Efforts on Using Standards for Defining the Structuring of Electronic Health Record Data: A Scoping Review

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Abstract
Using a scoping review technique, this paper investigates approaches, challenges, and success factors when adopting highly structured Electronic Health Records (EHRs). Our findings are consistent with previous literature that reports that the most common methods for structuring patient data consist of a combination of codes, terminologies, reference information models, and standards. However, the review identified new factors and challenges previously not considered as critical areas for the successful implementation of highly structured EHRs; challenges related to human factors seem to be of paramount importance for the success of standard-based EHR adoption. The review revealed that main challenges are related to maturity of the technologies; methods for governance of clinical models; slow adoption of standards; high cost of running pilots; lack of standard compliance and validation mechanisms; and unclear terminology binding of information models. Key success factors are the availability of validated Clinical Information Models (CIMs) and value sets; properly leveraging and managing the complex technology stack; rapidly coordinating EHR implementers with governance bodies; performing agile requirements management; involvement of all stakeholders in the development of standard specifications; and implementing early pilots evaluating the adoption of structured EHRs.

Keywords
Structured EHR, health information standards, terminologies, decision support, review.

1 INTRODUCTION

Successful health care delivery is a service that requires efficient coordination and communication for both patient and provider benefits [1, 2]. Digitalization of work processes and the use of information systems such as the EHR has been though to alleviate some of these challenges [3]. However, the healthcare sector consists of a large number of actors – from highly specialized hospitals to general practitioners and home care providers – that often use different information systems [4]. The use of health information standards and structured data formats can through its common language and expectations provide semantic interoperability across organizational boarders and between different systems [5]. These concepts and technologies have been developed to define a standardized way of how health information should be structured and communicated [6]. The use of standards, terminologies and information models are also argued to be a prerequisite for realizing the potential in Clinical Decision Support Systems (CDSS), automatization of data reuse (secondary use) and efficient communication and information exchange [3, 7]. Currently, the adoption of shared and agreed-upon standards for EHR data structuring are being pushed through different initiatives internationally, both for the purpose of patient safety, accessibility, interoperability, privacy, and re-use of health related data [8].

There is a need for more comprehensive knowledge about experiences on using information standards for defining the structure of EHR data [5]. This paper investigates and discusses different approaches and related challenges to structuring patient data in EHRs.

1.1 Objective

This paper aims to identify and present methodologies and technologies used for structuring EHR data in general. The results of this scoping literature review will be used to inform recommendations and guide future research in the Norwegian medical informatics community on the adoption of standard-based EHRs.

Research questions (RQ) are:

1. What are current approaches to orientate the transition to structured and standard-based EHR data?
2. What are the specific problems and characteristics related to different methods of each approach for standardizing EHR data?
3. What factors are commonly predefined as crucial for a successful transition to a structured and standard-based EHR, and what is the relationship between the factors and actual implementation outcome?

2 METHOD

In this study, we used a scoping literature review for data collection. Scoping literature reviews are a well suited method to provide an overview of a broad and unfolding topic and for identifying relevant key concepts [9]. Argued to be as comprehensive as a systematic review, a scoping review allows for the treatment of broader research questions and provides greater flexibility in comparison [10]. In this study, we were interested in a diversity of relevant papers ranging across multiple methodologies and

disciplines and the scoping review technique is therefore well-suited.

2.1 Search strategy and study selection

In cooperation with a research librarian, we outlined the purpose and scope of the review in a search strategy document. In addition, we defined inclusion and exclusion criteria, as well as a concept definition. Search terms were identified using MeSH and through discussion among the authors. Search terms were subsequently categorized in one of four categories: i) IT system – electronic health records, medical records; ii) Terminology and classification – specific terminology or codes used; iii) Structure and standards – methods or standards used for structuring; and iv) Implementation and outcome – experiences or lessons learned. Categories were defined based on workshop sessions between the authors and project partners, as well as available literature and knowledge.

