Measuring Perceptions of Openness in Health Information Technology Platforms

Results from Pilot Testing Proposed Survey Framework

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Abstract— **The paper focuses on the concept of Open Platforms as an emerging Health Information Technology and investigates how subjective perceptions of platform openness can be investigated across different socio-technical dimensions by piloting a novel survey framework among a small sample of domain experts. Using six main topics of inquiry, the framework was able to distinguish between type and degree of platform openness across different implementations of Health Information Technology platforms. The results indicate high aptness and relevance of the included topics. The paper proposes a step towards operationalizing the concept of Open Platforms within the e-health domain, with a special focus on patient records and interoperable systems.**

Keywords-Health Information Technology; Open Platform; Platform Openness; Interoperability; Data Standardization.

I. INTRODUCTION

The concept of *Open Platforms* has emerged in the research and applied fields of Health Information Technology (HIT) domain as an elusive sub-category of traditional digital platforms. However, an authoritative definition of Open Platforms is still lacking [1]. This is a hindrance for healthcare organizations and implementers, that need to carefully consider the type and degree of openness their case requires. Furthermore, socio-technical research on real-world HIT settings requires the means to identify systems that more or less conform to the principles of Open Platforms. Therefore, a method for measuring openness over different central socio-technical platform principles is needed.

In this paper, we propose a definition of an Open Platform that we break down into six topics, which can be operationalized to measure openness in HIT platforms. The aim is to propose an early step towards establishing a measurement that can be used in real-world settings to evaluate a platform's degree of conformity towards generally accepted principles for Open Platforms. The paper describes a set of principles and a proposal on how to operationalize them in a survey format. Finally, we present the results from an initial pilot test among a small sample of expert respondents.

We have not identified any equivalent instrument or measurement tool that can measure the extent of platform openness in a real-world context, and previous studies have stated that an agreed-upon method for how to dimensionalize and measure platform openness is lacking [2]. The research objective in the present study is as follows: Conduct a pilot survey of the drafted measuring instrument among a small sample of domain experts, investigating i) whether the instrument is able to distinguish between different levels of openness in HIT platforms, and ii) if the Open Platform principles are perceived as important by the respondents.

The remainder of the paper is organized as follows. First, we introduce the relevant background and the conceptualization of Open Platforms within the e-health domain. In Section 3, we describe the method employed in the present study. Section 4 presents the results of the survey pilot test. Finally, we discuss the findings, limitations, and contribution of the paper.

II. BACKGROUND

The digitalization of healthcare and the introduction of HIT systems has transformed the organization, provision, and planning of medical and care services. This transformation has affected organizations, healthcare professionals, patients, and decision makers alike. For clinicians, the Electronic Health Record (EHR) represents one of the most vital HIT tools for providing patients with treatment and care [3], and has ostensible benefits related to improved quality of care, patient safety and increase in productivity [4][5]. However, interoperability and data communication remains a challenge [6][7]. One reason for this is a failure to adhere to a common data representation; data from many sources must conform to a common representation that faithfully specifies certain aspects, such as the context of data, the structure of the information, and its precise meaning [8][9]. Although the usefulness and importance of standards for building shared health information networks has been proved, adoption and standardization processes have shown to be slow [10]. In addition, a lack of regulatory requirements, technology governance and supportive legislation has contributed to slowing down the progression [8].

In a recent scoping review, a combination of codes, terminologies, reference models, Clinical Information Models (CIMs) and standards were identified as the most common methods for structuring patient data [10]. Traditionally HIT generally, and EHRs specifically, are built using primarily proprietary technologies, with technical standards and CIMs developed, controlled and maintained by the vendor [1]. From a business perspective, the idea behind these monolithic mega-suite systems has been to offer most, if not all, required software functionality and features in a single solution [11]. While this approach can yield great stability, it inevitably leads to 'vendor lock-in', a situation where the vendor controls the data, and information interoperability and agility are impeded [12]. Consequently, organizations become heavily reliant on single vendors and 'closed HIT systems'. As a result, healthcare organizations struggle with a fragmented system portfolio with limited possibilities for integration, numerous legacy systems, siloed data repositories that challenge (semantic) data exchange and interoperability, and costly and complex data migrations when applications are switched [8][13]. Arguably, this is a consequence of a largely application-centric focus instead of a data-centric one [14]. In addition, monolithic suite HIT tends to assume a generative form, requiring extensive adaption and customization to fit local context. This is illustrated by the challenges, and subsequent failures, of implementation efforts of large-scale suite systems in local contexts which they were not originally designed for [15].

