Transitions from One Electronic Health Record to Another: Challenges, Pitfalls, and Recommendations

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Appl Clin Inform 2020;11:742–754.

Abstract

Objective We address the challenges of transitioning from one electronic health record (EHR) to another—a near ubiquitous phenomenon in health care. We offer mitigating strategies to reduce unintended consequences, maximize patient safety, and enhance health care delivery.

Methods We searched PubMed and other sources to identify articles describing EHR-to-EHR transitions. We combined these references with the authors' extensive experience to construct a conceptual schema and to offer recommendations to facilitate transitions.

Results Our PubMed query retrieved 1,351 citations: 43 were relevant for full paper review and 18 met the inclusion criterion of focus on EHR-to-EHR transitions. An additional PubMed search yielded 1,014 citations, for which we reviewed 74 full papers and included 5. We supplemented with additional citations for a total of 70 cited. We distinguished 10 domains in the literature that overlap yet present unique and salient opportunities for successful transitions and for problem mitigation.

Discussion There is scant literature concerning EHR-to-EHR transitions. Identified challenges include financial burdens, personnel resources, patient safety threats from limited access to legacy records, data integrity during migration, cybersecurity, and semantic interoperability. Transition teams must overcome inadequate human infrastructure, technical challenges, security gaps, unrealistic providers' expectations, workflow changes, and insufficient training and support—all factors affecting potential clinician burnout.

Keywords
- electronic Health records
- clinical governance
- EHR migration
- EHR transition
- data management
- cybersecurity

received
May 31, 2020
accepted
September 7, 2020

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DOI https://doi.org/10.1055/s-0040-1718535.
ISSN 1869-0327.

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Conclusion EHR transitions are remarkably expensive, laborious, personnel devouring, and time consuming. The paucity of references in comparison to the topic's salience reinforces the necessity for this type of review and analysis. Prudent planning may streamline EHR transitions and reduce expenses. Mitigating strategies, such as preservation of legacy data, managing expectations, and hiring short-term specialty consultants can overcome some of the greatest hurdles. A new medical subject headings (MeSH) term for EHR transitions would facilitate further research on this topic.

Background and Significance

The HITECH Act and meaningful use (MU) programs led most U.S. health care systems to transition from paper to electronic health records (EHRs) within the decade. Increasingly, however, many systems have since transitioned to a second or even a third EHR. Mergers with larger systems that had existing EHRs, vendor products that no longer meet MU certification, perceived brand prestige, and consolidation of vendors also motivate transitions to subsequent EHRs.[1,2] Despite these incentives and necessities, there is neither an extant set of EHR transition best practices, nor a corpus of systematic studies on the topic. The available literature usually reflects hospital personnel's personal observations and experiences rather than synoptic data collections.

Why Transition?

Prior to MU, between 2003 and 2008, more than 30% of surveyed hospitals had switched vendors or shifted from a home-grown system to a vendor's EHR, perhaps due to the relative immaturity of the technology at the time.[3]

Since MU, many health care organizations changed from existing to certified EHRs to become eligible or maintain certification for MU incentives.[4] With the rise of health system acquisitions and increasing affiliation, the acquiring health care organization often imposed its EHR on the acquired hospitals and practices—especially when larger hospital systems bought smaller ones, or when creating integrated physician arrangements.[2] Some implemented new EHRs in hopes of improving coordination of patient care,[5] billing, and of enhancing productivity. Still other health care organizations transitioned from one EHR to another because of vendor market consolidation where EHR vendors ceased operations or no longer supported their legacy EHR systems. Although EHR vendors promised customers that new applications and functionalities in their latest versions would increase patient safety and clinical workflow efficiencies,[2,6] even updated EHRs often failed to meet providers' or institutional expectations, necessitated complex decisions, additional time for configuration, and interfacing with existing systems, leading to decisions to change EHR products.[7]

Objective

This article reviews and summarizes EHR-to-EHR transition domains identified through literature search and the authors' experiences. It then offers lessons to facilitate successful transitions from one EHR to another.

Methods

All authors have either led or experienced EHR-to-EHR transitions personally, observed institutions that have undertaken such migrations, or both.[8] One of our authors (R. K.) coauthored AHRQ's guide to EHR implementation.[9] A preliminary Internet search retrieved numerous blog posts, anecdotal reports, and news articles,[10–12] as well as five papers mentioning EHR-to-EHR transitions. Based on content and terms from these sources, a professional medical librarian (C.K.C.) formulated and executed a PubMed search query on July 24, 2019; updated on August 10, 2020. See ►Table 1 for query details. Note that no medical subject headings (MeSH) term exists for the concept of "EHR transition/migration." Migration and transition are arising as preferred keywords for the concept. Among 1,351 citations retrieved and reviewed, 43 were appropriate for full article review. Eighteen of them (►Table 1) met the inclusion criteria: literature focused on a facility's change from one to another EHR, whether those were homegrown or vendor products; evaluations of the transition itself; or a comparison between before and after the transition. Exclusion criteria were an analysis of transition from paper to EHR; evaluation of a particular process, such as training, that applied irrespective of a transition; or evaluation of the new EHR without regard to the impact of the transition itself.

