Software engineering risk factors in the implementation of a small electronic medical record system: The problem of scalability

Michael F. Chiang, MD,1,2 and Justin B. Starren, MD, PhD1,3
Departments of Medical Informatics1, Ophthalmology2, and Radiology3
Columbia University
New York, NY

Abstract

The successful implementation of clinical information systems is difficult. In examining the reasons and potential solutions for this problem, the medical informatics community may benefit from the lessons of a rich body of software engineering and management literature about the failure of software projects. Based on previous studies, we present a conceptual framework for understanding the risk factors associated with large-scale projects. However, the vast majority of existing literature is based on large, enterprise-wide systems, and it is unclear whether those results may be scaled down and applied to smaller projects such as departmental medical information systems. To examine this issue, we discuss the case study of a delayed electronic medical record implementation project in a small specialty practice at Columbia-Presbyterian Medical Center. While the factors contributing to the delay of this small project share some attributes with those found in larger organizations, there are important differences. The significance of these differences for groups implementing small medical information systems is discussed.

Introduction

The development and implementation of medical information systems requires cooperation from clinicians, administrators, vendors, information technologists, and other end-users. Unfortunately, communication among these participants is often difficult because of their widely disparate backgrounds, perspectives, and goals. This is a traditional explanation for the fact that a significant number of clinical information system projects fail to be deployed successfully, despite continuous infusions of manpower and financial resources.

However, this phenomenon of project failure is very common within the general software engineering community. Surveys have consistently shown that only about 25% of large software projects are completed on time, within budget, and with the desired functionality. A study by the Standish Group revealed that 31% of new information system projects were canceled before completion, at an estimated cost of $81 billion. Even among completed projects, 53% were over-budget by an average of 189%, and at a cost of $59 billion. Projects that fail severely in terms of budget, target date, or reduced functionality have been termed "runaway" projects. In 1994, a British survey of 120 organizations disclosed that 62% had experienced a major runaway project. These projects are notoriously difficult to manage. A well-known rule from Brooks' classic book, The Mythical Man-Month, states that "adding manpower to a late software planning project makes it later" because new workers bring additional organizational overhead and learning-curve effects.

There is a rich body of computer science and management literature which discusses runaway projects, methods for recognizing them, and possible solutions. As an example, a highly-publicized computer-based travel reservation system called Confirm was developed by the Marriott, Hilton, and Budget Rent-a-Car corporations. Budgeted at $55.7 million in 1988 and scheduled to take three years to complete, it was ultimately cancelled in 1992 following $125 million in expenditures. Not surprisingly, the vast majority of published studies analyzing software project failure have involved large, enterprise-wide, multimillion-dollar projects.

In contrast, typical departmental clinical information systems are smaller-scale projects. Recent research suggests that these small projects and organizations are qualitatively and fundamentally different from large, enterprise-wide projects. However, few studies have examined the risk factors for failure of these smaller projects. In particular, it is unclear whether the lessons contained in the computer science literature about large runaway projects may be scaled down and applied to smaller information technology problems in the medical domain.
The purpose of this paper is to determine the extent to which the previously-studied factors that govern success or failure of large projects are relevant for smaller-scale medical informatics projects. This will be done in three steps: (1) To develop a conceptual framework for risk factors in large projects based upon the existing computer science and management literature. (2) To analyze a small departmental electronic medical record project at Columbia-Presbyterian Medical Center which has been significantly delayed, and to identify the risk factors present in this project. (3) To compare this situation with that of the large-scale projects previously described.

**Background: Large-scale project failures**

Studies in the management and computer science literature have identified a number of factors that are associated with *large-scale* runaway projects\(^{2,3,10,11}\). These may be used to recognize projects that are at a significant risk for escalation. As shown in Table 1, these factors may be broadly organized into three major categories. The relative significance of each risk factor has been graded on a scale from "0" to "+++", based on the number of times that the factor was cited or alluded to in a review of seven studies\(^{2,3,10,11}\). Collectively, these studies represent the opinions of over 70 project managers and authors.

The first category includes issues *primarily related to the organization*: (1) Lack of commitment from upper-level management to the project. In a Delphi survey of 41 software project managers from three continents, this was consistently ranked as the most important risk factor\(^1\). (2) No clear statement of objectives for the new system. (3) Lack of an end-user "project champion" to market and support the new system within the organization. (4) Inability to gain end-user commitment to the project. (5) Inadequate technology infrastructure to support project requirements.

The second category includes factors *primarily related to the system developer*: (1) Inadequate knowledge, technical skills, resources, or experience among project personnel. (2) Failure of system developers to understand the requirements or scope of the project.