The search was performed in May 2018 using Ovid MEDLINE. The full set of returned publications were exported to Rayyan QCRI, a systematic review web application tool.

The included papers were randomly divided into three equal parts, and title and abstract were reviewed by one of three authors (LMR, ER, KMN). Papers were categorized as "INCLUDED", "EXCLUDED", or "UNCERTAIN". Papers could not belong to the same category at the same time. Any uncertainty or conflict was resolved by discussion until consensus was reached. The inclusion rate between the reviewing authors ranged from 20.1 % to 20.8 % in the first screening. The included papers were randomly assigned between three of the authors (LMR, ER, KMN).

2.2 Eligibility criteria

Publications were eligible if they met any of the following criteria:

1. The paper described experiences or lessons learned from transitions into a standard-based EHR by hospital senior management or medical head of departments.
2. The paper described how technologies were used in the adoption of, or transition to, standard based EHRs.
3. The paper described methodologies followed for the transition into standard-based EHRs.
4. The paper described data reuse methods/infrastructure and, at the same time, complied with one or more of the other eligibility criteria.

Exclusion criteria were applied: i) during the review in title and abstract for marking why a study was not included; and, ii) during the full text review to determine which papers would not be considered for the final analysis. Papers were removed after being revised in full text if they met any of the exclusion criteria:

1. The paper was excluded if it described a general interoperability strategy without organizational or technical details about the EHR adoption process. For example, the paper described a funding framework, a legal requirement, or a declaration of interest for adopting standard-based EHRs, but it did not provided organizational or technical details on how to perform it.
2. The paper was excluded if it defined the impact of a standard-based EHR on the clinical or patient side, but did not provided information about organizational or technological aspects used in the standardization process.
3. The paper was excluded if it did not report clearly on how the EHR was used to extract data and store structured data.
4. The paper was excluded if it only reported on impact for secondary use of data without complying with any of the other inclusion criteria.
5. Other- the paper was excluded if it did not meet any inclusion criteria during the review in title and abstract but could not be marked with any of the aforementioned exclusion criteria. In that case the reviewer wrote a small explanation about the reason for exclusion.

2.3 Data extraction and analysis

The included papers were randomly assigned to one of the authors (ER, LMR, KMN). A data extraction schema was designed as a tool to summarize the papers and justify either inclusion or exclusion by assigning them a corresponding pre-defined criterion. The authors extracted data during the full-text review process. The applied method resembles the scoping review stages proposed by Arksey et al. [11].

3 RESULTS

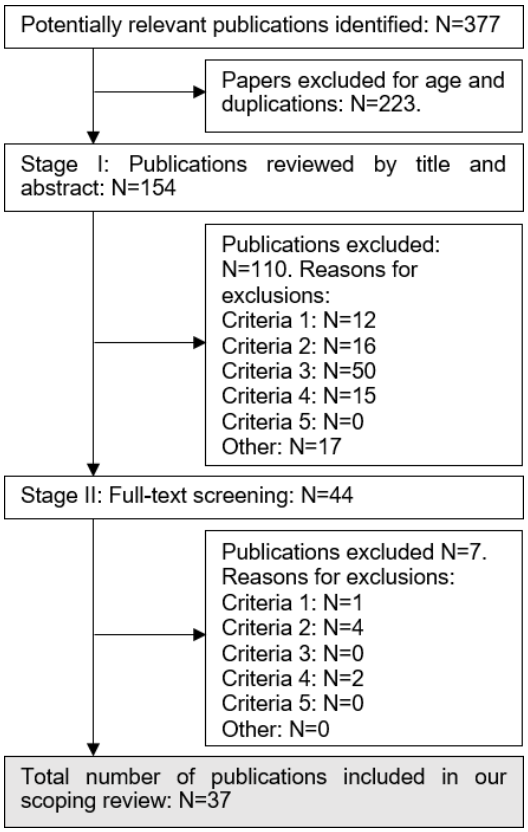
Approximately 24% (37/154) of the papers identified in the literature search were included in the final review. The initial search produced 377 potentially relevant publications. Of these, 223 publications were excluded due to duplications and age, as we restricted to papers published between 1st January 2010 to 21st May 2018. The 154 studies remaining were reviewed in title and abstract applying the eligibility criteria described in section 2.2. Forty-four remained after the review in title and abstract for being reviewed in full-text. After full text review, 37 publications were included in the review, and seven were excluded for complying with the exclusion criteria defined in the following section.

