teece<sup>13</sup> also points out that the Dominant Design paradigm does not characterize all industries. In fact, the dominant design paradigm is more suited to mass markets and less characteristic of niche markets where absence of scale and learning economies does not penalize multiple designs.

Anecdotal evidence to support this movement toward standardization and modularization are the experiences of many US HMOs who have tried to interface different legacy systems in their institutions. They have learned the hard way that interfacing costs are very large –many in the US invested heavily in projects that never came to fruition, or if they did, were behind schedule and over budget by several-fold. This has given greater impetus to standards and standard setting bodies, as more and more players realize the potential benefits of standards.

Additional evidence comes from major players in the EMR business. It is quite interesting to see that both Epic Systems and SOAPware provide their system in a modular way: SOAPware does this by providing optional modules that the physician can add at their convenience at an additional cost<sup>10</sup> and Epic does this by providing an ‘integration tool kit’ that allows large organizations to interface Epic’s systems to their other legacy systems, allowing them to fit the Epic ‘module’ into other existing modules in their institutions.

**Standards for Electronic Medical Records:** There are many standards that have to be met in providing electronic medical records. These standards are set by many different organizations, each having different ability to enforce or encourage their use.

The most obvious standards are those of privacy and confidentiality. These standards have been set by government through Privacy Acts and through regulation of professional licensing and accreditation bodies. In Canada, the latest legislation is the Personal Information Protection and Electronic Documents Act (PIPEDA). Although the Act is new and people are still grappling with its implications, it is likely to have a significant impact on EMR technology.

Other standards that are required include vocabulary standards to record symptom and diagnostic information and medication standards to allow decision-support tools to work properly and to support research; these all fall into the class of similarity standards. The major standards in this area are SNOMED (symptoms), ICD-9CM (diagnoses), AHFS and ATC (medications), LOINC (laboratory information) and CPT (procedure codes used for billing purposes).

New initiatives in both the US and Canadian markets are underway to create industry-wide platforms and standards for the creation of software and systems for EMRs and EHRs. In Canada, both Alberta and Ontario have developed specifications for EMRs. Vendors must conform to these specifications to be eligible to participate in government supported EMR initiatives. In addition to platform specifications, other initiatives are concerned with the *transmission* of data between systems so that various healthcare institutions involved in patient care can share information. These standards fall into the category of compatibility standards.

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<sup>10</sup> <http://www.docs.com>

Health Level Seven, Inc. is a not-for-profit, ANSI-accredited standards developing organization that provides an open, consensus-based process for standards development. Collaborators represent a broad sector of the healthcare community. The collaboration is focused on the HL7-developed EHR Systems Functional Model & Standard. HL7's open ballot process supports industry review and input, and will ultimately forge an EHR System Functional Model and Standard that achieves broad industry acceptance. The federal governments in both the US and Canada have recently committed to adopting HL7 messaging standards.

In Canada, Canada Health Infoway is an independent, not-for-profit corporation, formed through a partnership of federal, provincial, and territorial governments and funded by the federal government. Its members are the deputy ministers of health from across Canada. Infoway has Can. \$1.1 B for its 5 year mission. Infoway's mission is to accelerate the implementation of an interoperable EHR across Canada.

Infoway has released its Electronic Health Record System (EHRS) Blueprint. Focused on interoperability—the capability of computer and software systems to seamlessly communicate with each other— this document provides a modular and scalable architecture that lays out the business and technical considerations and approaches that will ultimately guide the sustainable development of EHR systems in Canada.

The role of government in driving the industry forward cannot be underestimated. In the billing and scheduling market, many players get weeded out when the government comes out with a new requirement for billing purposes. This occurs in the US in addition to Canada, since the US government is the largest purchaser of health care in the world.

