

Fast Healthcare Interoperability Resources (FHIR)-Based Interoperability Design in Indonesia: Content Analysis of Developer Hub's Social Networking Service

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Table of Contents

Original Manuscript..... 5

Supplementary Files..... 21

0..... 21

0..... 21

0..... 21

..... 21

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Lukman Heryawan¹ PhD; Yukiko Mori² PhD; Goshiro Yamamoto² PhD; Naoto Kume² PhD; Lutfan Lazuardi³ PhD; Anis Fuad³ DEA; Tomohiro Kuroda² Prof Dr

¹Department of Computer Science and Electronics Faculty of Mathematics and Natural Sciences Universitas Gadjah Mada Sleman ID

²Division of Medical Information Technology and Administration Planning Kyoto University Hospital Kyoto University Kyoto JP

³Health Policy and Management Faculty of Medicine Public Health and Nursing Universitas Gadjah Mada Sleman ID

Corresponding Author:

Lukman Heryawan PhD

Department of Computer Science and Electronics

Faculty of Mathematics and Natural Sciences

Universitas Gadjah Mada

Sekip utara BLS 21

Sleman

ID

Abstract

Background: Interoperability in healthcare is a critical aspect for the exchange of health information. The Fast Healthcare Interoperability Resources (FHIR) framework has become widely adopted to provide interoperable data exchange in the healthcare industry. The COVID-19 pandemic has demonstrated the significance of interoperable data in tracking patients who have contracted the virus and keeping track of the vaccinated population. Indonesia is one of the many countries that have implemented interoperable data systems to track COVID-19 patients, and it has aspirations to expand the system to other use cases, particularly in the primary healthcare setting. The primary healthcare providers in Indonesia include Puskesmas (community health centers) and private clinics.

Objective: To promote interoperable health data exchange in the primary healthcare sector, the Indonesian government has launched the Satusehat project. The goal of the Satusehat platform is to make health data in Indonesia interoperable and exchangeable between healthcare organizations, particularly Puskesmas and private clinics.

Methods: For a successful implementation of the Satusehat platform in Puskesmas and private clinics, it is crucial to understand the challenges that may arise. This study analyzed the pain points of the Satusehat platform based on a content analysis of the Satusehat Social Networking Service (SNS) Telegram group messages. The study revealed the pain points and suggested existing approaches to address them, which can be used as a proposed design of interoperability for Puskesmas and private clinics, making it easier for these organizations to adopt the Satusehat platform.

Results: The pain points identified in this study include issues with the FHIR server, problems with FHIR profile selection, and the mapping of EMR data into standardized data, such as mapping into the SNOMED-CT terminology. To address these issues, the study proposed practical approaches, including a federated architecture for the FHIR server instead of a centralized architecture, a FHIR writer and FHIR viewer system inspired by the Standardized Structured Medical Record Information eXchange (SS-MIX) system in Japan, and a FHIR conversion framework that integrates with our FHIR writer and FHIR viewer system.

Conclusions: These proposed solutions can help resolve the pain points identified in the study and ensure the successful implementation of the Satusehat platform in Puskesmas and private clinics in Indonesia.

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Original Paper

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Lukman Heryawan¹; Yukiko Mori²; Goshiro Yamamoto²; Naoto Kume²; Lutfan Lazuardi³; Anis Fuad³; Tomohiro Kuroda²

¹ Faculty of Mathematics and Natural Sciences, Universitas Gadjah Mada, Sleman, DIY, Indonesia

² Kyoto University Hospital, Kyoto University, Kyoto, Japan

³ Faculty of Medicine Public Health and Nursing, Universitas Gadjah Mada, Sleman, DIY, Indonesia

Corresponding Author:

Lukman Heryawan, Ph.D.

Faculty of Mathematics and Natural Sciences

Universitas Gadjah Mada

Sekip Utara Bulaksumur, Mlati

Sleman, DIY, 55281

Indonesia

Email: lukmanh@ugm.ac.id

Phone: +62 812-2894-4870

Abstract

Background: Interoperability in healthcare is a critical aspect for the exchange of health information. The Fast Healthcare Interoperability Resources (FHIR) framework has become widely adopted to provide interoperable data exchange in the healthcare industry. The COVID-19 pandemic has demonstrated the significance of interoperable data in tracking patients who have contracted the virus and keeping track of the vaccinated population. Indonesia is one of the many countries that have implemented interoperable data systems to track COVID-19 patients, and it has aspirations to expand the system to other use cases, particularly in the primary healthcare setting. The primary healthcare providers in Indonesia include Puskesmas (community health centers) and private clinics.