In addition to articles identified through the PubMed query, the authors cite 45 additional relevant articles known to them, 24 of which are PubMed indexed, 6 of which are peer reviewed and indexed in other citation databases, and 14 of which are part of the gray literature. We repeated the PubMed search, except with synonyms for migration and transition (e.g., conversion, convert*, and switch*) which retrieved 1,014 citations. After citation review, we reviewed 74 full articles and 5 from this second query met criteria for inclusion. We also reviewed references from these, and PubMed suggested "similar articles," plus other articles that the reviewers suggested to us for consideration. Ultimately seven articles from this round met inclusion criteria (►Table 2). A total of 70 articles from all sources are cited here. The lead authors (R.S. and C.H.) read all the selected

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Table 1 Initial PubMed search query, criteria for citation exclusion and inclusion, additional resources included on EHR-to-EHR transitions, and counts for each

PubMed query 1 for EHR-to-EHR transitions through August 10, 2020	Number of citations retrieved and reviewed
(((“Medical Order Entry Systems”[MeSH]) OR ((((((((((“Electronic Health Records”[MeSH]) OR EHR*) OR “electronic health record”) OR “electronic health records”) OR “electronic medical record”) OR “electronic medical records”) OR EMR*) OR CPOE) OR “computerized physician order entry”) OR “computerized provider order entry”))) AND ((migration*) OR transition*)	1,351
Full articles from PubMed query reviewed, excluded, included	**Number of articles**
Total full articles from query reviewed	43
Full articles from query reviewed and excluded by focus	
Paper-to-EHR transition	5
Exploration of specific function in the new EHR	14
Opinion piece	6
Total full articles from query reviewed and excluded	25
Full articles from query reviewed and included	
All those on EHR-to-EHR transitions	18
Additional articles/resources with information for EHR-to-EHR transitions included by source type	**Number of articles/ resources reviewed**
Articles indexed in PubMed but *not* retrieved by query	24
Scholarly articles indexed in other citation databases	7
Gray literature including online blogs, newsletters, etc.	14
Total nonquery articles and sources included	45
All articles from query1 + 1st round additional resources—included	**Total number of articles/ resources cited**
	63

Abbreviations: CPOE, computerized provider order entry; EHR, electronic health record; EMR, electronic medical record; MeSH, medical subject headings.

papers; all authors also reviewed many of the papers, after which we developed consensus regarding whether the articles met the inclusion criteria and to decide the domains each paper discussed.

Results

Our literature search revealed a minimal number of empiric studies or data for evidence-based guidelines to facilitate and plan EHR transitions. This gap was especially true for community-based hospitals where resources are often scant. Existing literature largely comprises retrospective observations from staff at single institutions or from surveys of users' experiences and satisfaction with EHR transitions.

On first review, we observed that most of the literature focuses on the difficulties of integrating complex EHR systems into the existing human and technical structures, as well as challenges from: vast sums required for software, hardware, consultants, and installation; deploying additional staff and training; linking hundreds of ancillary electronic systems (many legacy) to the new EHR; data migration; cybersecurity costs and technology; and recreating safe and effective clinical decision support tools. With further review, we were able to classify discrete domains that the literature covers even as many of the articles overlap in the domains addressed (►**Supplementary Table S1**, available in the online version).

Domains Identified

The available literature covered one or more of the following 10 domains:

1. Financial considerations—for software, hardware, consultants, data migration, and linkages with legacy systems, devices, laboratories, pharmacies, inventory, as well as interfaces.
2. Human infrastructure—including diverting existing and new information technology (IT) and informatics staff, as well as business associates, laboratory personnel, suppliers, and pharmacists
3. Technical considerations—installing new hardware, interface building, Wi-Fi improvements, data integrity, ongoing patches, and updates.
4. Data migration—accuracy, methods, electronic versus manual, and technical difficulties.
5. Patient safety—data availability, migration, clinical decision support (CDS), new build, including order sets, installation of disease/treatment protocols, addressing changing, or expanded patient populations.
6. Provider expectations—user satisfaction, adaptation, workflow changes, and efficiencies.
7. Patient expectations—satisfaction with providers and efficiencies.
8. Training and support—for new and existing staff, ancillary staff, others, help desk, and at-the-elbow support.