Krechmer<sup>11</sup> points out that compatibility standards for public communications are becoming too important for the public to allow any private organization an overwhelming proprietary advantage. Similarly, in the health care industry, compatibility standards are crucial for the public good and most key stakeholders, government being one of the largest in most developed countries, are not willing to accept proprietary standards. Hence, there are few lock-ins or increasing returns to standards available in the health care sector, especially when it comes to medical records. Even where companies have been able to achieve lock-ins and monopolies from being defacto standards, the government has come down hard on such companies: viz, First Data Bank has become the defacto standard in drug-drug interactions databases. Even in this case, the US government has recently threatened them with an anti-trust suit.<sup>12</sup>

**Appropriability regimes in the healthcare sector:** We conducted a search of the US patent office<sup>13</sup> database for patents that related to electronic medical records. Although there have been a few that were granted in recent years, they have tended to be very generic, broad patents that have not really added anything new to the industry. In fact, all the patents we found describe technology that has been around for the last 5-8 years and describe technology that has been widely written about. For example, one patent describes an electronic medical record system that can be used on a tablet PC with pen-based input was granted in 2001. A Canadian vendor has been promoting such a system since at least 1998 and possibly before that. A search of open source EMR projects on the web shows that there are over a dozen EMRs freely

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<sup>11</sup> [www.csrstds.com/fundtec.html](http://www.csrstds.com/fundtec.html)

<sup>12</sup> <http://www.ftc.gov/opa/2001/10/hearst.htm>

<sup>13</sup> <http://www.uspto.gov/>

available on the Internet. We conclude that the appropriability regime in the area of EMRs is extremely weak.

**A bad market to be in?** If there are no increasing returns to development of standards *and* modularization quickly leads to commoditization of components *and* there is a weak appropriability regime in the industry, why should any player wish to remain in this industry? One potential answer may come from Teece<sup>14</sup> who writes a compelling article about industries with weak and strong appropriability regimes and how incumbents can profit, even in an industry with a weak appropriability regime.

**The role of complementary assets:** With so many drivers toward a commodity, perfect competition type market, Teece advises that having access to special know-how and other capabilities can be much more advantageous than having a superior product. Most technology products in this marketplace will require assets such as marketing, brand recognition, after-sales support, training, help-desk and customization competence. The more specialized and difficult to emulate the complementary assets, the better off an incumbent would be. Access to generic assets such as hardware or other assets which can easily be purchased or contracted for, are not valuable as a competitive edge. It is likely that these specialized assets would tend to change over time as markets change and requirements change. Teece also advises that in weak appropriability regimes, innovators need to be intimately coupled to the market so that user needs can fully impact designs. The saving grace for firms entering the health care information technology space may not be in the innovative technology they develop, but the complementary assets they hold and the capacities they bring to meeting customer needs.

**Forecasting the future of EMRs:** Forecasting the future of EMRs is extremely difficult. Although there are some time series data available for this market place (Exhibit 4 and Exhibit 5), the data mixes EHR and EMR components as the market suppliers do not make a distinction between physician needs and health care system needs. Although we expect that the two markets are likely to move hand-in-hand, they are different and distinct markets. Exhibit 4 and 5 show clearly the impact of Y2K planning on EMR and EHR purchasing. The cumulative number of installs has been growing steadily since 1998 and the post Y2K incremental growth rate for this market is around 15-25% annually. With some effort, it is possible to separate the EHR data from the EMR data. Currently, the market for EHRs is quite a bit larger than the one for EMRs (Exhibit 6) and is growing at a substantially greater rate. This is not surprising as we should expect that the major funders of health care would invest in technology for their own use before they would invest in technology for the use of physicians.

In fact, a recent study has shown that the major customers for EMRs will not be physicians as they are only small beneficiaries of these systems. Wang et al<sup>15</sup> have estimated that a health care system that implements an EMR will stand to benefit, on average, \$86,000 US over 3 years. This figure represents savings from prevention of medication errors, decreased utilization of laboratory testing and improved billing capture. For physicians, the benefits come only from the improved billing capture, which represents a very small proportion of the total savings.

Rather than provide some sort of quantitative model for how the EMR industry will unfold –which would be meaningless in this context –we will provide some potential scenarios, looking at major determinants of whether or not the technology will diffuse into the medical sector and how fast.

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<sup>14</sup> Teece, David J. (1986). Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Research Policy*, 15: 285-305.

<sup>15</sup> Wang S, Middleton B, et al. *Am J Med*. 2003;114:397– 403.

There are several barriers to widespread EMR implementation: 1) Total Cost of Ownership (TCO), 2) Speed of data input, 3) Inability to grow the top-line to recoup IT investments.