A. Defining and conceptualizing Open Platforms

Increasingly, the market trends indicate a significant shift from the traditional single-vendor mega-suite scenario towards Open Platform-based multi-vendor system ecologies based on international and open technologies [1]. However, research concerned with the concept of platform openness within a HIT perspective is limited, with most studies assuming a domain-agnostic perspective [16]. Arguably, the inherent socio-technical complexity and multifaceted interdependencies between different stakeholders (e.g., clinicians, patients, vendors, IT staff) within the HIT and medical field, requires conceptualizations and knowledge based on the specific domain in which the platform is embedded [17].

While Open Platforms have several aspects in common with *traditional digital platforms,* as defined by Rolland et al. (2018), these definitions lack a dimension of openness which we argue distinguishes an Open Platform from traditional digital platforms. A key principle for an Open Platform is that it provides an infrastructure and core services that are extensively based on openly published standards and used in common or reused across implementations [18]. Another important distinction is that between an Open Platform and an *open-source platform*; while we can regard all open-source platforms as Open Platforms, not all Open Platforms are *open source*. The main difference is that an open-source platform makes available the source code, while an Open Platform provides the interfaces and data modelling rules but may still contain proprietary components and technologies (e.g., source code). Hence, a necessary first step is therefore

to provide an objective and comprehensive definition of Open Platforms. We formulate the following working definition based on a synthesis and further development, including a broader socio-technical perspective:

An Open Platform provides a vendor- and technology-neutral digital infrastructure and associated services that are based on open, published standards that, in principle, everyone can use to access the platform. The platform makes it possible to link applications and services from many different suppliers without discrimination, such that there is a many-to-many substitutability between applications and services, and support for data portability and sharing in defined, standardized formats using common APIs. Through a governed and modularized architecture, the platform provides flexibility by facilitating features for a heterogenous user group, supporting a multitude of use cases, and promoting innovation [13][19].

Based on this definition, an Open Platform architecture potentially limits the challenges related to non-standard interfaces and proprietary data formats traditionally used in HITs. Building the platform on open standards, interfaces and technologies through a modularized and well-governed architecture also allows for far greater flexibility for the organization to adapt and compose their system ecology as requirements change, which the interconnected network of monolithic systems lack [20][21]. In a previous multicenter case study of hospitals that recently had implemented large-scale clinical HIT platforms, we identified the flexibility to adapt the systems to individual or group level needs as significant contributing factor in reducing user resistance and increasing perceived system usability, illustrating the importance of the flexibility characteristic of Open Platforms [22].

Building on existing literature and the definition provided above, we defined six distinct topics that should be considered when assessing the similarity between a real-world HIT case and the concept of open platforms [23]. The topics are constructed to cover multiple dimensions of the platform's architecture and services, and we use the notion of both technical and organizational aspects to expose the necessary characteristics. Each of the six topics are supplemented with a principle designed to envision the maximum extent of possible openness in a platform.

1) Vendor neutrality

Open Platforms are designed to reduce reliability on single systems and vendors by utilizing openly published standards. This contrasts with traditional HITs where proprietary technologies have been the norm. Any application that adheres to the open standards can operate, produce, and consume data on the platform, eliminating challenges with vendor lock-in and overdependence to closed systems [13][24]. This promotes continuous and agile change and growth in line with emergent user needs.

Principle: To ensure broad compatibility and interchangeability between products and technologies, the platform is based on open, available, and published technologies and standards and does not depend on individual suppliers and vendors.

