The present and future of dynamic e-Health interoperability in Switzerland:
Results of an Online questionnaire

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Abstract: The research in the medical health care systems is shifting towards solutions that enable dynamic data exchange. To achieve this shift, interoperable solutions have been proposed by initiatives such as the integrating Healthcare Enterprise (IHE). IHE focuses on defining interoperable solution by specifying recommendations that foster standard based integration between healthcare systems. Using the results of an online questionnaire, in this work we study the current use of standards in the health care systems of Switzerland. The questionnaire identifies four dynamic data exchange scenarios that enhance the interoperability and the integration between different healthcare systems. The novelty of this work is that the identified scenarios are currently not addressed by the IHE recommendations and, they can improve the current interoperability solutions. The questionnaire confirms that those scenarios are useful and we suggest some technical solutions that may help to achieve them.

1 INTRODUCTION

Electronic Health Records (EHRs) are electronic collections of health information about patients (Gunter and Terry, 2005). EHRs are easy to transfer and, if linked to best-practice guidelines, they can support care decisions (Grimson et al., 2000). Many of the current EHR systems operate in a closed environment where patient's EHRs can be dynamically exchanged only within the health organisation that creates them. As the focus of health care delivery shifts from specialist centers to community settings (Kalra, 2006), new approaches are focusing on the integration of such records across the institutional boundaries (Wozak et al., 2008).

The health industry is recognizing the importance of dynamic exchange of EHRs by adopting interoperability standards and by seeking integrations with external platforms. In particular, the Integrating the Healthcare Enterprise (IHE) [1] is an initiative that specifies guidelines on how healthcare providing systems can integrate and communicate more effectively. IHE enjoys high acceptance due to its practical complement to existing standards such as HL7 CDA [2]. The IHE consortium specifies various IHE Integration Profiles which define solutions to specific problems. The Integration Profiles are constantly checked against practical experiences and are continuously adapted (Wozak et al., 2008). Despite this, IHE lacks features to handle dynamic scenarios where caregivers can dynamically connect and exchange data (IHE, 2008), and mechanisms on how patient's data are found and exchanged are yet to be defined.

Using an online questionnaire, this paper discusses the gap between the interoperability standards and what healthcare system solutions are currently missing in order to support the dynamic data exchange. The questionnaire confirms that there is a gap between the use of interoperability standards and the current ability to dynamically connect and share patient data at a cross community level. The participants recognized as very important for health systems to rely on interoperability standards and found useful to have more dynamic scenarios for EHR exchange.

The paper is organized as follows. Section 2 introduces the current standards and semantic dictionaries defined in health care systems. Section 3 discusses

[1] `www.ihe.net`

[2] HL7 CDA is a standard supporting message-based information exchange of medical data `www.hl7.org`

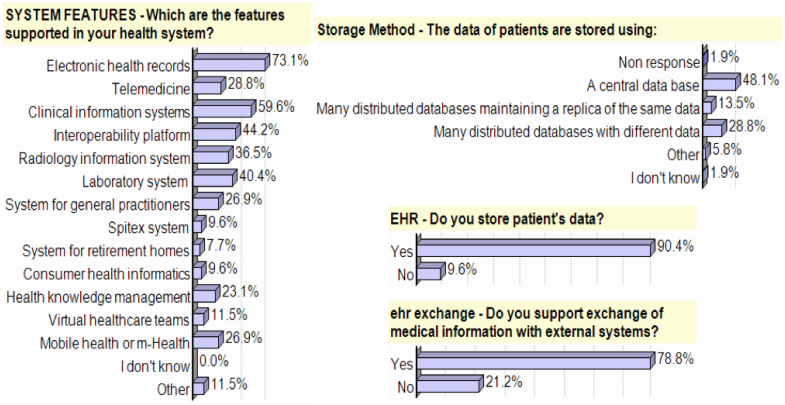

Figure 1: The characteristics of the represented systems.

the focus of the survey, the recruiting of participants and the design of the online questionnaire used for the study. Section 4 illustrates the results of the questionnaire. Section 5 discusses how future technical solutions may drive interoperability in healthcare systems. Finally, Section 6 summarizes this work.