The major determinant of diffusion of computers into physician offices in most countries in the world has been the existence of subsidies. This has also been shown in Canada with the COMPETE (Computerization of Medical Practices for the Enhancement of Therapeutic Effectiveness) study in Hamilton.<sup>16</sup> The principals of the study subsidized the cost of EMRs for physicians who were willing to participate in the study. The study was able to get a significant number of physicians to join at a price previously determined through a willingness to pay study. This experience has been borne out in Alberta and Ontario with government subsidies for small scale projects.

In the absence of subsidies, the major breakthrough required in this sector is some form of cost lowering. If a combination of technology and process could be developed that lowered the total cost of ownership to about \$3-5K per year, a significant number of physicians would likely embrace the technology.<sup>17</sup> Given current costs of about \$10-20K per year, there is a long way to go to get to an acceptable price. A breakthrough of this magnitude is unlikely to come from the health care technology industry, but is more likely to come from the mainstream technology industry. There are some promising approaches, such as the Application Service Provider (ASP) model, the pen-based tablet PC and PDAs. However, each has its strengths and weaknesses. None has strengths greater than weaknesses at this time.

It is unlikely that a breakthrough in data input technology, by itself, would lead physicians to embrace the technology. Some physicians who use current technology claim that they are able to see more patients after implementing an EMR. They claim that the additional patients they are able to see justifies the cost of implementing the EMR. However, not all physicians who have implemented EMR have experienced this and most physicians feel that they see enough patients and why would they want to see more just so they can have an EMR!

Currently, physicians in Canada are in the bind that if they were to implement an EMR, that they cannot recoup their investment by increasing their revenues. This is because to a great extent the government controls how much physicians earn. However, there are several proposals being suggested at a policy level that could see this changed for physicians who use an EMR. The first proposal is that, for physicians who use a particular feature of an EMR, the government will pay a premium to those physicians for the care of particular patients. For example, in British Columbia, physicians are paid a visit premium for their diabetes patients if they use an electronic medical record system. The second proposal is that the government would provide an annual fee to physicians for maintaining a centralized emergency health record so that patients and their health care providers can access the data in case of emergency.

This approach does have some merit, as physicians who use the EMR would be providing superior care using new the technology and since the government pays for use of other technology, why not pay for use of EMR technology? The key issue is what rates the government will pay for these types of patients and how many eligible patients a physician actually has. Given that there would not be a mandate for physicians to use it and physicians

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<sup>16</sup> <http://www.compete-study.com>

<sup>17</sup> K Keshavjee, R Kyba, P Naisbitt, A.M. Holbrook “**Electronic Medical Records in Family Practice: What Drives Physician Interest and How Much Are They Willing to Pay?**” Proceedings of Towards an Electronic Patient Record (TEPR) conference, San Antonio, Texas. May 1998 available at <http://www.compete-study.com>