The third category of risk factors includes issues *primarily related to communication*: (1) Unrealistic end-user expectations for system. (2) Ineffective communication among project team members and organization members. This is particularly important in large groups with multiple programmers and administrators. Accordingly, traditional software engineering approaches have intertwined management and coordination issues with technical problems\(^1\). (3) Insufficient user involvement in project design and planning.

**Overview of a small EMR project**

A twelve-physician specialty group practice based at Columbia-Presbyterian Medical Center decided to purchase an electronic medical record (EMR) system in late-1998. At the time, the patient scheduling, registration, and billing were performed with Columbia's institution-wide IDXtend system (IDX, Burlington, Vermont), but the remainder of the group's medical records were completely paper-based.

An intensive six-month search process was conducted, which involved a request for proposal, multiple product demonstrations, and advice from an industry consultant. A vendor was selected, and a contract was negotiated by late-1999. This vendor had developed a successful prototype EMR system, although that particular system had not previously been implemented at any other location. A project team was formed, which consisted of programmers and managers from the vendor, administrators and physicians from the medical group, and several information technology specialists from Columbia-Presbyterian Medical Center.

Over two years after negotiation of the contract, the EMR system had not yet been implemented because of multiple delays. As part of a study to determine the most appropriate way for this project to proceed, the status of this project was analyzed in detail.

**Methods**

The above EMR system implementation project was analyzed in depth. Semi-structured interviews were conducted with nearly every member of the project team. These included two managers and one programmer from the vendor corporation; two managers, one physician, and the chairman of the medical group; and one information technologist at Columbia-Presbyterian Medical Center. Additional semi-structured interviews were conducted with four group physicians and two senior information technology specialists at Columbia-Presbyterian Medical Center, none of whom had been directly involved with the project team activities.
Table 1: Risk factors for project failure

<table>
<thead>
<tr>
<th>Risk factor for project failure</th>
<th>Significance in large projects (0 to +++)*</th>
<th>Significance in small EMR project (0 to +++)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Related to organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Lack of commitment from upper management</td>
<td>+++</td>
<td>0</td>
</tr>
<tr>
<td>2. No clear statement of system objectives</td>
<td>+++</td>
<td>0</td>
</tr>
<tr>
<td>3. Lack of “project champion”</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>4. Inability to gain end-user commitment</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>5. Inadequate technology infrastructure</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>6. Difficulty working with “parent organization”</td>
<td>0</td>
<td>+++</td>
</tr>
<tr>
<td>Related to system developer or vendor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Inadequate technical skills of developer</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td>8. Failure of system developers to understand project requirements or scope</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>9. Turnover of developer project team members</td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td>Related to communication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Unrealistic end-user expectations</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>11. Ineffective communication among project team and organization members</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td>12. Insufficient user involvement in project design and planning</td>
<td>+++</td>
<td>+</td>
</tr>
</tbody>
</table>

*Based on number of citations from seven studies2,5,8,12-15 (0: no citations; +: <3 citations; ++: 3-4 citations; +++: 5-7 citations)
** Based on analysis of small departmental EMR system in this paper (0: no effect on project delay; +: minimal contribution to delay; ++: moderate contribution to delay; +++: significant contribution to delay)

Documents were reviewed regarding the patient volume and demographics of the group practice, the annual expenses and revenues of the group practice, and the expenses associated with the EMR project.

Results: Analysis of the EMR Project

Factors contributing to the delayed implementation of this EMR system will be assessed and discussed within the conceptual framework for risk factors of project failure, as shown in Table 1.

Factors related to the organization

Within this small specialty group, high-level commitment to the EMR project (Factor 1 in Table) was very strong. The organization’s requirements were specialized and well-defined, and the desired objectives of this system were clearly expressed during the contract negotiation process (Factor 2).

Several difficulties occurred during the process of integrating this EMR system into the larger computing infrastructure of the group’s “parent organization,” Columbia-Presbyterian Medical Center. This parent organization has an extensive enterprise-wide medical information system, maintained by the Department of Medical Informatics, which integrates a clinical data repository with administrative systems, research databases, and billing systems14. Several members of the Department of Medical Informatics were included on the project team for implementing this vendor EMR system. This was primarily to ensure that appropriate interfaces could be developed by the vendor to share patient financial and demographic data with the Columbia enterprise-wide databases. No immediate plans were made to integrate clinical data from the vendor EMR system with the Columbia enterprise-wide repository.