2 SEMANTIC INTEROPERABILITY

Semantic interoperability in a medical context means that medical data are exchanged and processed in distributed systems by unambiguously sharing the meaning of the document content (Reinhold et al., 2011). Standard models for EHR exchange play a fundamental role for achieving semantic interoperability. Among the standardisations efforts, the most adopted nowadays have become HL7 (Dolin et al., 2001) and OpenEHR (Garde et al., 2007), for structuring the health data, IHE for defining the architectural aspects of EHR exchange, and SNOMED CT (Stearns et al., 2001), LOINC (McDonald et al., 2003) and MEDICINE (Goltra, 1997) as code based systems for the medical terminology.

HL7 is a standard supporting message-based exchange of medical data. The most adopted HL7 standard is the HL7-Clinical Document Architecture (HL7-CDA). HL7-CDA specifies the syntax and supplies a framework for specifying the full semantics of a clinical document. The focus of HL7 is in the message exchange and not in the organization of the EHR, thus this standard alone is not enough to achieve interoperability. OpenEHR is standard that describes the management, storage, retrieval and exchange of EHR. Like HL7, OpenEHR proposes a set of models for clinical data with the difference that the reference model is based on building blocks and its underlying modeling style is strictly object oriented, thus, solving several limitations of the message based exchange model proposed by HL7-CDA. Healthcare terminologies such as SNOMED CT, LOINC and MEDICINE define universal code names and identifiers to medical terminology. Their purpose is to associate codes to medical terminology so that, if everyone was to share them, it would be possible to share and automatically understand the health data, such as the one exchanged in HL7 messages.

The IHE Integration profiles are becoming the glue to these standardization efforts. They complement these standards with concrete recommendations on how to achieve interoperability in terms of how to construct the messages that enable data to be exchanged and what are the actors that involved in these interactions. There are many IHE profiles that address interoperability between health care systems. We focus on the ones that propose solutions for EHR exchange (denoted as XC*), namely Cross-Enterprise Document Sharing (XDS), Cross-Community Access (XCA), Cross-Community Patient Discovery (XCPD) and Cross-Community Fetch (XCF).

The XDS (IHE, 2011) profile defines how health enterprises can inter-operate to share patient-relevant documents by working as one health community with the same set of policies, patient identifications and security mechanisms. Since XDS does not resolve document sharing among multiple communities, the XCA profile specifies how medical data held by other communities can be queried and retrieved. XCA assumes that communities have pre-established agreements, knowledge of one another and have ways to know the correct patient identifiers in different communities (IHE, 2008). XCPD locates communities which hold patient's relevant health data and translates patient's identifiers across communities. XCPD does not automate the discovery of communities and it still requires communities to have pre-established agreements for exchanging the documents. Finally

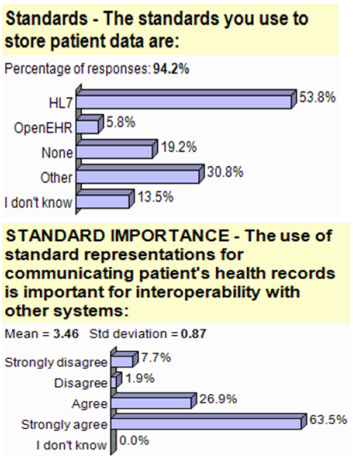

Figure 2: Standard's use and importance.

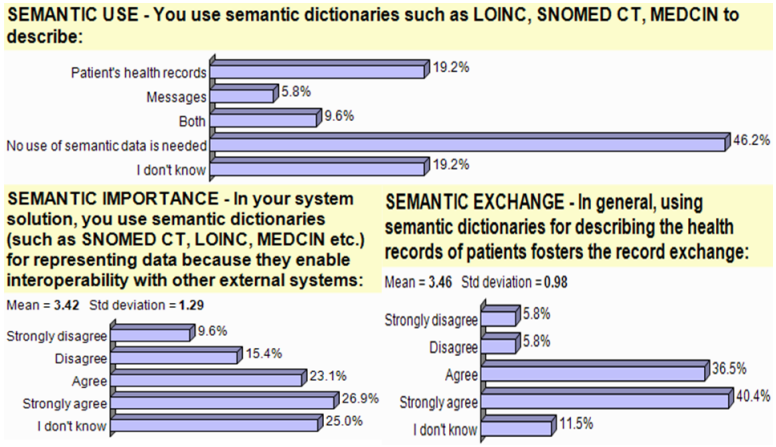

Figure 3: The use and importance of semantic dictionaries in EHR exchange.