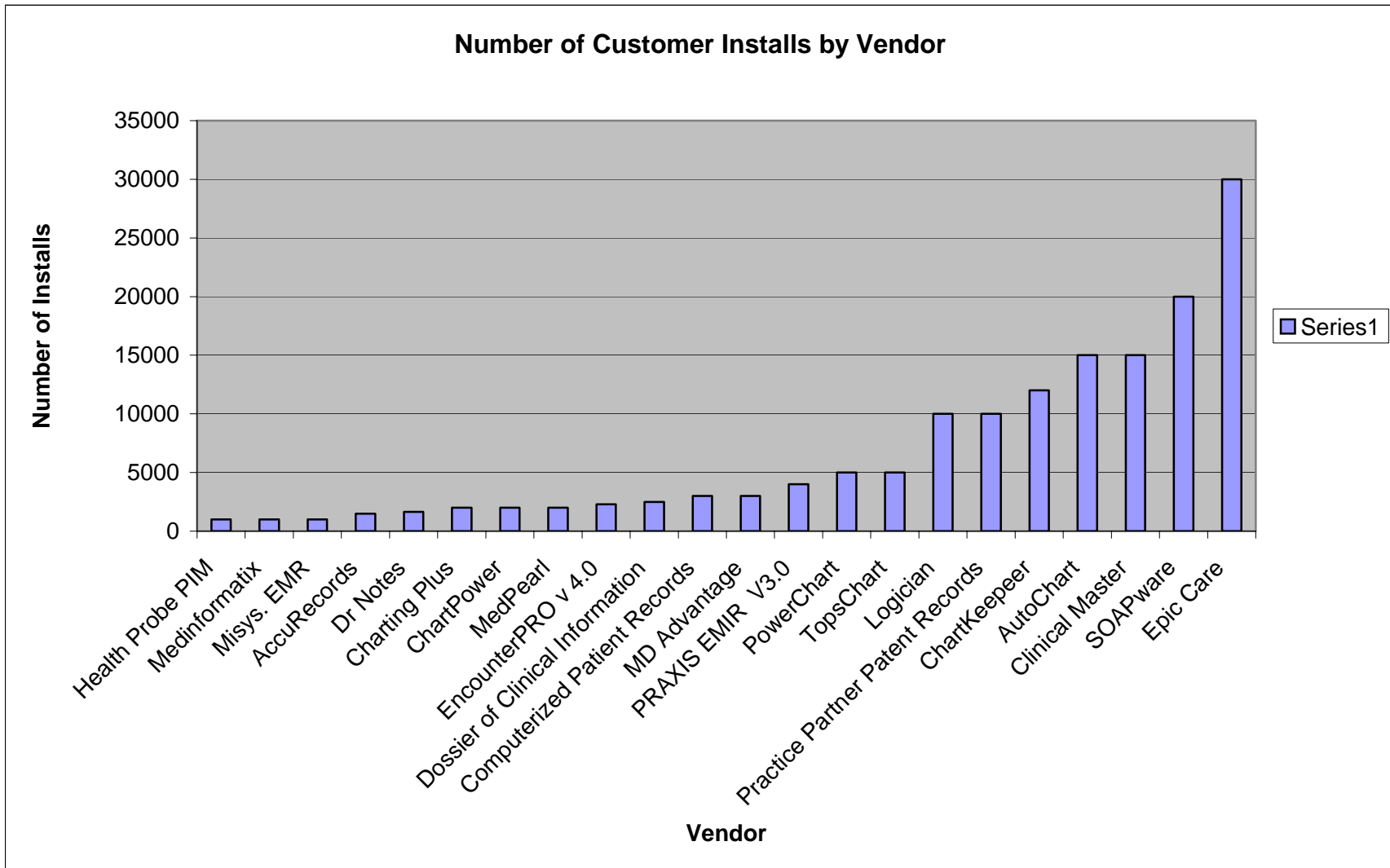
would have to take on the risk of investing in the technology, it is likely that uptake would be slow in this particular scenario.

As a side note, it is instructive to point out that in any industry, the next disruption will usually be driven by the market participant that is least served by the current paradigm. In the current scenario, it is the patient that is under-served by the medical system. So it is entirely possible that some new technology could be developed that would allow patients to take care of themselves, decreasing their dependence on physicians. If this were to occur, then this could become a competence-destroying innovation –something that doctors have feared for a long time.

**Conclusion:** EMR technology has been around for a long time and has not taken off in the market place. This technology is very dependent on innovations and breakthroughs that occur outside of the health care space. The dominant design paradigm does not appear to hold for core health care applications in the EMR, even though it does hold for many parts of the EMR because the EMR depends on the general information technology marketplace for many of its components. It appears that the Modularization of Design paradigm explains developments in the area better than the Dominant Design paradigm. There do not appear to be any increasing returns or lock-ins from standards, as standards are increasingly determined through consensus processes in the industry. There are few patents for EMRs and the few that do exist are extremely weak and general. There are many Open Source EMRs freely available. All the above leads us to conclude that this marketplace has a weak appropriability regime and that having and wielding specialized complementary assets is likely to be a major determinant of competitive advantage.