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Table 2 Additional PubMed search query, criteria for citation exclusion and inclusion, additional resources included on EHR-to-EHR transitions, and counts for each

PubMed query 2 for EHR-to-EHR transitions through July 17, 2020	Number of citations retrieved and reviewed
(((conversion) OR (convert*)) OR (switch*)) AND ((((((((((EMR) OR (EHR)) OR (medical order entry systems[MeSH Terms])) OR ("computerized physician order entry")) OR ("computerized provider order entry")) OR (computerized physician order entry system[MeSH terms])) OR (CPOE)) OR ("electronic health record")) OR ("electronic health records")) OR ("electronic medical records")) OR ("electronic medical record")) OR (electronic health record[MeSH Terms]))	1,014
Full articles from PubMed query reviewed, excluded, included	**Number of articles**
Total full articles from query reviewed	74
Full articles reviewed and excluded, by focus	
Initial implementations	29
Paper-to-EHR transition	5
Training changes alone, not during transitions	3
Workflow changes alone, not during transitions	8
Data conversions, not EHR conversions	2
Previously retrieved	3
Other	19
Total full articles from query reviewed and excluded	69
Total full articles from query reviewed and included	
All those on EHR-to-EHR transitions	5
Additional articles with information for EHR-to-EHR Transitions by source type	**Number of articles**
Retrieved by examining references from the 8 included articles from PubMed query, and reviewed	7
Retrieved from examining PubMed's "similar articles" based on eight included articles from PubMed query, and reviewed	3
Articles suggested by reviewers as potentially related to EHR-to-EHR transitions, and reviewed	7
Full articles reviewed from these additional sources	17
Full articles from these additional sources reviewed and excluded	
Primarily focused on non-EHR-to-EHR transition topics	15
Full articles from these additional sources included	2
All articles from query 2 + 2nd round additional resources—included	**Total number of articles/ resources cited**
	7
Grand total articles/resources cited in this review	**70**

Abbreviations: CPOE, computerized provider order entry; EHR, electronic health record; EMR, electronic medical record; MeSH, medical subject headings.

9. Cybersecurity at transition and continuing.
10. Chiefs' suite, chief medical informatics/informatician officer (CMIO), and chief information officer (CIO) team responsibilities.

►**Table 3** outlines these domains, including challenges and proposed avoidance and mitigation strategies.

Financial Considerations

The financial burden of an EHR transition is not merely the cost for the new EHR software and its implementation but also includes ongoing costs of the prior EHR until transition is complete, and then costs to maintain access to the legacy system's data. Aside from software licensing fees, EHR implementation project costs include purchasing additional hardware, consulting, other operational fees, costs of personnel skilled in configuration and build, testing, training, retrofitting existing equipment, connections to in-house and outside laboratories, connections to suppliers and inventory systems, and any other upgrades that the facility requires.[13–15] These can total hundreds of millions of dollars in the initial period and almost always continue in the future with each upgrade, patch, and version. These costs sometimes exceed $1 to 2 billion for larger systems.[16] In health system mergers, there are often sizable costs related to the prior EHR. These are often unavoidable, for example, existing contracts require continued payments or renegotiating contracts with third parties. Sunk and continuing costs include sustaining infrastructure for

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Table 3 Problem avoidance and mitigation strategies for EHR-to-EHR transition challenges

Domain	Issue	Challenges	Problem avoidance and mitigation strategy
Financial	New purchase	$250 million– > 1 billion	Join or consolidate with another (often larger) system
	Total cost of ownership of legacy and new systems	• Costs considerable, if relatively new system • Inevitable if older	Plan for new long-term costs, and even for costs of legacy systems if still needed
	Consulting fees	1.5–10 × analyst rates	• Determine if internal personnel available and have expertise • Budget for outside consultants • Determine who is responsible in event of serious problems
	Conversion costs not listed above (cost of staff, physicians diverted from other duties)	• Non-quantifiable costs of personnel shifted to other duties • Lost revenue from physicians diverted to IT projects and not generating income from patient care	Plan for possible: • Data abstraction (manual) • Maintenance of legacy EHR • 3rd party archive • 3rd party migration • Big data repository • Use of consolidated clinical documents (CCD) • Consider substitutable medical applications, reusable technologies using fast healthcare interoperable resources (SMART on FHIR), and SMART on FHIR transfers • Hire experienced consultants
	Maintain legacy EHR	$100,000s/year	• Archive with business partner • Import to data warehouse
	Staffing up	Considerable cost, unless able to harness internal staff	Hire short-term specialty consultants
Human infrastructure	Divergence of staff from ongoing projects	Address possible: • User dissatisfaction • Regulatory compliance • Increased costs of delays	Stretch out implementation timeline
	Training costs	Note that better training usually reduces needs for ongoing support; and ongoing support increases user satisfaction and efficiency	Hire short-term specialty consultants
Technical	New and upgrades to hardware and software	Even relatively new systems likely require increased bandwidth	Budget and plan for increased personnel for known and routine costs
	Interface building	Considerable effort if preserving old non-EHR systems	Consider purchase of all-in-one EHR and ancillary modules (which increases costs if other systems not end-of-life)
	Wi-Fi and internet improvement	• New systems generate significant infrastructure disruption • Even relatively new systems likely require increased bandwidth	
	Preservation of data integrity	Mandatory	Consider part of total cost of ownership
	Availability of legacy data	Mandatory for medical/legal needs	Consider part of total cost of ownership (and see above)
Data Migration	Preserve semantic interpretability	Lack of data standards and format	
	Accuracy of data migration and data abstraction	Mandatory	Consider part of total cost of ownership, and build safety monitoring, evaluation, and remediation programs into the transition process and aftermath
Patient safety	Assumptions about persistence of legacy workflows, practices versus changed communication patterns and relationships	• Legacy processes may not work with the new EHR, contributing to errors • Destination EHR may require providers to spend less time on patient care: changes relationships/trust with nurses and other clinical staff • Workflow changes may impact patient safety	• Start early and maintain an ongoing change management program • Display current state and expectations for future, including similarities and differences from current system. • Set explicit guidance about appropriate use of EHR • Maintain team building programs • Configure new system with similar workflows, or warn users of changes
Workflow changes	Preconceived notions	Unreasonable requests	Manage expectations and provide additional training; solicit and respond to constant feedback

