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COMPARATIVE OVERVIEW OF INTEROPERABILITY IN DISTRIBUTED MEDICAL SYSTEMS THROUGH DATA EXCHANGE STANDARDS IN MACEDONIA, USA AND AUSTRAILA REGARDING HEALTH PROVIDERS AND INSURANCE AGENCIES

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Abstract

Distributed medical systems play a crucial role in modern healthcare by enabling seamless access to patient data across various healthcare facilities. However, interoperability challenges often hinder the efficient exchange of medical information between disparate systems. Health Level Seven (HL7) standards have emerged as a cornerstone for facilitating data exchange in healthcare settings. This paper explores the significance of HL7 standards in improving interoperability within distributed medical systems. It discusses the key components of HL7 standards, their role in enhancing data exchange, and their impact on improving patient care. Furthermore, the paper addresses challenges associated with implementing HL7 standards in different countries like Australia, USA and Macedonia. Also, we discuss integration involvement of health insurance, and propose strategies for the best model.

Keywords: Practice Management System, HL7, interoperability, Health Care Systems, Electronic Medical Record

JEL classification: I13, I18

INTRODUCTION

The rapid advancement of healthcare technologies and the increasing complexity of healthcare delivery systems necessitate efficient and reliable methods for managing and exchanging medical information. Distributed medical systems, which involve multiple interconnected healthcare applications and devices, play a crucial role in modern healthcare environments. These systems enable the seamless sharing of patient data across various healthcare settings, including hospitals, clinics, laboratories, and even patients' homes.

The core challenge in implementing distributed medical systems lies in achieving interoperability among diverse healthcare applications. Interoperability ensures that different systems can communicate effectively, share data accurately, and use the exchanged information meaningfully. This is where data exchange standards become

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indispensable. Data exchange standards provide a common framework and language for representing, transmitting, and interpreting healthcare information. By adhering to these standards, disparate systems can integrate more smoothly, leading to improved patient care, enhanced clinical decision-making, and streamlined healthcare operations.

However, interoperability challenges often hinder the efficient exchange of medical information between disparate systems. Several health standards have emerged as a cornerstone for facilitating data exchange in healthcare settings.

This paper provides an overview of distributed medical systems through the lens of data exchange standards. Explores the significance of HL7 standards (Dolin et al., 2001) in improving interoperability within distributed medical systems. It discusses the key components of HL7 standards, their role in enhancing data exchange, and their impact on improving patient care. Furthermore, the paper addresses challenges associated with implementing HL7 standards in different countries like Australia, USA and Macedonia. Also, we discuss integration involvement of health insurance, and propose strategies for the best model.

The paper is organized as follows. Section 1 reviews the known interoperability standards and frameworks. Section 2 discusses the current implementations of medical health care software and the medical data exchange. Section 3 addresses the health insurance agencies take on interoperability. Section 4 concludes.

1. INTEROPERABILITY STANDARDS

Medical interoperability standards are essential for ensuring that different healthcare systems and applications can work together seamlessly, enabling the secure and efficient exchange of health information. There are several frameworks that are now standardized.

The most used is HL7 (Health Level Seven International) which is a set of standards that state the exchange, integration, sharing, and retrieval of electronic health information. These standards are developed by HL7 International, a not-for-profit, ANSI-accredited standards developing organization. HL7 v2 (Rajeev et al., 2010) is one of the oldest and most widely used, which focuses on the exchange of clinical data. It's very flexible but can be complex to implement. HL7 v3 (Goossen and Laura, 2014) is more robust and structured version of HL7, using an XML-based messaging standard. However, it was less adopted compared to HL7 v2. The last iteration of HL7 is HL7 FHIR (Fast Healthcare Interoperability Resources) (Bender and Kamran, 2013). This is a modern standard designed for the web. Uses REST APIs and supports JSON, XML, and RDF data formats, making it easier to implement and more suited to modern web technologies.

Another standard is DICOM (Musta, Delac and Grgic, 2008) (Digital Imaging and Communications in Medicine) which is used for handling, storing, printing, and transmitting information in medical imaging. It ensures that medical imaging devices and systems can exchange information reliably.

