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Review Article

IHE XDS-Based HIE Infrastructure Performance and Data Exchange Metrics

Hamster A, Klautke U

Founda Health BV, Netherlands

Abstract

This paper presents four Key Performance Indicators (KPIs) designed as crucial metrics for assessing the effectiveness and influence of IHE [1] Cross-enterprise Document Sharing (XDS) based Health Information Exchange (HIE) infrastructures, with a focus on supporting collaborative healthcare and care coordination use-cases. The identified KPIs center around registered document volumes (70 million), exchanged DICOM studies (91.000/month), exchanged documents (525.000/month), and the count of registered patients (21 million). Through a comprehensive analysis of these KPIs, the study draws insights from an IHE XDS-based health information exchange in the Netherlands, encompassing data from 27 healthcare institutions utilizing the Dutch XDS Cloud service. The findings contribute valuable insights that extend beyond the specific context, providing applicable knowledge to the broader landscape of XDS-based health information exchanges. The KPIs identified in this paper show evidence that the Dutch XDS Cloud Service successfully supports care coordination and patient referrals use-cases in the Netherlands.

Introduction

In the ever-evolving realm of healthcare, streamlined data exchange stands as a linchpin, vital for ensuring optimal patient care and nurturing collaboration across varied healthcare institutions. Within this dynamic landscape, the Dutch XDS Cloud infrastructure has emerged as a pivotal player, serving as a cornerstone in facilitating secure, reliable, and compliant information sharing. Rooted in the Integrating the Healthcare Enterprise (IHE) framework, this infrastructure adheres to standardized protocols, enhancing interoperability and seamless data transmission.

To comprehensively assess the efficacy and pertinence of real-world health information exchange scenarios, this paper undertakes an exploration of four Key Performance Indicators (KPIs). Aligned with IHE principles, these KPIs delve into the infrastructure's performance and impact, providing valuable insights into its ability to support collaborative healthcare and care coordination initiatives. The selected KPIs focus on essential aspects, including registered document volumes, exchanged DICOM studies, exchanged documents, and the number of registered patients, each reflecting the multifaceted dynamics of health information exchange.

This paper aims to contribute not only to the understanding of the Dutch XDS Cloud infrastructure but also to the broader adoption of IHE XDS-based health information exchanges for use-cases beyond (traditional) patient referral and care coordination processes. The adoption of IHE standards aims to ensure a more harmonized approach to interoperability, compliance, and data security, thereby fostering a more robust and universally applicable framework for health information exchange initiatives globally.

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***Corresponding author:** Andries Hamster, Founda Health BV, Netherlands, Tel: +31655823289

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The following four key performance indicators are defined.

Registered Document Volumes (KPI 1)

Gaining insight into the quantity and variety of XDS documents within an IHE XDS-based Health Information Exchange (HIE) is pivotal for assessing its practical value in real-world care coordination scenarios. This KPI classifies documents into distinct types, encompassing DICOM Studies, Patient Consent, Medical Documents, Lab Results, and Workflow Documents. By doing so, it provides valuable insights into the diverse spectrum of clinical information actively shared within the system

Total Number of Exchanged DICOM Studies (KPI 2): This KPI assesses the volume of DICOM

Studies exchanged across healthcare institutions within an IHE XDS-based HIE. It distinguishes between outbound (provide) and inbound (retrieve) exchanges, providing a nuanced understanding of the collaborative nature of diagnostic imaging data sharing within an health information exchange network.

Total Number of Exchanged Documents (KPI 3)

Focusing on the exchange of medical and clinical documents excluding DICOM Studies, this KPI offers insights into the broader data-sharing landscape. It distinguishes between outbound and inbound actions, providing a holistic view of (clinical) document exchange dynamics.

Number of Registered Patients (KPI 4)

Patient registration is a fundamental aspect of healthcare data management. This KPI reveals the total number of unique patients registered at each institution, offering insights into the reach and potential impact of an IHE XDS-based HIE.

The relevance of these KPIs lies in their ability to gauge the efficiency, interoperability, and collaborative potential of an IHE XDS-based HIE as they relate to the potential use (KPI 1 and KPI 2), and actual usage (KPI 3 and KPI 4). Furthermore, understanding document types, exchange dynamics, and patient registration trends enables healthcare stakeholders to make informed decisions, optimize system performance, and identify areas for improvement. As healthcare systems and health information exchanges evolve, these KPIs serve as vital benchmarks for assessing the impact and continued efficacy of IHE XDS-based HIEs in facilitating seamless and secure data exchange.