XCF defines a single transaction to retrieve a small number of documents (ideally one). XCF requires document properties to be known prior to the document retrieval. Other IHE profiles support cross-community data exchange by providing: security (Audit Trial and Node Authentication); privacy (Basic Patient Privacy Concent); mapping of user identifications (Cross-Enterprise User Assertion); point-to-point e-mail notification of updates (Notification of Document Availability); and a consistent time (Consistent Time). Not all of these profiles are mandatory to integrate in the healthcare systems that support cross-community document exchange, however they provide important technical solutions for secure interoperability at a cross-community level.

3 METHOD

Our study focuses on the use of interoperability solutions in Switzerland. The health system in Switzerland is a combination of public (i.e. hospitals) and private systems (i.e. private clinics) and health conditions can be treated in any of the competent healthcare providers. The Swiss Government has recently recommended the adoption of IHE profiles to achieve interoperability. The first pilot deployments have been released, such as the eToile project (Geissbuhler et al., 2004) in Geneva and Infomed (Michelet et al., 2011) in Valais. The objective of the questionnaire was to find out the current state and the future directions with regards to the dynamic EHR exchange.

The survey was based on an online questionnaire which was sent to the Swiss eHealth summit [3], a leading event for ICT in medicine and healthcare for Switzerland, with around 200 experts interested in ways technology can improve medicine and healthcare in general. Fifty two participants took part on the survey. The majority of the participants (28.8%) were holding an IT role, followed by 15.4% and 13.5% respectively holding Chief Technology Officer, or Chief Executive Officer roles. These roles are very important for our questionnaire as they can best answer the technical and strategical aspects of the represented systems. It also suggests to us that we met our target audience for having relevant results within the scope of the questionnaire. We asked the participants about their represented system, the use of standards and how interoperable their systems is. Figure 1 summarizes the features of the systems represented by the participants. The majority were systems dealing with EHR and with clinical information (73.1% and 59.6% respectively). Also, 44.2% of the participants said that their represented system solution provides a solution to interoprerability. Storage of EHR accounted for 90.4% with 78.2% also supporting EHR exchange. The storage of EHR was mostly done within a central database (49%). The results described in Section 4 are based on what the participant said about these types of systems.

In order to specify future directions in terms of healthcare interoperability, we defined four scenarios that were drawn from an analysis of the state of the art, with specific focus into what is currently missing in the IHE interoperability solutions. The scenarios were described as follows:

- Scenario 1: A patient is treated in the hospital A, rather than the hospital B of its residence area. The system of hospital A can find the patient's data in the system of hospital B without prior integration between the two.
- Scenario 2: A patient is treated in the hospital A, rather than the hospital B of its residence area. Hospital A creates new health records on the pa-

[3] http://www.ehealthsummit.ch/

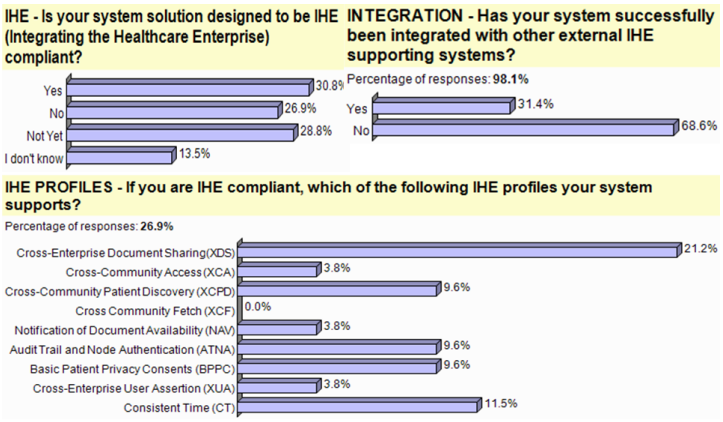

Figure 4: The use of IHE Interoperability Standards.

tient. The Hospital A, upon patient's consent, automatically updates the system B about these records.