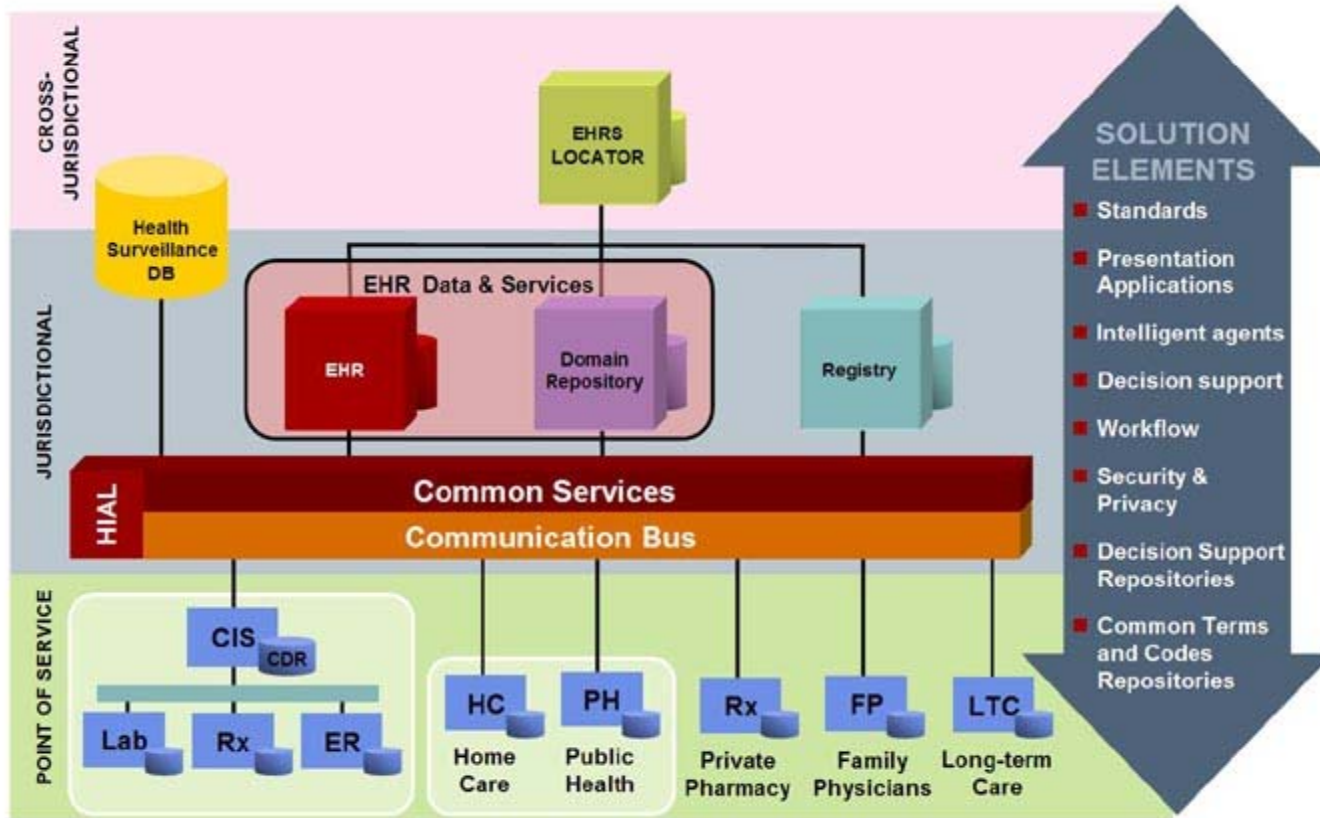
Finally, we conclude that there is only one major obstacle to widespread EMR uptake: the high total cost of ownership. If this can be brought down, either through subsidies or through technological breakthroughs, then we will see EMR uptake at a relatively rapid pace. However, if the cost cannot be brought down, then, even if other major problems are resolved, we should not expect that the market place would take off quickly.