Figure 1 illustrates the literature search and article screening process.

3.1 Study characteristics

Through an inductive process of discussion between the authors, six main categories that encompass the dimensions involved in the implementation of structured EHRs were identified in the included papers: i) terminologies and decision support; ii) implementation of structured data; iii) technical infrastructure; iv) clinical information models governance and terminology binding; v) extraction transformation and load; and, vi) organization and management. Each category represents a specific approach, or use of standards, for structuring EHR data. Table 1 details a summary of the categories identified in the included papers. Note that the categories are non-mutually exclusive, meaning that the same paper can be plotted to multiple categories in the table.

Figure 1 Flow diagram of literature screening process.



In the following, the paper describes the empirical material from the scoping review using the identified categories. Within each category, we will present the related challenges and critical factors described in the included papers.

Table 1 Categories identified after analysis of included papers.

Category	Reference	N
Terminologies adoption and management	[12-27]	15
Implementation of structured data	[13, 19, 20, 22, 25, 28-34]	12
Technical infrastructure	[14, 16, 24, 35-41]	10
Clinical information models governance and terminology binding	[14-16, 24, 26, 27, 31, 36-38, 40, 42-45]	14
ETL-process	[24, 39, 40, 42, 44, 46, 47]	7
Organization and management	[14, 25, 36, 38, 45, 48]	6

3.2 Terminologies adoption and management

A systematic literature review by Hyppönen, Hannele, et al. reported that the most common methods for structuring the patient data consisted of a combination of codes, terminologies, reference information models and documentation standards, standardized forms (templates), and post-hoc structuring using Natural Language Processing (NLP) [20]. Multiple papers discuss interoperability, mainly from a technical perspective, reporting on ongoing efforts and challenges from an architectural and information standard perspective. Previous studies, both from research and practical application developments [12, 15, 16], focused on the use of terminologies and data formats for achieving information interoperability. Other studies [13, 22] discusses how the use of different terminologies for representing different clinical domains poses a challenge for connecting data elements if there lacks a homogenous system to support interaction, i.e. mapping between corresponding concepts in different terminologies, needed in some instances of decision support systems. Multiple studies [12, 21, 23] states that while terminologies and terminology services have proved effective for both direct-capture of data from live EHR for use in CDSS, for facilitating interoperability, and improve information management, Kuperman et. al. points out that unsolved challenges of version control and management of standards remain [14]. In addition, multiple papers discussed different architectural approaches best suited to serve multiple user sites or national solutions; two papers [14, 23] reported on successful projects using remote distributed terminology services. When comparing and evaluating different terminology services, Pathak, Jyotishman, et al., showed that there were significant differences in API performance between the services when performing queries that directly affected the quality and ability to support CDS, stressing the importance of thorough technical testing and API considerations in systems acquisition [27]. One paper [17] reported that a Data Management Strategy (practical user guidelines for documenting patient data) could improve both quality and quantity of coded clinical data from clinicians. Multiple papers [17-19] also identified clinicians to be important actors when developing coding strategies and templates for efficient use in clinical settings, as healthcare professionals were better equipped to see limitations in current coding systems based on the crucial clinical domain knowledge they hold.

3.3 Implementation of structured data

DeBlieck, et al. reported that documentation procedures of patient data using guidelines and templates developed by clinicians also partly improved clinical outcome in postoperative patients and resulted in more complete and reliable records [22]. Other papers [20, 29, 30] identified additional factors affecting implementation and adoption rate of clinical standards and structured data entry as system flexibility for customization and adaptation, systematic education and training, leadership support, and strategic planning , and that the introduction of a coding system for structuring clinical data improved both interdisciplinary collaboration and user satisfaction among healthcare professionals. User satisfaction with the implementation of structured EHRs were also showed to be affected by the perceived benefits and implications it would have on workflow, compliance, and reimbursement, and Jackson and Muckerman states that there need to be a sense of urgency for change among users [29].