Although the vendor worked closely with both the practice group and its parent organization, a delay resulted from difficulty with installation of networking infrastructure into the office building (Factor 5). An additional significant delay was caused by the inability to develop an interface for transferring financial and demographic data between the vendor system and the Columbia enterprise-wide system. This was in large part because of failure to reach a consensus on the standards for data transfer (Factor 6).
Support among physicians within the group practice was initially high. However, during the two-year implementation process, increasing resistance toward the EMR system began to develop. Several physicians felt satisfied with the existing paper-based record system and became skeptical about the EMR (Factors 4 and 10). There was no end-user “project champion” to support the new system within this small group (Factor 3).

Factors related to the system developer

The vendor was a small organization whose prototype product was based on a system that had been voted “best EMR” at a major national conference. The vendor project team possessed excellent technical capability and knowledge (Factor 7). However, they had never implemented an EMR system for this specialty domain. They therefore pursued a difficult, iterative process of soliciting knowledge and suggestions from group physicians to better understand project requirements (Factor 8). This process was further delayed by turnover of several project team members (Factor 9).

Factors related to communication

Communication between the vendor and group practice was facilitated by the relatively small size of both groups (Factors 11 and 12). Most project team members worked closely together. However, the requirements of this particular project demanded that a large amount of domain knowledge be transferred from the group to the vendor.

Discussion

While factors contributing to project failure in large and small organizations share some attributes, there are important differences. Risk factors that have been shown to be important in large-scale projects such as lack of a project champion (Factor 3), inability to gain end-user commitment (Factor 4), and failure of system developers to understand project requirements (Factor 8) did contribute significantly to the difficulties with this small-scale EMR project.

One significant difference is that lack of commitment from upper management is typically cited as the most significant risk factor for failure of large projects (Factor 1). This problem did not at all contribute to delays in this case study of a small project. Likewise, the “lack of clear statement of system objectives” was not factor in this EMR project (Factor 2). A possible explanation for these differences is that large groups are sufficiently complex that upper-level organizational leaders are often separated from project managers by several intermediate layers of management, and therefore may be less directly involved with the project management process. In contrast, project team leaders in small groups typically work much more closely with upper management, as was the case in this project. Therefore, it is not surprising that the risk factors involving organizational commitment and objectives were much less important in this small EMR project than is typically seen in larger projects.

Furthermore, the classic large-project risk factors of “ineffective communication” and “insufficient end-user involvement in project planning” were not important in causing delay of this small EMR project (Factors 11 and 12). Traditional software engineering methodology has emphasized these issues by focusing on management, reporting, communication, and the separation of roles. However, the limited size of small organizations and projects inherently facilitates communication among team members, often without these formalized techniques. An implication for developers of small medical information systems is that the traditional, communication-intensive software engineering approach may require more administrative overhead than can be sustained by small organizations.

It is also important to note that the vendor in this project encountered significant problems while working with the “parent organization” of the group practice, Columbia-Presbyterian Medical Center (Factor 6). Delays were caused by difficulties with installing appropriate network infrastructure, as well as difficulties with reaching agreement about standards for data transfer between the vendor EMR system and the Columbia enterprise-wide clinical information system. Similar problems have not been frequently reported in the literature for large-scale projects, most likely because these large projects usually do not fall under the control of a larger parent organization. In contrast, small medical groups usually do not have their own information technology groups, and often must be supported by a hospital-wide IT department that will not necessarily have the same underlying goals and commitment to the project. Smaller medical groups will benefit from securing this commitment and technical support from their parent organizations before undertaking information system project implementation.

Finally, the risk factor of “turnover of developer project team members” is only rarely cited in the literature on large-scale project failures (Factor 9). Yet it was among the most significant causes of the delays in this small-scale EMR implementation. It is
reasonable to hypothesize that stability of the project team may be most significant for small-scale projects, since individual team members will have bigger roles in these smaller projects.

It is critically important for medical information system developers to identify projects whose characteristics place them at high risk for failure. In this paper, we have presented a framework for understanding the risk factors in small-scale medical informatics projects, and have contrasted them with those seen in larger-scale projects. The problems with the small EMR system described in this paper are currently being addressed, for example by designating a "project champion" with affiliation to the medical organization as well as the Columbia information technology department. It is too early to determine the outcome of this scenario.

Of course, it is not sufficient to recognize troubled projects. The reality is that these often become "runaway projects" because they continue to be supported by an escalating commitment of personnel, money, and other resources. Explanations for this phenomenon are related to financial factors such as sunk costs and low salvage value of incomplete projects, social factors such as the association of persistence with strong project leadership, and organizational factors such as the difficulty of overcoming administrative inertia to disrupt existing project plans. By understanding the risk factors associated with project failure, the role of scalability, and the most appropriate response to difficulties that arise, the developers of small medical information systems will maximize the likelihood of successful project implementation.

References