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Table 3 (*Continued*)

Domain	Issue	Challenges	Problem avoidance and mitigation strategy
Provider expectations	Prior experience	Change is difficult from one vendor product to another, or even from an older version of the same product	Manage expectations and provide additional training
	Satisfaction with new and old systems	Change is difficult from one vendor product to another, or even from an older version of the same product	Manage expectations and provide additional training
	Personnel	Identify human behavioral factors	Note that better initial training may lead to less ongoing support; ongoing support increases user satisfaction and efficiency
Patient expectations	Satisfaction	• Access for appointments • Press Ganey scores • Increased time for visits	• Anticipate decline during transition and for a time thereafter • Provide advance communication
Training and support	Duration of support Experience with new system	• Identify human behavioral factors • Training is expensive; requires constant vigilance plus both technical and human expertise	Note that better initial training may lead to less on-going support; ongoing support increases user satisfaction and efficiency
Cybersecurity	Preventing intrusions, ransomware, data theft, blackmail	Cost and availability of cybersecurity experts	• Budget for expensive IT personnel, constant training of staff, ongoing backup of data, and examination of emerging threats • Employ a cybersecurity taskforce and team, including 'white hat' hackers to test systems.
CMIO	Differences between systems	Identify gaps	Plan for new EHR that may not have desired configurations
	Workflow analysis	Identify current and future workflows	Note that new EHR may have added benefits not envisioned
	Data conversion	Identify semantic equivalents and gaps	While may be desirable, it is often fraught with problems
	Expectations	Identify human behavioral factors	Provide adequate training and support
	Reducing existing operational variation prior to transition	• Seldom if ever part of vendor playbook for needed resources and time • Reconcile various workflows	• Expect operational changes • Allocate resources, time and budgets to examine, remediate, and coordinate workflows prior to launch of EHR transition, if possible • Standardize processes where possible
	Planning for long term maintenance and monitoring of the destination EHR	May not be part of vendor playbook; may require hiring or repurposing staff to participate in ongoing monitoring; safety hazards and events may be very difficult to detect	• Budget and plan for system maintenance and monitoring needs early • Make EHR monitoring a routine report out item in leadership meetings

Abbreviations: CMIO, chief medical informatics/informatician officer; EHR, electronic health record; IT, information technology.

legacy systems still needed to assure data access, billing systems, and stability, and must be included in the budget to assure financial preparedness.[1,17]

Conversion of legacy data from one EHR system to another is complex and stunningly expensive.[18] Some health systems only convert certain key demographic and clinical data to the new EHR while keeping legacy systems available to clinicians and health information personnel to access patients' historical data for medical or legal inquiries.[19] Costs of maintaining the legacy system plus funding the new EHR can be extremely taxing depending on the medical specialty and length of time for medical record retention required by law. Organizations with multiple legacy systems may have long-term contracts requiring persistent interfaces with the attendant maintenance costs.

Institutions that change EHRs do not in general suffer declines in their bond ratings,[20] although there have been some high-profile exceptions.[21] Failure to use certified EHRs incurs significant penalties as part of the MU/promoting interoperability regulations, notwithstanding that no study of certified EHRs has found positive effects on mortality or readmission statistics.[22] Use of certified EHRs may improve quality of care.[23]

Human Infrastructure

Working with the human infrastructure—the medical and technical staff, leadership, consultants, and ancillary personnel necessary to successfully transition an organization onto a new EHR—demands meticulous planning and resource allocation. Vendors often claim that a new system will reduce need for IT staff, for example, analysts, builders, technicians. This is not our experience; we have observed that IT staffing needs continue to grow with time. Optimally, those involved in the transition should not have other duties concurrently. EHR transition is an enormous undertaking; the literature reveals successful transitions require adequate staff and time allocations.[24] In addition to the expanded planning staff, hospital systems required networks of clinical specialists to participate in EHR content development, support, and training.[8,24] We have observed transitions requiring dozens to hundreds of additional staff—some of whom continue for several years, especially to preserve legacy systems.