3.4 Technical infrastructure

SOA architectures have been extensively used for better scalability and maintenance. Chipman et al. and Chronaki et al. presented a CDS functionality for risk assessment offered as a web service that relied on HL7 messages for

structuring the messages payload [16, 35]. Nagy et al. also relied on SOA to build a broker of HL7 v3 messages that allowed organizations in the Czech republic to share clinical data [36].

The use of standards and their importance in building effective regional and national health information networks has been acknowledged in several studies. Chronaki et al. presented the work towards the standardization of ePrescription in Greece and Finland using HL7 CDA, HL7 v3, and IHE profiles [16]. Multiple studies [14, 16, 37] found that the adoption of standardized structured health information systems is slower than originally planned, and that the reasons are the complexity of the HIT environment, the steep learning curve of the technologies, the time needed to become familiar with standard specifications, and the amount of resources needed to test new deployments before going live.

Standardization of extracts needs syntactic and semantic validation of the generated instances. Methods for validation are found in Goosen et al. who provided syntactic validation by using XML schemas to validate Care Provision Domain Model messages [38]; and, in Kuperman et al. that relied on Schematron-based validation of XML documents [14]. Microservices are earning momentum to deal with the complexity of HIT architectures allowing better scalability, evolution, and independence from large main frames [24].

Poulymenopoulou proposed a framework that combined the use of standards (HL7 CDA and IHE) with technologies such as NoSQL DBs and semantic web technologies for including both clinical and patient- reported data [39]. Rea et al. illustrated in their paper that the combination of different technologies are common to provide the functionality needed for each of the Extract Transform and Load (ETL) stages; they used a rich technology stack to approach a complex structuring and standardization process for data reuse [40], Mirth Connect was used to transform HL7 v2 messages into other semi-structured formats, and Apache UIMA as NLP technology for structuring free-text sections contained in the messages delivered by Mirth Connect into a relational database. A Drools rule engine was used on top of the for implementing phenotyping algorithms. It is also worth mentioning that Rea et al. had to deal with complex security layers in order to transfer information between different health institutions.

3.5 Clinical information models governance and terminology binding

The definition of CIMs is a complex process, and the same clinical concept may be modelled in different ways, all of them valid [15]. Thus, careful governance and participation of future users and implementers of the model is needed to ensure that their modelling pattern is correct [37, 38]. As with value sets, reuse of CIMs should always be attempted, provided that they are a corner stone for both syntactic and semantic interoperability [37], therefore implementers should leverage which standards offer reliable CIMs in an openly and transparent manner. However, depending on the clinical subdomain, the availability of validated CIMs may be different; Richelsson pointed to the absence of coverage for psychological items in the standardization of psychological questionnaires [37].

Formal ontologies based on description logics are earning momentum for structuring complex biomedical vocabularies. In addition, they have played a role in integrating different vocabularies in projects that need to deal with equivalent terms from different coding systems [16]. Nowadays, many organizations rely on their own legacy coding systems and will need to map these to standard terminologies (LOINC, SNOMED-CT etc.) [14, 36]. However, terminology mapping is still a challenge due to the lack of appropriate tooling and the idiosyncrasies inherent to the design of each coding system (point of view, objective, amount of post-coordination etc.) [14, 36]. This results in imperfect matching and poor coverage of some areas when mapping from one terminology into another [42]. We found that the amount of information captured by the CIM and the terminology, and whether post-coordination should be used, is highly dependant on the maturity of the IT infrastructure [12]. The use of post-coordination is often avoided due to its complexity and requirements, but it results in data more consumable for clinical decision support than pre-coordination [15].