LOINC (Logical Observation Identifiers Names and Codes) is a standard for identifying medical laboratory observations (McDonald et al., 2003). It enables the exchange and aggregation of clinical results for care delivery, research, and management.

SNOMED CT (Systematized Nomenclature of Medicine – Clinical Terms) is a comprehensive, multilingual healthcare terminology that provides codes, terms, synonyms, and definitions used in clinical documentation and reporting (Lee et al., 2014).

ICD (International Classification of Diseases) represents a standard for reporting diseases and health conditions (Harrison et al., 2021). ICD codes are used for epidemiology, health management, and clinical purposes.

CDA (Clinical Document Architecture) is HL7 standard that specifies the structure and semantics of clinical documents for the purpose of exchange (Müller et al., 2005). It allows documents to be exchanged in a way that preserves the meaning and context of the information.

IHE (Integrating the Healthcare Enterprise) is a framework that promotes the coordinated use of established standards such as DICOM and HL7 to address specific clinical needs and improve the interoperability of health information systems (Bergh et al., 2015).

XDS (Cross-Enterprise Document Sharing) is part of the IHE initiative (Noumeir and Renaud. 2010). XDS enables the sharing of clinical documents across health enterprises, facilitating a longitudinal patient record.

2. CURRENT IMPLEMENTATIONS

This section provides an overview of medical data exchange between health organizations in 3 countries: Australia, USA and Macedonia.

There are 3 major software products that provide Practice Management System (PMS) services in Australia: Best Practice, Medical Director and Genie which are majorly using by health organizations (Healy, Sharman and Lokuge, 2006). Regarding PMS activity flow, earlier version of these products allows for generation of HL7 messages in a text file format which suitable for exchange. However, since 2023, the PMS venders stopped generation of HL7 and implemented apis for exchange between health organizations. In doing so, the introduced apis are available commercially pricing each transaction.

In United States of America there is one major vendor EPIC (Johnson, 2016) for PMS services that covers up to 47% of the PMS market share. While it offers numerous benefits, including improved patient care and streamlined workflows, EPIC presents challenges related to cost and complexity. Thus, proper planning and training are essential for successful implementation and utilization of the system. Regarding interoperability Epic Systems provides a robust framework for integrating with other healthcare systems and third-party applications by utilizing interconnects like web apis, bridges for HL7 messaging, custom relation database Clarity (Sholle et al., 2017) or custom data warehouse Caboodle (Biering-Sørensen et al.) and App Orchard approach

which is a developer program and app marketplace that provides access to APIs, technical documentation, and resources for developing and integrating applications with EPIC (Scalia et al., 2021).

There are third parties products that can facilitate integration to EPIC like redox. This platform provides healthcare integration that simplifies the process of connecting different healthcare systems like Epic, with other healthcare applications. Redox acts as a middleware that standardizes and facilitates data exchange, enabling seamless interoperability across various healthcare technologies.

Additionally, there is another approach for integration by utilizing a product called Iguana by Interfaceware (Ludwig and Jenq, 2013). Iguana is an integration engine designed to facilitate the exchange of healthcare data between different systems and applications. It provides tools to simplify the process of connecting various healthcare systems, ensuring seamless data flow and interoperability. Iguana supports a wide range of healthcare standards and protocols, making it a versatile solution for healthcare data integration by supporting multiple standards like HL7, FHIR, X12, DICOM making it compatible with a broad spectrum of healthcare applications. There is user-friendly graphical interface for designing integration workflows, as well as scripting using Lua. Additionally, Iguana offers real-time data processing and transformation, ensuring that information is promptly and accurately exchanged between systems.

The last approach for integration with EPIC can be achieved by implementing RPA (Robotic Process Automation) service (Aguirre and Rodriguez, 2017). In case of graphical access to EPIC, a bot can be trained to recognize forms and data for the user interface and push that data to a different health care system.

There are many pros and cons regarding choosing the right approach for interoperability with EPIC. The direct approach with EPIC involves a development effort and it carries fixed charges for data transfers. Third-party middleware like redox or Iguana require less development effort, however the IP (Intellectual Property) is tied to a third-party company, thus slightly more cost than the direct approach, however implementation is quite fast. The last RPA approach requires training of the bot and issues with reliability. There is always a charge for retraining the bot, since the EPIC UI constantly changes.