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Technical Aspects

Implementation of new software almost always requires vendor engagement for software updates, network connections, and downloading test results.[25]

EHR transition involves multiple systems and interfaces which increase technical difficulties. New interoperability challenges arise when individual sites within a single health care system, even if using the same vendor product, make configuration changes specific to a site. Internal and external interoperability challenges include database integrity, data accessibility, readability in the new system, data sharing, lack of data standards, and data conversion to another system that are discussed here further. Makar described a situation where automatic data transfer was infeasible due to architectural differences between systems.[26]

These technical challenges often emerge with unexpected vehemence at times of EHR transitions. Staff must prepare for proper data backup for server downtimes and to prove data provenance. Maintaining data integrity is foundational to patient safety, clinician satisfaction, and better health care outcomes.[27] Backup plans in the event of server dysfunction are critical to prevent data loss or corruption, to maintain data completeness, and to facilitate continuity of workflow. Without knowing the source of transferred data, such as the original owner or location, data trustworthiness is suspect or worse. Indeed, Gettinger and Csatari concluded that partially or inconsistently converted data can result in persistent clinical inefficiency and errors while using a new EHR.[19]

Data Migration

Data migration is one of the most crucial aspects of EHR transition.[18] Although automated conversion can migrate structured data reliably, underlying discrepant structures and embedded content can cause data inconsistencies and compromise patient safety.[1,28] One incident highlighted a technology error in which data conversion caused a patient's medication dosage to be double the intended dose.[25] A formal risk assessment with near-real time supervisory review processes should be effected prior to automated data migration. An alternative approach used only occasionally in our experience is manual data entry,[18] still requiring some form of validation process that consumes much time, labor, and money.[1]

Unstructured data, including dictations and textual documents, can potentially be migrated via an automated process depending on system compatibility. Empiric studies of transitions rarely or only briefly discuss the use of natural language processing (NLP) techniques. The volume and intended use of the migrated data will determine the best method of migration for unstructured, free text data,[1] for example, partial[29] or full data conversion,[19,30,31] NLP, or manual extraction and entry from legacy to destination system.[18]

Several factors influence what data to migrate from an existing EHR. These include the following:

- The time the legacy system will be available: if only for a limited time, organizations may elect to migrate more legacy data into the new EHR. When access to legacy systems will endure, organizations may choose to migrate less data, and postpone decisions on a patient-by-patient basis.
- How an organization interprets document requirements in the legal medical record: organizations that interpret legal medical record requirements as more encompassing may elect to migrate more legacy data than others. The legal standard of medical records may differ between electronic and paper records.[32–34]
- The cost of storing electronic records is now far less expensive than before.
- The complexity and delicacy of data migration itself. Migrating old records is a daunting task; data integrity and confidentiality require extra human resources and cost to verify accuracy. For some organizations maintaining access to the legacy EHR has become an expedient solution to those obstacles despite ongoing licensing and server maintenance costs, workstations, and user support issues.[32]

MU compelled users to adopt certified EHRs that include the ability to transmit continuity of care documents (CCDs) using consolidated clinical document architecture (CCD-A) standards, which may be one method for data migration. At least one institution used CCDs for data migration.[18] Although these electronic documents are interoperable, they include only a limited dataset. Even for fully certified EHRs, D'Amore et al, elucidate numerous issues such as semantic interoperability conflicts, errors in transmission, and "permissible heterogeneity" that defeat accurate data transfers.[35]

Substitutable medical applications, reusable technologies using fast healthcare interoperable resources (SMART on FHIR) may enable more reliable data migration,[36] and recent developments promise greater functionalities.[37] It remains unknown if use of FHIR for transitions is scalable and feasible given the huge size and varied types of data in legacy EHR databases.

When two systems do not share semantic interoperability, a data intermediary or archive system is necessary to retain or migrate data—first from the legacy system to the intermediary, then another conversion to the new EHR.[38] Use of third party applications also raises additional security concerns.[31,39,40]

Patient Safety

There are risks to patient safety in the data migration and data storage processes. Patient safety requires that clinicians have expeditious access to trustworthy legacy data[19] irrespective of the mechanism. A qualitative study comparing paper-based and electronic-based users' responses to migration to a new EHR revealed that electronic-based users perceived the transition to another EHR was harmful to patient safety and confidentiality even with layers of data security in place. In contrast, paper-based users believed the transition to electronic systems improved patient safety due to better security and sign-in processes.[7] There are numerous other examples of major problems such as data distortions, garbled or lost data, data that are difficult to find, and usability issues that threaten patient safety,[13] or that impair

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clinicians' ability to meet care guidelines due to lesser familiarity with the new EHR.[41]