Another challenge related to terminologies is their management. Rea et al. warned about the costs involved in maintaining different versions of terminologies [40]. For example, obsolete codes need to be mapped to new ones when upgrading the terminology version [40]. Oniki et al. advocate for prioritizing clinical usefulness and “static” knowledge in the terminology and leave instance data in the CIM [15]. However, Bennett state that these decisions are highly dependant on the requirements of each individual organization [12]. Richelsson and Nadkarni state that it is necessary to emphasize the use of terminologies for semantic interoperability [37].

Peterson identified that matching of analogous terms between different terminologies requires a dedicated terminology service [24]. Relying on standards that count on specific tools for supporting the ETL process and allow the analysis of source and target data schemas and terminology mapping is important [24], in addition to pre-defining the value sets containing the codes that will be used by the EHR system. Terminology servers will need to provide an environment for the management of value sets and mapping between concepts from different terminologies with a GUI that supports these tasks [24]. Standards such as the Common Terminology Services 2 (CTS2) and FHIR terminology server API, are available and have the potential to help developers abstracting them from the complexities of terminology management.

The adoption of SNOMED-CT involves additional challenges. Even with expert terminologies, the choice of codes for creating value sets or coding CIMs, has proved to be ambiguous and requires careful consideration [37, 43, 44]. Some authors deal with these challenges using local guidelines. However, local guidelines cannot control terminology inconsistencies among different organizations, indicating that guidelines need to be provided and audited at a higher level in order to improve SNOMED-CT consistency. Also, few SNOMED-CT projects for large-scale adoption in large healthcare organizations are documented [43]. Several studies agreed on the necessity

to define best practices and experiences about the use of controlled terminologies in combination with CIMs [15, 24, 37, 40, 43].

3.6 Extraction Transformation and Load process

When migrating from EHRs that allow lots of free-text content, the pipeline often starts by Natural Language Processing (NLP) identifying the key sections that are likely to be structured [45, 49]. When information in the legacy (source) system is unstructured, or minimally structured, the task becomes an information extraction challenge where counting on a robust validated CIM can be of great help to act as target information schema during the NLP process [45]. Also, terminology codes and their synonyms can be of help in the process of identifying key words that allow for identifying which piece of information should populate each section of the CIM [45, 48]. When the ETL process involves several data sources and nested data structures that need to be integrated before transforming them into the standard form specified by the CIM, a canonical intermediate plain view is often created. That view is then used to map its fields to the elements of the CIM using transformation rules [42, 49]. That transformation can be carried out using ad-hoc scripts, rules languages, or tools specifically designed for such a task.

Paraiso-Medina split the process into data normalization and semantic harmonization [42]. Due to the complexity of the domain, many tasks need to be supervised manually and cannot rely on fully automatic processes [42]. In addition, once information is structured into a standard format, it is convenient to split different types of information into different repositories for privacy and management convenience. For example, Zhou describes how different types of information are structured in different tables (demographics, diagnoses, prescribing etc.) [44].

3.7 Organization and management

Goosen and Kuperman show the importance of pilots coordination for eliciting standards and CIMs, the importance of getting feedback from several stakeholders, and involve stakeholders with complementary views (government, health organizations, vendors etc.) [14, 38]. Further, they state that it is important to rely on standards that are balloted and piloted by different stakeholders before making them normative so reliable information about the challenges involved in implementing each standard can be understood [14, 38]. The local workflows of each organization establish a need for pilots in order to clearly understand the requirements of each implementation.

This is shown in Goosen and Kuperman where the HL7 CDA and IHE profiles are piloted before eliciting the final stable version of the standard [14, 38]. The management of requirements needs collaboration among all the stakeholders involved, thus working groups need to be multidisciplnar. For example, Kuperman reported on the organization of four different working groups in the implementation of IHE: IT infrastructure specifications development (Technical and Security Work Group), data specification development group, testing and coordination group, and coordination of participants for the data use agreements specification. Cooperative working among members of different backgrounds (managers, vendors, technicians, and specially clinical users) have been pointed out as a key factor in the success of structuring and standardizing the EHR [14, 38].