**Exhibit 1**



Source: <http://www.elmr-electronic-medical-records-emr.com/>

Exhibit 2



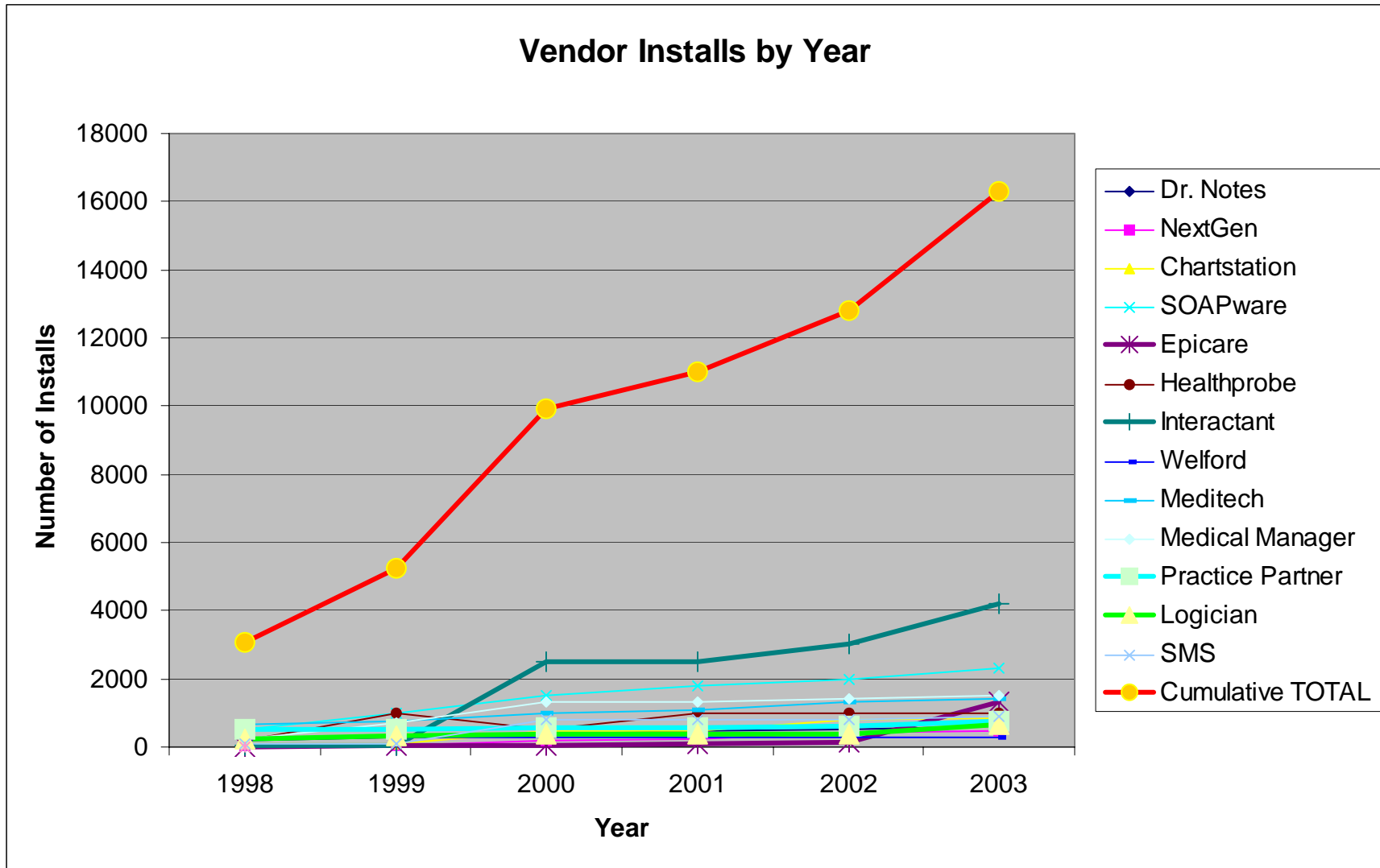
Source: <http://www.infoway-inforoute.ca/>

### Exhibit 3

Technology elements	Current status of design (DC vs DD, II)	Year	Description of current technology	Function
EMR User interface - text template	Dominant design	1972	User can enter pre-written text strings which can be edited	Text based interface prior to introduction of GUI software
Billing	Dominant design	Cards-1976 Diskettes-1987 EDI – 1995	80% adoption by industry as of 1984	Faster and more accurate billing process
Hardware	DD	1979	WinTel PC technology	Interface with medical staff and the data storage
EMR User interface - point-and-click	Design competition	1986	Several interfaces in use –no dominant player yet	Intuitive interface for ease of use
Database	Dominant design	1984	Relational DB	Local storage of patient data
Scheduling	Dominant design	1984	Allows flexible scheduling of MDs and patients	Digital scheduling of patient appointments
Interface with industry partners	Lab interface –DD	1998	Use of LOINC (content) and HL7 (transmission) standards	Easy exchange of patient data between industry partners
	Pharmacy interface – standards in development	2003	Standards being negotiated	Exchange of patient data
Document management	Dominant design	1995	Scanning and filing of data records	Storage and retrieval of patient data records
Internal e-mail communication	Dominant design	1998	Interoffice e-mail	Intra and Inter office communication
Drug-drug interaction decision support	DD	1994	On-going updates to knowledge base	Detection and notification of potential interactions between drugs
Clinical Decision Support	Design Competition	2001	One-off technologies used in innovator hospitals	Provide physicians with advice, reminders and alerts for taking care of patients