2) Flexibility of system portfolio

By design, an Open Platform facilitates flexibility and adaptability over time [25]. This is important as the platform represents a non-static HIT expected to change. In addition, the modular architecture allows for applications to be exchanged in line with newly arising needs, e.g., the organization or users have greater access and flexibility to integrate with vendors and applications that are a better fit [11]. Using well-defined and published interfaces also allows for use in ways other than initially intended or implemented [26]. The inherent tension between flexibility and increased standardization needs special attention; standardization must be coherent and comprehensive enough to allow reuse, semantic interoperability, and common points of integration, while still allowing for differences in actors' needs, emerging requirements, and variances in workflow.

Principle: The platform allows flexibility that allows users to adopt and use applications differently and independently, based on individual or group level needs. New applications can be integrated with existing systems and can share, consume, and produce data.

3) Clinical information models

Common CIMs and data models are a core component of an Open Platform. CIMs are used to provide an unambiguous description of the clinical content, to represent it across applications on the platform, and support persistence and querying of structured data [27]. Hence, CIMs should provide the data in a sharable, open, and computable format. However, efficient use of CIMs depends on sufficient governance and development models; the same clinical concepts may be modelled in different ways, each of which correct [28]. User involvement in design is therefore essential, but not trouble-free; collaborative user development increases the risk for extensive negotiation processes and show of power-relations between actors, often with unpredictable outcomes [29]. This underpins the need for proper governance models for management and control of the technologies [10]. For shared HITs, such as an Open Platform, the governance should be performed centrally (e.g., by government bodies).

Principle: Applications on the platform share open information models in a way that preserves the semantics in the data when it is moved between applications.

4) Open data

In accordance with good patient information governance practice, the Open Platform should present all data it contains in a usable and open format. While there are different methods for operationalizing this (e.g., either by using the open format natively in data storage or through mapping and transformation from other open or proprietary formats), the purpose is to provide patient information in a form that supports interoperability, data portability and reuse [8][13].

Principle: The platform supports open data, and data is exposed as needed (subject to good information governance practice) in an open, shareable, computable format in near to real-time.

5) Technical openness in the platform

APIs are the technical interfaces used by applications to connect to the platform and access and interact with the data. In Open Platform the full specifications of the APIs should be published and freely available. This includes definitions of the types of data, features and functions that are provided through the APIs. Several mature open APIs exist, and ideally the Open Platform should support and provide multiple interfaces [30].

Principle: To support innovation and flexibility, open APIs that provide access to the platform and data are used.

6) Organizational openness in the platform

Besides technical aspects, there are organizational principles that must be fulfilled for the platform to be truly open. As healthcare is a highly regulated sector, it is possible that local, national, or international laws and regulations could prohibit total openness. We therefore consider this to be a context-sensitive principle, and implementers and providers should thoroughly assess the desired, necessary, and permitted degree of openness.

Principle: Organizational, financial, and legal frameworks does not prevent third-party suppliers and the integration of additional functionality or applications.

III. METHODS

A. Survey development and design

A survey based on the six topics presented in the previous section was developed in an iterate process between the authors. Complementary statements have been defined for each main topic for further probing and exposure of the specific topic. The statements were operationalized into 5-point bipolar Likert items that could be administered in a web-based survey (Table I) [31]. For five of the six topics, multiple Likert items were formulated in order to allow for more extensive probing. A web-based questionnaire was developed in Questback (Questback AS, Oslo, Norway). For each item, respondents gave their response over two dimensions: 1) Extent of presence in the platform: To which extent do you agree that the statement is true for your hospital's HIT platform, and 2) Overall importance: To which extent do you agree that the statement is important for an open HIT platform.

The method employed in this study is designed to measure openness as a subjective construct in the eyes of domain experts [32]. First, we wanted to measure the respondent's perception of the extent to which their HIT platform corresponded to the Open Platform principles. Secondly, we were interested in testing the respondents' perception of the Likert items' relevance for Open Platforms in general. The resulting questionnaire had 16 items, that each included both a presence and an importance rating. The survey was piloted among two domain experts and adjusted based on feedback prior to finalization. We assess the survey by evaluating whether the measurement can distinguish between varying degrees of adherence to the Open Platform principles between systems, and perceived face validity of the survey items. We explore this by considering two variables: i) presence of either floor or ceiling effects, indicating that items might be able to discriminate, and ii) items score on perceived importance to assess face validity.