Other studies demonstrated instances where data migration jeopardized patient safety.[42] Interviews and field observation during a transition between EHR systems discovered that one physician found "incomplete and inaccurate transfer of medication data into (the) newer system," for which the physician had to spend significant time reviewing the transferred medication data for accuracy. Although not an error caused by migration itself, a case study[43] discussed an adverse event in which managers agreed not to transfer the allergy list to the new EHR and instead asked clinicians to review allergies with patients upon use of the new EHR. Unfortunately, clinicians never updated many patients' allergy lists—which are often error-laden even before transitions—despite having multiple outpatient appointments after the EHR transition. An investigation of the effects of EHR transition on pediatric medication safety concluded that medication errors may occur no matter how extensive the preimplementation planning is, and mitigation strategies should be in place to minimize adverse events.[44] Organizations may want to consider upgrading their efforts to detect errors, recognizing that EHR-related error detection remains a vexing problem even during normal operations and especially around the time of EHR-to-EHR transitions.[45,46]

Moving from one to another EHR may highlight unique contrasts between the systems. Partners health care transitioned from their homegrown system to a commercial vendor product resulting in markedly reduced effectiveness of drug-drug interaction (DDI) alerting.[47] The authors ascribed this to two factors: (1) the homegrown system had its own library of interaction severities and triggered DDI alerts immediately upon order entry, whereas the vendor product used a commercial DDI library and triggered all potential alerts upon order signing; thus users encountered the alerts after they had made the mental effort of prescribing and often confronted multiple simultaneous alerts; and (2) in the legacy system, users had to address each DDI, whereas in the new EHR, they could dismiss all alerts in bulk, a much easier but far less effective response.

Provider Expectations

Physicians' apprehension about learning new processes and workflows can pose a barrier to effective EHR use.[48,49] As would be the case for anyone undergoing major transitions, physicians approach migration to a new EHR with expectations, hearsay, prior experiences, and a desire to ensure patient safety.[26,40,44,50] In ►Table 4, we provide guidelines for including physicians and other staff in the process.

In addition to the usual concerns about addressing expectations and involving stakeholders, the EHR-to-EHR transition literature also notes that clinicians were dissatisfied with the need to redocument history and allergies, recheck drug information, write new prescriptions, recreate lists, track health maintenance, and look for clinical guidelines, tasks they expected would be complete upon transition without their input.[51] The most valued EHR functions that boosted clinicians' satisfaction were features of remote EHR access and access to laboratory and radiology results in particular. Overall, users were somewhat satisfied with the new EHR when they were also satisfied with the transition and their level of work-related stress.[27] Despite efforts to ease the transition, experienced clinicians in another study attempting to electronically prescribe medications found the transition extremely difficult;

Table 4 Recommendations for EHR-to-EHR transitions

- The CMIO, clinical informaticists, and/or suitable clinician leaders should be the core drivers for EHR transitions.
- Identify specific goals and plans to provide a blueprint for costs, human resources, and areas where patient safety might be at risk. Survey gaps between the two EHRs, including semantic interoperability. Determine which data, if any, can transfer via an automatic process from the legacy system.
- Plan immediate and later training schedules: budget for both. Consider how long support should persist. Seek ways training can promote EHR user satisfaction, which in turn may influence patient care. Facilities will differ in needed support, depending on how similar the old and new EHR systems are, users' capability with technology, or specialties. Plan for year-round training if staff turnover rate is high and/or not cohort based.
- Recognize that destination EHRs may not support the same configurations and workflows as the legacy EHR
- New EHR may offer desirable workflows requiring training and support.[54]
- Ensure sufficient budget for:
  - Contingencies;
  - Availability of staff—leadership, as well as IT and informatics levels;
  - Adequate technical infrastructure;
  - Incorporation of a validation process to protect data integrity; and
  - Supplying adequate data availability to protect patient safety.
- Every facility should review, and prepare for, the concerns enumerated in ►Table 3.
- Address new and ongoing cybersecurity needs

  CIOs and leaders should realize that times of transition to a new EHR increase dangers of data breaches, ransomware, and the use of mobile devices with medical data.

  Both new authentication rules and current ONC rules specifically require enhanced cybersecurity for EHRs.

  In addition, preparations are needed for the myriad medical devices within the hospital (e.g., smart pumps) and on patients (e.g., insulin pumps, and heart monitors) create vulnerabilities that demand greater resources and personnel at times of transition—with the need to create and in some cases rebuild interfaces among electronic systems—and thereafter.

Abbreviations: CIO, chief information officer; CMIO, chief medical informatics/informatician officer; EHR, electronic health record; IT, information technology.

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physicians felt the commercial EHR was too complex, which contributed to reduced clinical efficiency.[25] Until there is a radical redesign of EHRs and payment systems, it will be challenging to counter prevailing physician notions that EHRs remain primarily billing and revenue capture tools rather than tools that aim to effectively satisfy clinical practice and patient care needs.