Source: <http://www.ontariofamilyhealthnetworks.gov.on.ca/>

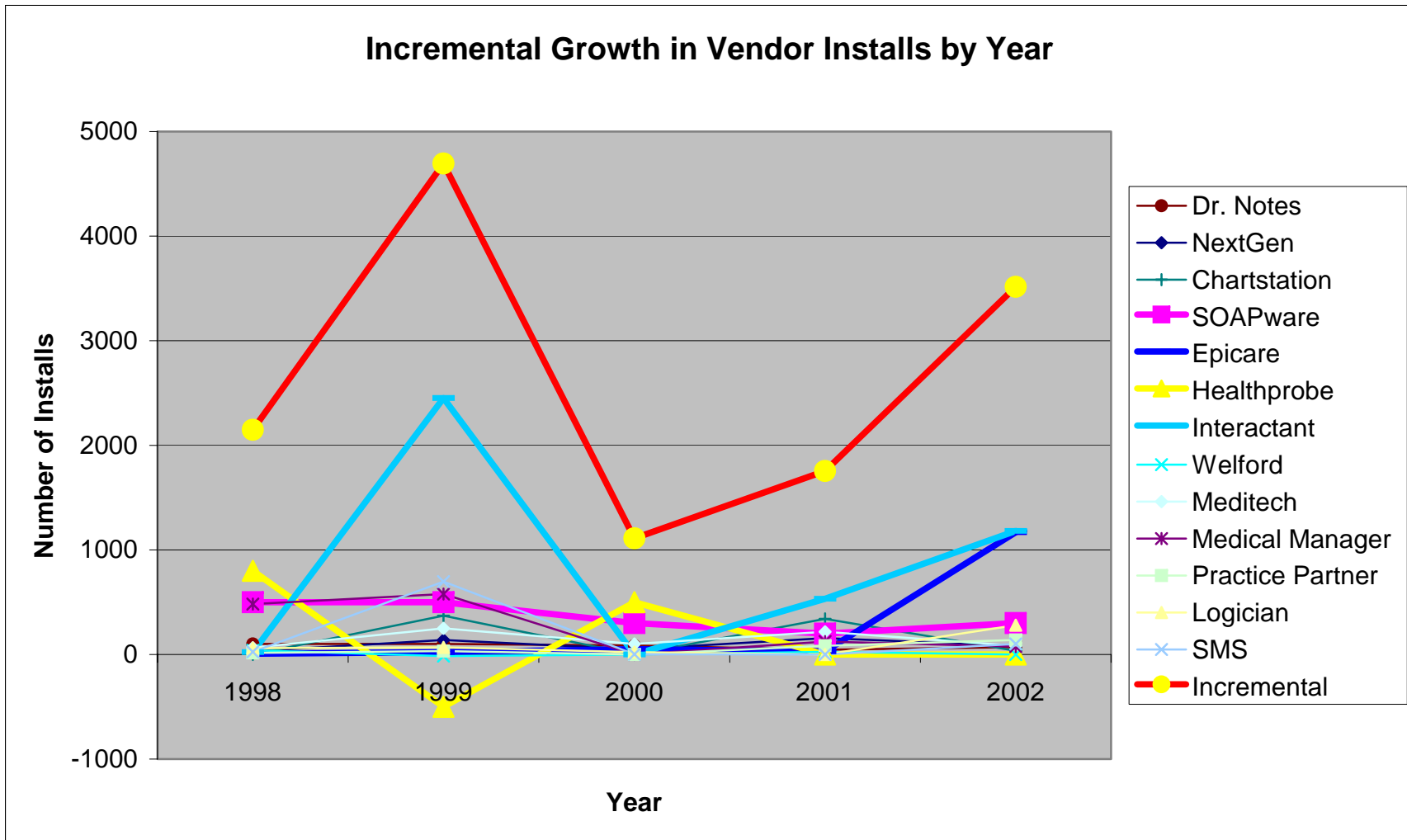
Exhibit 4



Source: Advance for Health Informatics Executives

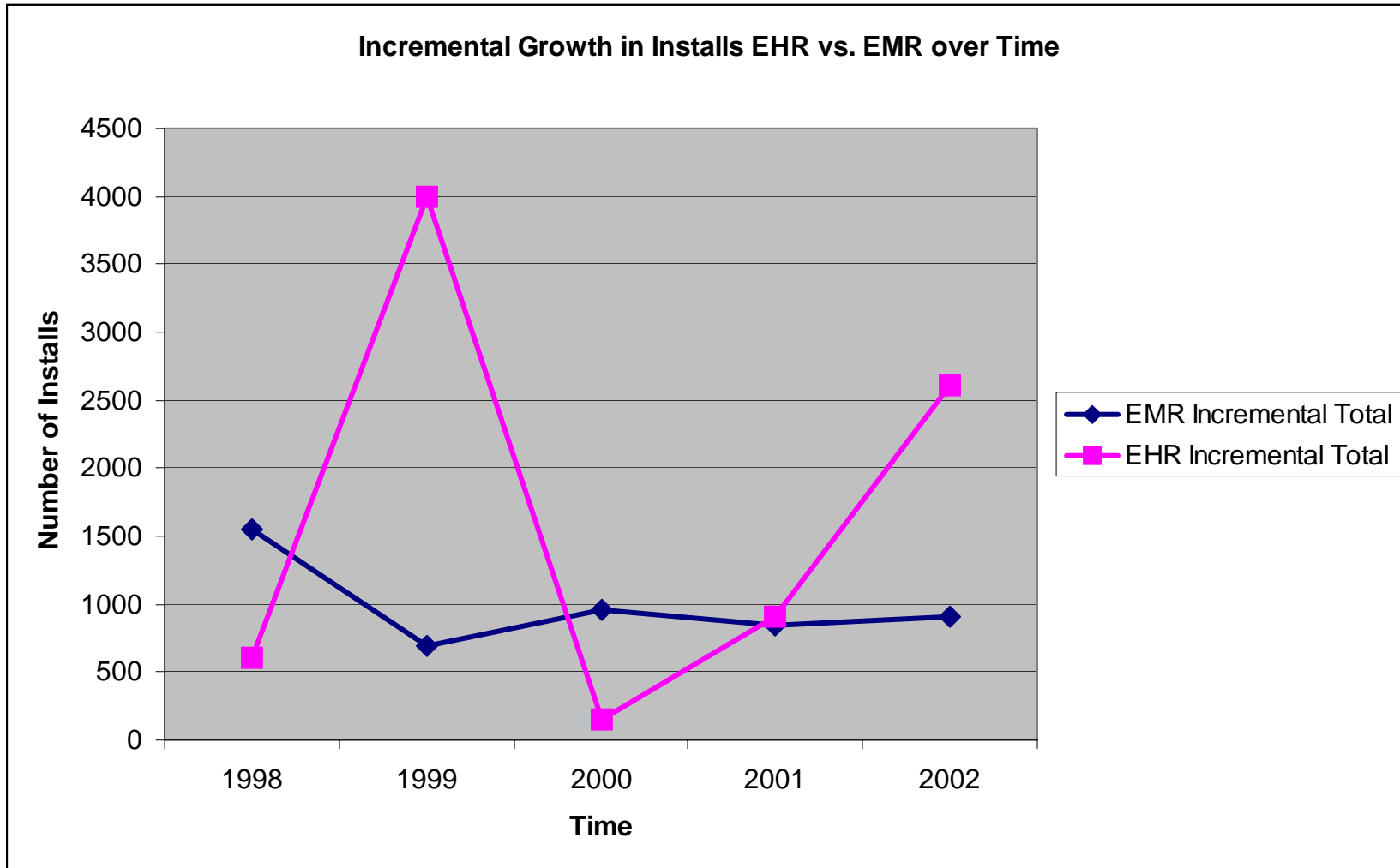
<http://www.advanceforhie.com/Common/editorial/editorial.aspx?CTIID=359&CP=6>

Exhibit 5



Source: Advance for Health Informatics Executives <http://www.advanceforhie.com/Common/editorial/editorial.aspx?CTIID=359&CP=6>

Exhibit 6



Source: Advance for Health Informatics Executives

<http://www.advanceforhie.com/Common/editorial/editorial.aspx?CTIID=359&CP=6>