- Scenario 3: A patient is treated in the hospital A. This patient has chosen that all the updates concerning his health should be sent to hospital B. The Hospital B collects all the updates on the health of its patients.
- Scenario 4: A Hospital B receives health updates on one of its patients. This patient has agreed that his general doctor should receive these updates as well. Hospital B, upon patient's consent, automatically propagates updates on patients to subscribing clinics.

4 RESULTS

4.1 Interoperability in Swiss Healthcare Systems

We asked what are the general trends towards interoperability? We focused on three factors that combined are known to foster integration within heterogenous health platforms, namely the use of standards, the use of semantic dictionaries and the use of IHE profiles for standard system architectures. We were interested to know the acceptance level of the existing standards. For this reason, we asked what standards were used to store patient data. Figure 2 shows that 63.5% agreed that standards are important for interoperability with other systems and, the most used standard for storing patient related data was HL7 (53.8%). The use of HL7 standard is highly recommended in the current IHE profiles. The result shows that the adoption of IHE interoperability solutions is possible.

In order to measure the extend to which semantic dictionaries are used in today's Swiss healthcare settings we asked the participants if, in their represented systems: i) semantic dictionaries were used to describe data, ii) if the reason for their use was to enable interoperability and iii) if the participants believed that using the semantic dictionaries fosters record exchange. Figure 3 shows the results to these three questions. The majority of the participants (46.2%) did not recognize the use of semantic data to be needed in describing patient health records or messages. This may be due to the fact that most of the data exchanged with external systems still requires human intervention and automated data exchange has a long way to go. The 26.9% and 23.1% of users did respectively strongly agreed and agreed that the use of semantic dictionaries in their system was made to enable interoperability with external systems. Additionally, 40.4% and 36.5% respectively strongly agreed or agreed that semantic dictionaries, if used to describe EHRs, foster their exchange.

In order to find out to what level the existing IHE interoperability solutions are integrated in the current health care systems, we asked if the represented systems were IHE compliant. Participants were given the possibility to express interest in using IHE in the future by answering "Not Yet". We considered that the IHE adoption is quite new with respect to the digitalization of the EHR and that these systems may, in the future, adapt to interoperate with other healthcare systems. We also asked what specific IHE profiles were supported and if they had been integrated with other external IHE compliant systems. Figure 4 summarizes the results which show that i) the use of IHE accounted for 30.8%, however, another 28.8% indicated an intention of using them, ii) In Switzerland, the IHE profiles that support EHR exchange are being adopted. XDS is the most used (21.2%) because it supports document exchange at the health organization level. iii) 30.8% of the participants said that there had been successful integration(s) with other external IHE supporting system(s).

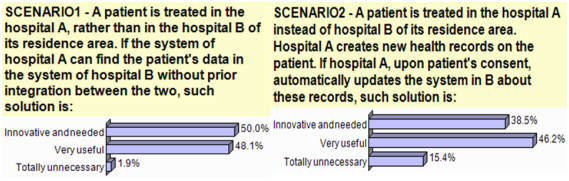

Figure 5: The results for Scenario 1 and 2.

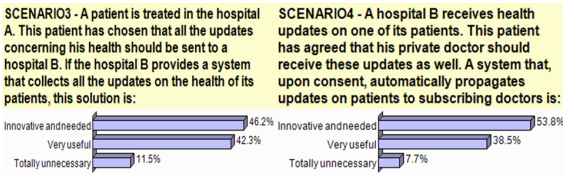

Figure 6: The results for Scenario 3 and 4.