Methodology

The Dutch XDS Cloud is a service based infrastructure design after the IHE XDS and XCA profiles, providing a robust network for health information exchange. Leveraging various IHE profiles, it ensures secure and seamless data transmission, adhering to international communication standards (DICOM, HL7v2, HL7v3, HL7v3 CDA, FHIR R4, oAuth2, SAML, XACML, etc.) for enhanced interoperability. As a central component in the Dutch National health information exchange infrastructure, the XDS Cloud plays a crucial role in enabling healthcare institutions to share clinical information efficiently and comply with regulatory requirements.

Although in more traditional query-based [2] HIEs healthcare institutions participate in a single

Affinity Domain, essential to the XDS Cloud architecture is the 1-to-1 mapping of an IHE XDS Affinity Domain to a single healthcare institution. As a result, healthcare institutions exclusively use IHE Cross-community Access for Imaging XCA(-I) based transactions to exchange clinical documents and diagnostic imaging studies with institutions. The latter is a crucial element in the reliability of the derived KPIs as only XCA(-I) transactions ITI-38, ITI-39 and RAD-75 have to be monitored to collect information about document exchange volumes.

At the first day of every month data is extracted from IHE ATNA compliant Audit Record Repositories using a script with specific audit Event Code filters. Metadata from a healthcare institution's XDS registry provides information about total registered patient and document volumes. XDS document format Codes are mapped to document types based on a predefined dictionary aligned with IHE XDS and XCA profiles.

Healthcare institutions using the Dutch XDS Cloud register patients both using their local institutions medical record number (MRN) as well as their Dutch National Patient ID (also known as BSN [3]). To collect information about document types the XDS Document Entry. Format Code of each registered and active document is extracted and mapped to a type. A DICOM Study is referenced by a XDS-I format Code, Medical Documents are referenced by XDS-MS format Codes, Patient Consent is referenced by BPPC format Codes, Laboratory Results by XD*-Lab format Codes, and workflow document by XDW related format Codes.

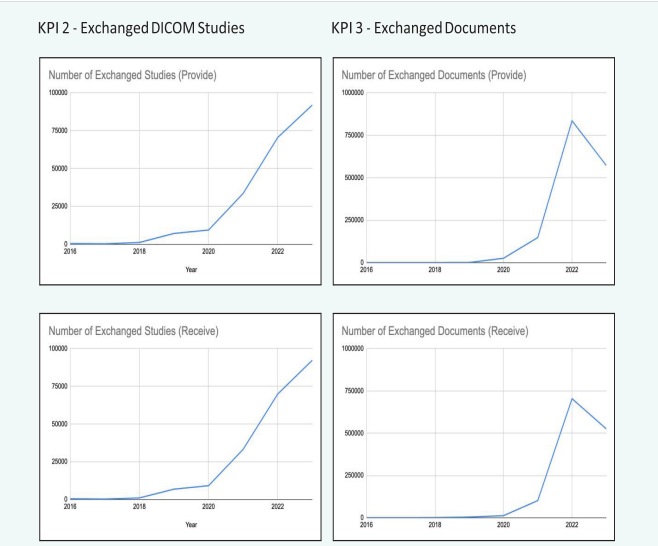
Before aggregation, full anonymization of data is carried out to comply with privacy regulations. Data sets are exported to .csv files from a centralized database, and Google Sheets™ "pivot tables" are employed for dynamic calculation and presentation of KPIs.

The combination of robust data extraction, meticulous mapping of format Codes to document types, and rigorous privacy compliance measures ensures the reliability and relevance of the presented findings.

Results

KPI 1: Registered Document Volume.

Number of registered documents	2024-01	Document Type	2024-01
Total	7,03,25,529	DICOM Study	3,78,72,289
		Patient Consent	51,36,716
		Medical Documents	2,67,45,382
		Lab Results	5,29,047
		Workflow Documents	42,095



Year	Provide	Receive
2016	458	458
2017	302	272
2018	1,176	1,012
2019	7,148	6,822
2020	9,400	9,126
2021	33,575	33,240
2022	70,515	69,926
2023	91,940	92,329

Year	Provide	Receive
2016	93	93
2017	89	129
2018	299	783
2019	976	4,130
2020	25,681	12,122
2021	147,827	101,388
2022	835,149	704,066
2023	572,122	525,624

KPI 4: Registered Patients.

Patient IDs	BSN	MRN
Grand Total	13,864,619	21,038,544

Discussion

KPI 1 reveals that per January first 2024 a total of more than 70 million active documents are registered in all XDS registries of the 27 XDS Cloud connected healthcare institutions combined.