4 DISCUSSION

Based on 37 included papers, this review identified and described six main categories related to critical factors, challenges and approaches to EHR data structuring and standardization. In the following, we discuss our results to the research questions defined in section 1.1. Objective.

4.1 RQ1: Common approaches for structuring

The findings in this review illustrate that there is a wide span in terms of technologies and approaches being used for structuring EHR data. Health professionals, governmental bodies, and hospital administrators are in general interested in the potential of structured and standard-based EHRs. The most common methods for structuring clinical data consisted of a combination of technologies and standards [20].

On top of EHRs, large regional and national health information networks also being deployed [16, 36]. These infrastructures can provide a greater landscape for information exchange and the possibility for local adaptability if validated standards and technologies are properly leveraged [35, 37, 40, 42, 46]. Service Oriented Architectures (SOA), and in particular RESTful-based microservices have been found useful for encapsulating software components of health information systems exposing them as web services that can be consumed remotely by several clients. This has allowed the re-use of complex components, thus reducing the cost of their deployment and maintenance tasks [50]. The latest developments in FHIR commit with these principles allowing developers to rapidly implement REST web services to exchange health information messages [41].

Few studies covered the importance of supplementing the implementations using clinical information standards with mechanisms for validating that the messages shared among stakeholders fully commit to the syntaxes defined by the CIM, and the semantics defined by the terminology. This is particularly needed when CIMs are refined to cover the needs of a specific scenario since their modification may result in the lack of interoperability [14, 38].

4.2 RQ2: Specific challenges when standardizing

There are several issues both technical and human that affect the successful standardization of clinical data. The first issue is the need for a proper governance of CIMs. HIT infrastructures are at this point not sufficiently mature for full-scale adoption of health Information standards, and organizations lack experience with the use of terminologies [7, 25]. The lack of effective governance of models is a main issue. For example, if FHIR profiling or openEHR archetypes development is not done in an ordered manner, i.e. with coordination from a national body, two systems operating in the same standard may not be able to interoperate seamlessly. In addition, some studies point out that legislation and management of the technologies reduces the possibility of exploiting the full potential of structured EHRs [32, 35], implementers shoud be aware of legal aspects at project design time.

The second factor is the proper use of terminologies customizing their use to the requirements posed by EHR users because currently there are many open issues when it comes to the adoption of reference terminologies [25, 27, 30, 31, 42]. EHR users are not only the direct healthcare providers (physicians and nurses), but also researchers and managers. Terminology binding of CIMs is highly dependent on the needs of different actors [12]. Requirements from all data users need to be clearly understood for determining the load of terminology codes that are bound to CIMs. For example, terminology requirements are different when only interoperability of EHR extracts is required and when enabling efficient data reuse is needed. In the former case, it is enough to bind some terminology codes to the main sections and values of CIMs; in the latter case, i.e. secondary use of data in research, the relationships among terms needs to be processed and expressive queries that deal with, for example subsumption, need to be enabled [12]. Also related to the use of terminologies is the complexity involved in managing the use of several terminology systems since mapping among concepts from different terminologies is not a trivial task and needs careful assessment by terminology experts [13, 22]. Despite the efforts in clarifying the best strategies for adopting terminologies, unsolved challenges in version control, management of standards, and terminology mapping remain [13, 14, 22]. Implementers need to carefully design terminology adoption strategies and aim for using standard terminology services that help to homogenize the access to value sets [14, 23, 27].

A third factor is the amount of work involved in structuring pre-existing clinical notes. Although NLP techniques have improved in the last decade, NLP is not a silver bullet that can directly establish equivalences between free-text and CIMs. Implementers need to take into account that in most cases, this task will need to be manually supervised by clinicians and NLP will be a helpful tool for them, but not a solution per-se. Implementers of structured EHRs should also be aware of the cost of the ETL stages involved in driving information from the free-text clinical notes to the standard structured CIMs [40, 42, 44].