TABLE I.   MAIN TOPICS AND CORRESPONDING ITEMS USED IN SURVEY, INCLUDING KEY REFERENCES

Topic	Code	Item
Vendor neutrality [33][34]	V1	The platform builds upon open and non-proprietary technologies
	V2	The platform builds upon open standards, such as HL7 FHIR, IHE-XDS and openEHR
	V3	The platform is not dependent on a single vendor
Flexibility in system portfolio [35][36]	F1	The platform allows flexibility for individual users to use applications based on their needs and preferences
	F2	The platform allows flexibility for sub-divisions of the organization (i.e., departments, clinics etc.) to use applications based on their needs and preferences
	F3	The platform allows new applications to be integrated with the existing systems on the platform and share/consume/produce data
Clinical information models [1][28][37]	I1	The specifications for information model and terminologies are openly available
	I2	The applications on the platform share information models such that the semantics in the data is preserved when moved between applications
Open data [38][39]	OD	Data is separated from application, in the sense that data is available in a readable, open and shareable format regardless of vendor or application
Technical openness in the platform [40][41][42]	T1	The types of data, features and functions that are offered through open APIs are defined
	T2	API specifications are published and available
Organizational openness in the platform [2][17][43]	O1	It is clearly defined who has access and what is required to further develop core functionality on the platform
	O2	It is clearly defined who has access and what is required to develop additional functionality (e.g., decision support, apps, analytical tools) on the platform
	O3	It is clearly defined who has access to use data from the platform
	O4	Requirements for compliance with technical standards or payment of license fees - are reasonable and non-discriminatory, that is, they are used uniformly for all potential platform participants
	O5	The hospital IT services have freedom to modify, query and map the information scheme of the platform with no added licensing cost

B. Recruitment to survey and data analysis

We identified nine hospital organizations across five different European countries relevant for the survey. The sample group was identified based on prior work by the researchers [1] and consisted of hospitals using both suite IT systems and systems based on open specifications, comprising systems from five different vendors. All hospitals delivered specialized care and were organized as public providers in socialized healthcare settings.

Participation invitations were sent to high-level managers in the health informatics domain of each hospital organization. From each of the hospitals, we invited one respondent to participate, in total nine individuals were invited. Electronic questionnaires were distributed to the respondents by email, starting on the 16th of June, and closing on 17th of August 2020. Data was exported from Questback into a spreadsheet software (Microsoft Excel for Mac OS, Microsoft 365) and structured for analysis. Analyses were conducted in SPSS (IBM SPSS for Mac OS, version 26.0.0.1). To explore the range and the central tendency in the responses, minimum, maximum, and median scores were calculated [44].

IV. RESULTS

Out of the nine respondents that were invited to participate, four completed the survey within the timeframe, yielding a response rate of 44%. The respondents of the completed surveys were from three different countries (Norway, Denmark, and the United Kingdom), using three different HIT systems. One organization refused participation based on perceived lack of study relevance.

Two had opened the survey but did not complete it. Two did not open the survey. See Table II for results, interpretation, and value distribution.

Overall, calculated median scores from all respondents show a degree of presence between Disagree and Agree for the items relating to vendor neutrality (V1-V3), while the same items have received a rating of Agree to Strongly Agree for importance. All items relating to flexibility in system portfolio (F1-F3) are rated as Agree in terms of presence, and Strongly Agree for importance. Items corresponding to the topic on CIMs (I1-I2) are rated as Agree for presence and Strongly Agree for importance. The one item on Open Data (OD1) is rated Agree for presence, while it was rated Strongly Agree for importance. Both items relating to Technical Openness (T1-T2) received a median value translating to Agree for the presence dimension, and Strongly Agree for importance. Value scores on the item in the category Organizational Openness (O1-O5) varied from Neutral to Agree, with the item describing access to core platform functionality receiving the lowest score. The same items received values translating to Agree and Strongly Agree on importance.