Physician satisfaction may improve or suffer because of an EHR transition. Reynolds et al found modest increases in provider satisfaction and comfort.[52] In contrast, Hanauer et al hypothesized that there would be a decrease in satisfaction after the transition from a homegrown to a vendor EHR, but expected a gradual rise back to baseline or even above baseline over time (a J-curve).[53] Instead only one of 14 scores (data entry in the patient room) showed a J-curve, whereas most showed an L-curve (descent without recovery), some were flat, and one revealed a U-curve (descent then return to baseline). It is important to manage expectations, and plan for dissatisfaction. Reynolds et al recommend addressing common reasons clinicians and staff feel uncomfortable with a transition and to communicate effectively about the EHR differences.[52]

Patient Expectations

We found only two studies that examined patient satisfaction during an EHR-to-EHR transition.[54,55] The one rigorous study, at Mayo Clinic, showed marked decreases in Press Ganey scores starting the quarter before the transition. The authors speculated that patients perceived decreased access, especially during scheduling appointments, due to staff's need to enter information into the current and soon to go-live new EHR. The decreased satisfaction was persistent, significant, and lasted 9 to 15 months.[54]

A small study at a glaucoma clinic found longer visit and wait times after installing a new EHR. But patient satisfaction was little changed.[55]

Training and Support

Most studies mention the need for adequate initial training for the new EHR, and then ongoing at-the-elbow support. Considerations for EHR-to-EHR transitions include physician expectations,[51,56] preconceived notions,[42] and prior experiences.[27] Although at first glance, this type of training and support may seem no different from that which would be needed to implement a first EHR, an important training difference in EHR-to-EHR transitions is that clinicians must "unlearn" and then relearn many tasks, shortcuts, and workflows.[2]

Hospitals operate multiple shifts and typically experience frequent staff turnover.[57] All shifts require adequate training —an expensive cost for distressed and small hospitals. Clinicians report they appreciate additional staff for training and support.[28] One challenge is the "retreat of the army of a dedicated team after the initial go-live phase."[8] Practitioners believed the availability of ongoing training for more than 6 months can greatly reduce user frustration.[28] A case study[50] involving an EHR-to-EHR transition concluded that training is a crucial component to solving clinicians' problems with system usage, especially with specialized staff and classes dedicated to EHR transition.[42] Training coursework should group providers by common workflow to maximize the efforts.[28]

Hospitals should conduct ongoing monitoring and support at a system level to best assess the health of the EHR itself and the end users.[14] Is the system functioning as designed? Are there hidden hazards within it? Where are the risk areas in the system? For end users, what kinds of surveillance might identify and aid those having challenges using the new EHR? Monitoring can detect users who are frequently writing clinic notes from home after hours. A program that provides focused 1:1 optimization support and coaching for these individuals might prove transformative for clinicians' effective EHR use and for clinician wellness generally.[58]

CMIO Team and C-Suite Responsibilities

Although decisions to purchase and implement new EHRs are often made by chief executive officers and chief financial officers, it is usually the CMIO or similar leaders who are in the best position to lead clinician involvement in the selection, analysis, configuration, and migration to a new EHR.

The CMIO should define strategies for the EHR transition. Examples of key strategic questions for CMIOs include: how much consistency versus site variation should there be within the destination EHR?[59] What is the correct governance process to intake, evaluate, and process EHR change requests?[60] How will the organization balance necessary changes against system consistency and adherence to strategic principles? Even with the best preparation, things may still go wrong. Vanderbilt formed a "Specialized Work Action Team" to gather technical, revenue cycle, clinical, and other people to serve on a moment's notice.[60]

A team of clinical informaticists can support the CMIO to help shepherd the multiple aspects of an EHR-to-EHR transition. The CMIO and team's skillsets[61–63] put those clinicians in the best position to identify gaps and opportunities in the destination EHR, and to perform the analyses required to ensure a smooth transition from the legacy system. Still, even if EHR transitions proceed with great care, researchers have found that challenges and risks remain abundant and consequential.[16,17] Every CMIO and organization should review and prepare for the responsibilities listed in ►Table 4.

It is critically important that senior organizational leaders support change management programs early in the EHR transition process.[60] Organizations need to prepare far in advance for the transition. The CMIO team can recruit respected health system leaders from various levels in the organization to signal publicly their readiness to change and to help engender trust in the transition. Selected leaders can spotlight anticipated benefits of the migration and acknowledge that every transition involves trade-offs that may be less desirable.

Cybersecurity

Cybersecurity issues were almost entirely absent in the EHR-to-EHR transition literature.[64–67] We present summary recommendations for EHR-to-EHR transitions in ►Tables 3 and 4.

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Discussion

We sought to enumerate challenges of EHR-to-EHR transitions based on the literature and the authors' experiences.[68] Many of the challenges are financial and involve trade-offs for competing resources. The authors observe that even after sites complete careful planning, unexpected challenges, even failures, and the need for rapid improvisations generate added costs, for example, purchasing data storage while addressing a failed data migration attempt, and other workarounds.[13] Any facility attempting an EHR transition may face serious stress and financial strain.