In the Republic of Macedonia, the primary electronic health record (EHR) system used is the Pinga platform (Winkelmann et al., 2021). Pinga was initially deployed in Macedonia to serve as a national booking platform and EHR, and it has since expanded to encompass various elements of a comprehensive public health solution. The platform supports functionalities like inpatient and outpatient management, financial management, and public portal management, providing a holistic approach to healthcare management. It is designed to be customizable and integrates seamlessly with other healthcare applications through comprehensive APIs Macedonia. This service allows scheduling health-related appointments online. It provides information about available appointment slots and details about healthcare institutions. MojTermin (Slawomirski et al., 2021) impact has significantly improved scheduling and waiting times for clinical appointments and diagnostic tests. The Macedonian Ministry of Health, based on Moj

Termin launched an e-Health platform which integrates several healthcare providers (UNICEF, 2023). Though there is some HL7 support the integration is mainly via REST apis.

3. HEALTH INSURANCE AGENCIES

In Macedonia, the health system operates with a compulsory insurance-based approach, providing near-universal coverage. There is a national mandatory health insurance fund which is applicable to all Macedonian citizens by access to essential health services. These services are automatically authorized if the patient documents are valid, and the patient procedure can be immediately billed to the health insurance fund and the patient with a symbolic participation in the total invoice.

Additionally, there are Voluntary Health Insurance companies. Macedonians are using this when mandatory health insurance is not applicable since it provides additional coverage beyond the mandatory system. However, the invoice is paid by the patient first and reimbursed only if the procedure is authorized by a Private Insurance Agency in case of emergency. The invoice is paid by the Private Insurance Agency directly to the health provider only if the procedure is authorized before the performing of the procedure. In this flow, there are no ICT systems that facilitate this flow of information, and the whole paperwork is manually done. Additionally, for cases when authorization on a procedure is not issued there is a national law that regulates the legal conduct (Miseva and Ampovska, 2017).

The Macedonian Insurance Supervision Agency which is another insurance oversight in Republic of Macedonia reports that since March 2022 over 180,000 patients invested in private insurance (Macedonian Insurance Supervision Agency, 2022).

CONCLUSION, IMPLICATIONS AND LIMITATIONS

It is apparent that in Australia there are possible integration approaches between health organizations. However, these approaches are controlled by the PMS vendor, thus further development in integration is driven by profit and not the wellbeing of the patients.

In the USA the conduct between participants in the health industry is heavily regulated. There are different laws that apply to different states in the country. Nevertheless, there is no national approach for central medical data exchange, and the integration is driven by PMS vendors like Epic or interface providers like Iguana.

In Macedonia, there is a central national web service that facilitates medical data exchange. However, this only applies for governmental activities like disease registers, National Helth procedures that are covered by.

REFERENCES

Dolin, Robert H., Liora Alschuler, Calvin Beebe, Paul V. Biron, Sandra Lee Boyer, Daniel Essin, Elliot Kimber, Tom Lincoln, and John E. Mattison. "The HL7 clinical

document architecture." Journal of the American Medical Informatics Association 8, no. 6 (2001): 552-569.

Rajeev, Deepthi, Catherine J. Staes, R. Scott Evans, Susan Mottice, Robert Rolfs, Matthew H. Samore, Jon Whitney, Richard Kurzban, and Stanley M. Huff. "Development of an electronic public health case report using HL7 v2. 5 to meet public health needs." Journal of the American Medical Informatics Association 17, no. 1 (2010): 34-41.

Goossen, William, and Laura Heermann Langford. "Exchanging care records using HL7 V3 care provision messages." Journal of the American Medical Informatics Association 21, no. e2 (2014): e363-e368.

Bender, Duane, and Kamran Sartipi. "HL7 FHIR: An Agile and RESTful approach to healthcare information exchange." In Proceedings of the 26th IEEE international symposium on computer-based medical systems, pp. 326-331. IEEE, 2013.

Mustra, Mario, Kresimir Delac, and Mislav Grgic. "Overview of the DICOM standard." In 2008 50th International Symposium ELMAR, vol. 1, pp. 39-44. IEEE, 2008.