The minimum and maximum results for the presence dimension indicate neither floor effect nor ceiling effect. Further, the results indicate that the principles were present only to a limited degree in existing HIT platforms. Overall, for the importance dimension, all items received median scores translating to Agree (18.75%) and Strongly Agree (81.25%) indicating strong relevance and aptness.

TABLE II. SURVEY RESULTS OVER BOTH DIMENSIONS, SHOWING MEDIAN (MDN) AND MIN-MAX VALUES FOR EACH LIKERT ITEM. LIKERT SCALE INTERPRETATION AND DISTRIBUTION OF VALUES: 1 STRONGLY DISAGREE (1.0-1,49); 2 DISAGREE (1.5-2.49); 3 NEUTRAL (2.5-3.49); 4 AGREE (3.5-4.49); 5 STRONGLY AGREE (4.5-5.0).

Topic	Code	Presence			Importance		
		Mdn	Min	Max	Mdn	Min	Max
Vendor neutrality	V1	3	2	4	5	4	5
	V2	4	3	5	5	4	5
	V3	2	1	4	3.5	3	5
Flexibility in system portfolio	F1	3.5	2	4	4.5	2	5
	F2	3.5	3	4	5	4	5
	F3	3.5	2	4	4.5	4	5
Clinical information models	I1	4	2	5	5	4	5
	I2	4	2	4	5	4	5
Open data	OD1	3	1	5	5	4	5
Technical openness in the platform	T1	4	2	4	4.5	4	5
	T2	4	2	4	4.5	4	5
Organizational openness in the platform	O1	2.5	2	4	4	4	5
	O2	3	1	4	4	4	5
	O3	3.5	3	5	5	4	5
	O4	4	3	5	4.5	4	5
	O5	4	1	5	5	4	5

V. CONCLUSION AND FUTURE WORK

In this paper, we were able to pilot the measuring tool among a small number of domain experts. Even though we consider them highly informed respondents, it is likely that further drivers, challenges, and topics should be considered. While the study was designed to only include a small number of respondents, the survey achieved a response rate comparable to other internet based surveys aimed towards professionals [45]. The respondents in this survey were a convenience sample of mid-to-high level professionals. The results suggested that the measuring tool was able to distinguish between different degrees of open platform presence in the surveyed HIT implementations. The range between minimum and maximum scores indicated that on most items, the respondents had not answered uniformly. Furthermore, the results indicated that the respondents perceived the items as important. The median item scores indicate that the included platforms are positioned far from the end of an openness spectrum. This corresponds well with the actual platform market landscape we can observe; Open Platforms as a HIT approach are still in the early stages, with some immature technological traits and lack of supporting regulations and governance models.

The present study has some clear but intended limitations and should be considered an early proposal on how to move towards operationalization and application of concepts that originates in a highly theoretical field of research. Real-world implementation and use of Open Platforms are complicated at several levels. Our framework for measuring perceptions of openness deliberately excludes topics relating to regulatory aspects and law as these are highly context sensitive and vary greatly. The miniscule sample of respondents rules out the possibility for any meaningful ordinary validation procedure with measurements of internal consistency and factor analyses. However, given the consistent high importance valuation of the items by the respondents, we consider it worthwhile to further investigate the Open Platform concept within this framework. This study resides within a larger research portfolio interested in design and implementation of shared large-scale HIT platforms. Based on the work presented in this study, we have conducted a qualitative study investigating the Open Platform principles in relation to an ongoing national HIT platform project in Norway. The topics and statements used in the framework guided the development of an interview guide, and we were able to investigate how the properties aligned with a HIT project described as an Open Platform. While not yet published, the results indicates that an ambiguous and disparate understanding of the concept of Open Platforms among different stakeholders created misunderstandings and contrasting expectations, and that the proposed HIT platform shared few of the characteristics outlined in our framework, although being described as an "open platform" [23]. While the present study is limited to the perspective of health informatics experts, we widen the scope to also include healthcare professionals and HIT vendors in our related work. The final results from the qualitative study will be used to further develop the framework presented in the present paper, establishing the basis for employing a larger survey and enabling a validation procedure. A validated set of measurable principles can provide important insight and grounds for a common and unambiguous concept understanding for implementors and organizations considering an Open Platform approach in their HIT infrastructure.

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