In our view a CMIO should be involved in key leadership discussions about EHR-to-EHR planning and assure that data that appear in the new EHR are in readable and usable formats. Indeed, recognizing that any particular CMIO may not be well versed in all aspects of EHR transitions, we hope that this work can help CMIOs by serving as a framework. The CMIO is also in the best position to anticipate, identify, and plan for the complex human behavioral and sociotechnical issues that arise during an EHR transition.[69] Assuring that providers have adequate training and support can ameliorate many anxieties about the new EHR and improve clinician efficiency. These efforts may also help reduce revenue losses during implementations.[58]

It is imperative to recognize and resolve hurdles prior to transition such as inadequate human infrastructure, technical challenges, unrealistic provider expectations, and insufficient training and support. Transitions are usually on a tight timeline. CMIO teams should anticipate organizational policy and process realignments and needs for early and robust change management. One example is the difficulty of aligning all facilities within a major consolidation or merger. That is groundwork that must be complete well before the transition. Vendors do not always account for this work which is difficult and time consuming.[8] Failure to attend to any one of our described domains could wreck the project timeline.

These challenges require money, institution-specific strategies, creativity, and the ability to learn from others' travails. There is limited guidance and no clearinghouse of the best practices. Many mistakes likely get repeated. Vendor expertise in how to navigate the thousands of decisions that institutions must make in planning for an EHR transition is occasionally adequate, but many times is not. Institutions must make decisions with incomplete information and without hands-on experience using the new system. While organizations can hire additional staff, they may be neither experienced nor affordable, nor able to provide year-round training. New or outside staff may not understand inherent complexities and cultural dynamics of a particular institution, potentially limiting their effectiveness.

Newer EHRs still suffer from unintended consequences of the technology when deployed in sociotechnical systems.[70] The expansion of EHR deployment and multiple EHR transitions reminds us to pay close attention to patient safety issues, as well as provider expectations, and the responsibilities of the C-suite and the CMIO.

Conclusion

EHR transitions are remarkably expensive, laborious, and yet largely unstudied. The reference scarcity in relation to the topic's salience makes it even more important as a subject for ongoing study. To this end, a new MeSH term for EHR transitions would facilitate further research. Every aspect of the transition requires significant money, time, and personnel. Transitions are unlikely to succeed without sufficient human and technology resources, and careful attention to patient safety, provider expectations, workflow and training, and tightened cybersecurity. In contrast, prudent and dedicated planning may streamline the process and reduce unexpected costs. The enumerated mitigating strategies may help CMIOs and other health system leaders to more effectively make the leap from one EHR to another.

Clinical Relevance Statement

EHR-to-EHR transitions are a commonplace occurrence with limited empiric literature to support the best practices. This review of the available literature, combined with the extensive experience of the authors, offers a framework for analysis of such transitions, delineates the domains which those contemplating changes should consider, and offers guidance on mitigation recommendations to ensure success.

Multiple Choice Questions

1. Which of the following strategies has proven to be optimal to ensure clinician adoption and satisfaction when healthcare facilities shift from one EHR to another?

a. Allocate funds and additional staff to assist in training for the transition.
b. Anticipate a reduction in training staff once the transition is complete.
c. Maintenance of interfaces with or same-screen access to the legacy EHR.
d. Plan on both short term and long-term training for clinicians and other staff.

Correct Answer: The correct answer is option d. The correct choice is to plan on both short- and long-term training. A transition from one EHR to another is similar to an initial EHR implementation in terms of training and support. The literature and experience show that optimal training includes optimization of workflows which takes time. This takes additional funds and staff, but more specifically requires long-term training. The evidence also shows that new EHRs will not allow organizations to reduce IT staff even when the transition is complete. Although clinicians often insist on access to all prior applications that is expensive, time consuming, not correlated with clinician satisfaction, and ultimately does not always occur.

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2. The authors note a paucity of research literature regarding EHR transitions. To promote formal research in this area the authors suggest which of the following?

a. Compilation and publication of all transitions by each vendor.
b. Creation of a national database of EHR transitions.
c. Development of a MeSH term for EHR transitions.
d. Surveys of sites that have undergone such transitions.

Correct Answer: The correct answer is option c. The correct choice is for PubMed to develop a new MeSH term. Although the other choices likely have merit, the authors found that beyond the problem of the scarcity of research, it is also evident that discovering that literature is difficult.

Authors' Contributions

R.S. conceptualized and organized the AMIA 2015 panel discussion, conceived of this manuscript, and wrote the first outline. C.H. wrote the first draft of the manuscript. All authors contributed significantly to the intellectual content of the manuscript and approved the final version for submission.

Protection of Human and Animal Subject

This paper includes neither experimental data nor personal health information. It is research that does not involve human subjects as defined in 45 CFR 46.102(f). The authors found no requirement for institutional review board review.

Funding

None.

Conflict of Interest

None declared.

Acknowledgments

We thank Dr. Andrew Gettinger for reviewing an early draft of the manuscript in a private, nonofficial capacity; and Edie Asbury, MLS, Geisinger Holy Spirit, Camp Hill, Pennsylvania, and Maylene Qiu, MLS, Biomedical Library, University of Pennsylvania, Philadelphia, Pennsylvania, for professional librarian consultations.

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