4.2 Future Interoperability Scenarios

In order to find out what are the trends with respect to interoperability solutions in health care systems, we asked the participants to determine if the scenarios presented in Section 3 were innovative, very useful or unnecessary. Only one response was possible. A distinction between innovative and useful was done in order to determine if the scenarios were novel for the participants as opposed to a useful feature which already may exist in some systems. Figure 5 and 6 show that all the scenarios are well received with an average of 84.7-98.1% of participants finding the four scenarios either innovative or very useful. The first scenario was the most important feature with 50% finding the scenario innovative, 48.1% very useful and 1.9% finding it as unnecessary. This result confirms that being able to dynamically view data of patients held in other healthcare settings is very beneficial.

5 DISCUSSION

The results of the questionnaire show that there is a need to exchange data in more dynamic settings. The realization of the four proposed scenarios requires health communities to adopt standard approaches and enable solutions for sharing their EHR in open and dynamic settings. Some attempts in this direction have already been done. The epSOS project provides cross-border health-services to patients seeking healthcare in different countries from their own. In Switzerland, e-Toile project proposes an universal information exchange service for e-Health that covers a geographic area (Geneva). SemHealthCoord project defines an architecture that enhances the current IHE profiles with more dynamic EHR exchange solution (Urovi et al., 2013). Presenting these works is out of the scope of this paper, but it suffices to say that all of those recent works rely on IHE profiles for the data exchange. It is also worth noting that, for the achievement of the four scenarios, ethical, legal and security aspects must be investigated as much as the challenges of the technical solution.

From a technical viewpoint, in addition to providing integration through use of standards, the results suggest two key components that are important for designing interoperable healthcare system solutions: (a) dynamicity and (b) scalability. A dynamic solution supports EHR exchange with functions for finding EHRs of patients independently from the system that creates and stores them while a scalable solution is needed to optimize the time and effort to find and exchange EHRs. A dynamic model for EHR exchange requires solutions that address the semantic interoperability between heterogeneous healthcare systems. By providing semantic descriptions of the data held in other health oganisations, it is possible to facilitate the interpretation and sharing of the health data (Hendler, 2001). The semantic interoperability enables local processing of the shared data; and it is also a prerequisite for intelligent decision support and care planning (Schloeffel et al., 2006). In this context, the agent technology brings advantages to interoperability of the health care solutions such as high adaptability in front of changes, distributed management of sources and remote access to patient data (Isern et al., 2010). In fact, agent-based systems can perform distributed communication and reason with semantic knowledge, thus enabling EHR sharing between such heterogeneous systems. Finally, to support the dynamics of the scenarios here defined, common coordination models are needed in order to decouple the interactions within different health organizations (Urovi et al., 2013).

Scalability on a dynamic network of health communities can be achieved by overlaying a Peer to Peer (P2P) network (Androutsellis-Theotokis and Spinellis, 2004) to link the heterogeneous health organisation's systems as peers (Kilic et al., 2010). The P2P allows communities to interact on top of existing network configurations without a central dependency. With the right P2P network configurations, the time to answer queries can be logarithmic with a growing number of peers (Androutsellis-Theotokis and Spinellis, 2004). The use of P2P technology in health care settings is a novel concept (Guo et al., 2011) and it requires security and privacy considerations. There are many factors to consider, from sharing confidential information in a secure manner, to guaranteeing the proper use of the EHRs. All these aspects require the security to be focal point to the design of such solutions because it will determine if these frameworks will, in the future, have a practical value.

6 CONCLUSIONS

We presented a study of the current situation and of the future directions in dynamic interoperable solutions for healthcare systems. We focused on the results of an online questionnaire collected from the participants of the Swiss eHealth summit. The results showed a general trend towards the use of IHE and HL7 which is a good indicator of solutions that can support integration with other systems. The results also suggested that the future interoperability will require more dynamic and open solutions towards record exchange. Finally we discussed some technical solutions that can make the difference towards supporting these future scenarios. As part of our future work, we plan to further investigate the implications of the four proposed scenarios. The technical solution is only one aspect of realising these scenarios. We plan to study what are the practical, legal and ethical aspects that may prevent institutions to go towards more dynamic settings and how to overcome them. Including issues of depersonalization and minimization of data and the way these can be integrated in cross-institutional IHE settings.