McDonald, Clement J., Stanley M. Huff, Jeffrey G. Suico, Gilbert Hill, Dennis Leavelle, Raymond Aller, Arden Forrey et al. "LOINC, a universal standard for identifying laboratory observations: a 5-year update." Clinical chemistry 49, no. 4 (2003): 624-633.

Lee, Dennis, Nicolette de Keizer, Francis Lau, and Ronald Cornet. "Literature review of SNOMED CT use." Journal of the American Medical Informatics Association 21, no. e1 (2014): e11-e19.

Harrison, James E., Stefanie Weber, Robert Jakob, and Christopher G. Chute. "ICD-11: an international classification of diseases for the twenty-first century." BMC medical informatics and decision making 21 (2021): 1-10.

Müller, Marcel Lucas, Frank Ückert, Thomas Bürkle, and Hans-Ulrich Prokosch. "Cross-institutional data exchange using the clinical document architecture (CDA)." International journal of medical informatics 74, no. 2-4 (2005): 245-256.

Bergh, B., A. Brandner, J. Heiß, U. Kutscha, A. Merzweiler, R. Pahontu, B. Schreiweis, N. Yüksekogul, T. Bronsch, and O. Heinze. "The role of Integrating the Healthcare Enterprise (IHE) in telemedicine." Bundesgesundheitsblatt-Gesundheitsforschung-Gesundheitsschutz 58 (2015): 1086-1093.

Noumeir, Rita, and Bérubé Renaud. "IHE cross-enterprise document sharing for imaging: interoperability testing software." Source code for biology and medicine 5 (2010): 1-15.

Healy, Judith, Evelyn Sharman, Buddhima Lokuge, and World Health Organization. "Australia: Health system review." (2006)

Johnson, Ralph J. "A comprehensive review of an electronic health record system soon to assume market ascendancy: EPIC." J Healthc Commun 1, no. 4 (2016): 36.

Sholle, Evan T., Joseph Kabariti, Stephen B. Johnson, John P. Leonard, Jyotishman Pathak, Vinay I. Varughese, Curtis L. Cole, and Thomas R. Campion Jr. "Secondary use of patients' electronic records (SUPER): an approach for meeting specific data

needs of clinical and translational researchers." In AMIA Annual Symposium Proceedings, vol. 2017, p. 1581. American Medical Informatics Association, 2017.

Biering-Sørensen, Fin, Stacey Cohen, Gianna Maria Rodriguez, Kelly Tausk, and Josh Martin. "Electronic medical record: data collection and reporting for spinal cord injury." Spinal cord series and cases 4, no. 1 (2018): 70.

Scalia, Peter, Farhan Ahmad, Danielle Schubbe, Rachel Forcino, Marie-Anne Durand, Paul James Barr, and Glyn Elwyn. "Integrating option grid patient decision aids in the epic electronic health record: case study at 5 health systems." Journal of Medical Internet Research 23, no. 5 (2021): e22766.

Ludwig, Jeffrey, and John Jenq. "nMapi A .NET HL7 Data Mapping Application." In 17th World Multi-Conference on Systemics, Cybernetics and Informatics, WMSCI 2013, pp. 130-134. 2013.

Aguirre, Santiago, and Alejandro Rodriguez. "Automation of a business process using robotic process automation (RPA): A case study." In Applied Computer Sciences in Engineering: 4th Workshop on Engineering Applications, WEA 2017, Cartagena, Colombia, September 27-29, 2017, Proceedings 4, pp. 65-71. Springer International Publishing, 2017.

Winkelmann, Juliane, Florian Tille, Yulia Litvinova, and Bernd Rechel. "Health Systems in Action: North Macedonia." (2021).

Slawomirski, Luke, Luca Lindner, Katherine de Bienassis, Philip Haywood, Tiago Cravo Oliveira Hashiguchi, Melanie Steentjes, and Jillian Oderkirk. "Progress on implementing and using electronic health record systems: Developments in OECD countries as of 2021." (2023).

UNICEF. "First web platform with information on health services and routine childhood immunization in one place." (2023).