4.3 RQ3: Crucial factors

Key success factors include both technical and human factors. Despite the technical advances, this review shows that practical use and real-life adoption of standardized HIT is slower than one might expect [14]. On the one hand, the slower adoption is due to immaturity of technologies and the complexity of standards. On the other hand, the slow adoption is caused by human and organizational factors such as lack of national and local competencies, lack of proper governance of CIMs and terminologies, poor management of requirements, and insufficient stakeholders involvement [29, 31]. Below we elaborate the findings about these success factors.

4.3.1 Technical factors

Technical factors are the best understood according to our review. They include the availability of validated CIMs and value sets, and the adequate management the complex technology stack [45].

Each organization must be aware of its limitations before starting the structuring process. Data quality of the legacy system may set boundaries for the completeness of CIMs that conform the first version of the structured EHR. Also, not all organizations will be able to code their information with some specified value sets [14]. The structured standard system may not be equivalent to the legacy data model (i.e. they may not be iso-semantic) leaving many attributes and sections of the target CIM unpopulated. This is something to take into account in order to avoid misunderstandings in a structured system. Projects producing a first structured version of the EHR may produce incomplete CIMs, but they will set the basis for a later project focusing on capturing clinical information with better quality and facilitate the adoption of clinical terminologies. This also applies to the amount of post-coordination allowed and the amount of information represented in the terminology space. In most cases, terminology binding of CIMs to clinical terminologies is crucial for appropriately specifying structured standard content [24, 40]. However, organizations with HIT infrastructures that are not mature and lack experience with the use of terminology servers should prioritize pre-coordination and capture of information in the CIM. More mature organizations may consider to increase the formality in the data they capture, making a heavier use of terminologies and post-coordination, but they need to be aware of the high costs involved both in terms of infrastructure and management [51].

4.3.2 Human factors

Human factors are less well understood and, at the moment, the most relevant when transiting to standard-based EHRs. They include the agile management of requirements by a rapid coordination with interoperability assets and governance bodies, proper system education and training, strategic planning, customization ability of the EHR, and early pilots evaluating the implementation of standards [6, 22, 38].

HIT is dependent on local workflows, this leads to requirements that can only be detected at implementation time. To minimize the risks derived from these local requirements, it is convenient to rely on standards that have formed traction among professionals that are able to report on the main challenges and aspects prior to implementation [14, 38]. Therefore, piloting any development is necessary to understand the risks associated with the structuring and standardization process and, often hidden by the complexity of the health domain. Also related with this finding is the need for involving stakeholders from the organizations that are part of a structuring and standardization process, thus including the perspectives from clinical users, vendors, standardization bodies, and health organization managers. Pilots that involve all these key stakeholders from an early stage will allow understanding the complexity and side effects of the standardization EHR project.

Every large implementation is likely to identify new requirements for information structures, and an agile management of requirements will be needed by the coordinating implementers and standardization bodies involved. Special attention must be paid to the structure of working groups and how the coordination with

standardization bodies will be achieved. Expert panels eliciting standards should contain representatives from the vendors and health organizations that are going to be using the standards for structuring their data [37, 43]. In a larger frame, local initiatives should, if possible, be coordinated if not nationally, at least with the surrounding organizational context.

5 CONCLUSION

Adherence to specific data formats was the main challenge related to interoperability and data exchange, including a lack of consensus on when different standards should be used [13, 14]. Incentives in the form of governmental enforcement, implementation funding and a shared implementation guide proved useful for increasing adoption of standards among EHR vendors [34].

In the review we did not find information about what was the best method to determine how to approach the period of transition where two systems (e.g. paper and structured EHR are used) and how long this period should last. Other studies should consider adding clarity in that regard.

Organizations considering adopting Health Information standards and structuring the EHR, should consider multiple approaches according to their specific needs. This assessment should carefully consider maturity of the technology, the extent of existing legislation and the need for governance models for management and control of the technologies.

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