Diagnostic imaging studies represent more than 50% of the total registered document volume. The second largest volume relates to medical documents of different kinds. They represent radiology reports, patient summary, referral letters, etc. and are directly linked to the primary use-cases that drive the need for health information exchange. 7% of the registered document volume is attributed to IHE BPPC-based (patient consent) documents. This can be attributed to the fact that under European and Dutch regulations [4,5] query-based health information exchange in The Netherlands is only allowed when the patient has explicitly consented to his/her information being shared.

As can be derived from KPI 2 and 3 the volume of exchanged documents exceeds the volume of exchanged DICOM Studies. Both KPIs show a gradual increase of exchanged volume over the past 7 years. This can be attributed to the fact that not all 27 hospitals joined the network at the same time. An initial group of 4 hospitals in and around Eindhoven joined early 2016. In 2018 the Utrecht region hospitals followed one after another. As of 2020 hospitals in the Amsterdam region joined, soon followed by hospitals in Brabant, South and North Holland. Furthermore, in 2021 the ability to exchange studies and documents with hospitals outside the XDS Cloud was made possible through XCA-gateways. As of 2020 the network effect [6] starts to be visible as the exchanged document volume of both DICOM Studies and Document combined shows a steep increase compared to the year before.

There is a difference in the provide and retrieve volumes for both DICOM Studies and Documents. The theoretical assumption would be that both numbers are equal as the "provide" volume of one healthcare institution should lead to a "retrieve" volume at another. Although it requires further study to derive more factual conclusions,, the authors believe that this can be attributed to the fact that healthcare institutions using the XDS Cloud have the ability to exchange DICOM Studies and Documents through IHE XCA(-I) transactions with healthcare institutions outside the XDS Cloud infrastructure. As the audit data for this study does not include data from these external institutions external "provide" and "retrieve" events are not captured. Furthermore, not all provide or receive transactions are successful as failures occur due to network issues or clinical systems that throw errors.

From KPI 4 it can be concluded that not all patients registered in all XDS registries collectively have been assigned a BSN since the registered BSN volume is less than the registered volume of local MRNs. At first this may seem an issue as Dutch legislation requires any patient related information that is shared to be associated with a unique BSN. However, the authors attribute the difference to the fact that most of the connected healthcare institutions first register a patient with his/her local MRN, after which the BSN is added only when the BSN has been validated, or when there is a need for sharing that patient's data. Furthermore, patients without a

BSN (tourists, short term residents, etc.) also exist, and are only registered using their local MRN. Given that the extracted data has been fully anonymized it cannot be determined if a particular patient is registered in more than one healthcare institution. However, given that the primary use-cases relate to patient referral and care coordination it is very likely a patient is registered in more than one hospital.

The authors have attempted to find other relevant articles [7-12] that discuss the health information exchange volumes within comparable XDS-based exchanges. Although these articles discuss the benefits of IHE XDS-based health information exchanges in qualitative terms, none include actual numbers related to the registered document and/or exchange volume. The authors therefore are hesitant to make quantitative statements about how the Dutch XDS Cloud compares to other IHE XDS-based networks globally.

Given that health information exchanges globally [13-15] strongly differ in the number of participating health institutions and geographical reach, the KPIs in this paper are not intended to compare health information exchanges with each other.

Conclusion

This paper's findings offer a nuanced understanding of the Dutch XDS Cloud infrastructure's performance, highlighting its role in fostering seamless and secure data exchange among healthcare institutions. The defined KPIs and the insights these provide may serve as a foundation for future research and enhancements in healthcare data exchange systems. The continuous evolution of health information exchanges that are aligned with IHE XDS and XCA profiles, are poised to further advance collaborative patient care and care coordination use-cases.

Author's Contribution:

Andries Hamster started his career in the domain for radiology informatics developing first generation PACS workstations, web viewers and (DICOM) archives. As an early adopter of IHE profiles he actively participated in advancing IHE in the Netherlands and internationally for the exchange of clinical data. As co-founder of Forcare has been instrumental in setting up many IHE-based exchange infrastructures globally. In his current role as Chief Product Officer at Founda Health he dedicates his time and energy to bringing IHE-based interoperability in the eHealth and mHealth domains.

Uwe Klautke has been working in the health information exchange domain since 2017 and has actively participated in implementing and supporting XDS-based health information exchanges in the Netherlands and Europe. Uwe's work forms the foundation of the data acquisition this paper is based on.

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