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REFERENCES

Androutsellis-Theotokis, S. and Spinellis, D. (2004). A survey of Peer-to-Peer content distribution technologies. *ACM Comput. Surv.*, 36(4):335–371.

Dolin, R. H., Alschuler, L., Beebe, C., Biron, P. V., Boyer, S. L., Essin, D., Kimber, E., Lincoln, T., and Mattison, J. E. (2001). The HL7 Clinical Document Architecture. *Journal of the American Medical Informatics Association*, 8(6):552–569.

Garde, S., Knaup, P., Hovenga, E., and Heard, S. (2007). Towards semantic interoperability for electronic health records–domain knowledge governance for open ehr archetypes. *Methods of information in medicine*, 46(3):332–343.

Geissbuhler, A., Spahni, S., Assimacopoulos, A., Raetzo, M., and Gobet, G. (2004). Design of a patient-centered, multi-institutional healthcare information network using Peer-to-Peer communication in a highly distributed architecture. *Medinfo*, 11(Pt 2):1048–52.

Goltra, P. S. (1997). *MEDCIN: a new nomenclature for clinical medicine*. Springer.

Grimson, J., Grimson, W., and Hasselbring, W. (2000). The SI challenge in health care. *Commun. ACM*, 43:48–55.

Gunter, D. T. and Terry, P. N. (2005). The emergence of national electronic health record architectures in the united states and australia: Models, costs, and questions. *J Med Internet Res*, 7(1):e3.

Guo, Y., Hu, Y., Afzal, J., and Bai, G. (2011). Using P2P technology to achieve eHealth interoperability. In *Service Systems and Service Management (ICSSSM)*, pages 1 –5.

Hendler, J. (2001). Agents and the Semantic Web. *IEEE Intelligent Systems*, 16:30–37.

IHE (2008). White paper: Cross community information exchange. `http://www.ihe.net/Technical_Framework/upload/IHE_ITI_TF_White_Paper_Cross_Community_2008-11-07.pdf`.

IHE (2011). Technical framework integration profiles vol 1. `http://www.ihe.net`.

Isern, D., Snchez, D., and Moreno, A. (2010). Agents applied in health care: A review. *International Journal of Medical Informatics*, 79(3):145 – 166.

Kalra, D. (2006). Electronic health record standards. volume 45, pages 136–144. Methods Inf Med.

Kilic, O., Dogac, A., and Eichelberg, M. (2010). Providing interoperability of ehealth communities through peer-to-peer networks. *Information Technology in Biomedicine, IEEE Transactions on*, 14(3):846–853.

McDonald, C. J., Huff, S. M., Suico, J. G., Hill, G., Leavelle, D., Aller, R., Forrey, A., Mercer, K., DeMoor, G., Hook, J., et al. (2003). LOINC, a universal standard for identifying laboratory observations: a 5-year update. *Clinical chemistry*, 49(4):624–633.

Michelet, C., Fragnire, F., and Gnaegi, A. (2011). Infomed, dossier patient partag en Valais. *Journal of Swiss Medical Informatics*, 72.

Reinhold, S., Henning, M., Dominik, A., and Patrick, R. (2011). e-Heallth Semantic And Content For Switzerland.

Schloeffel, P., Beale, T., Hayworth, G., Heard, S., and Leslie, H. (2006). The relationship between cen 13606, hl7, and openehr. *HIC and HINZ Proceedings*, 24.

Stearns, M. Q., Price, C., Spackman, K. A., and Wang, A. Y. (2001). SNOMED clinical terms: overview of the development process and project status. In *Proceedings of the AMIA Symposium*, page 662. American Medical Informatics Association.

Urovi, V., Olivieri, A., Bromuri, S., Fornara, N., and Schumacher, M. (2013). A P2P Agent Coordination Framework for IHE based Cross-Community Health Record Exchange. In *ACM 28th Symposioum on Applied Computing*, page to appear.

Wozak, F., Ammenwerth, E., Hoerbst, A., Soegner, P., Mair, R., and Schabetsberger, T. (2008). IHE based Interoperability - Benefits and Challenges. volume 136 of *Studies in Health Technology and Informatics*, pages 771–776. IOS Press.