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Methods: For a successful implementation of the Satusehat platform in Puskesmas and private clinics, it is crucial to understand the challenges that may arise. This study analyzed the pain points of the Satusehat platform based on a content analysis of the Satusehat Social Networking Service (SNS) Telegram group messages. The study revealed the pain points and suggested existing approaches to address them, which can be used as a proposed design of interoperability for Puskesmas and private clinics, making it easier for these organizations to adopt the Satusehat platform.

Results: The pain points identified in this study include issues with the FHIR server, problems with FHIR profile selection, and the mapping of electronic medical record (EMR) data into standardized data, such as mapping into the SNOMED-CT (Systematized Nomenclature of Medicine Clinical Terminology). The results show that the value of the mapping issue is 37, profile issue 9 and server issue 61. Among the three categories, server issues had the highest population, followed by mapping

issues and then profile issues. To address these issues, the study proposed practical approaches, including a federated architecture for the FHIR server instead of a centralized architecture, a FHIR writer and FHIR viewer system inspired by the Standardized Structured Medical Record Information eXchange (SS-MIX) system in Japan, and a FHIR conversion framework that integrates with our FHIR writer and FHIR viewer system.

Conclusions: These proposed solutions can help resolve the pain points identified in the study and help the advancement of the Satusihat platform implementation in Puskesmas and private clinics in Indonesia. We believed the proposed solutions have potential to be adopted to other countries with similar issues when conducting nationwide project in healthcare interoperability design.

KEYWORDS

Interoperability, Fast Healthcare Interoperability Resources (FHIR), Covid-19, Satusihat, Indonesia, SS-MIX

Introduction

Background

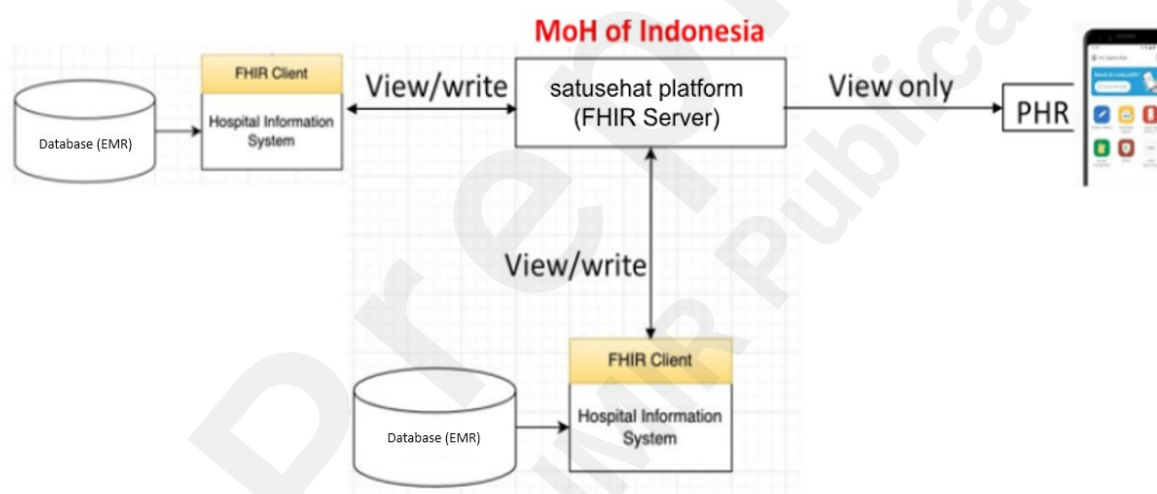
Health Information Exchange (HIE) involves the transfer of electronic health data between different health information systems, including the Electronic Medical Record (EMR) system, the Electronic Health Record (EHR) system, and the Personal Health Record (PHR) system. Notably, when the data is controlled by a health facility, an EMR system transitions into an electronic health record (EHR) system. Conversely, if the data is managed by the patient or consumer themselves, it transforms into a personal health record (PHR) system [1]. To facilitate this exchange, HIE requires a data exchange or data interoperability framework that provides a standardized format for transferring health data [2]. One of the organizations that provide such interoperability frameworks is HL7 (Health Level Seven) [3]. HL7 is a non-profit organization that develops interoperability frameworks, such as HL7 FHIR (Fast Healthcare Interoperability Resources). It is a newer standard that provides a modern and flexible approach to exchanging health information. It uses a RESTful (Representational State Transfer) web services approach and supports both structured and unstructured data. [4]. There have been several studies and reports on the implementation of Electronic Health Record (EHR) systems using the Fast Healthcare Interoperability Resources (FHIR) standard in different countries. One study, focused on the implementation of a FHIR-based EHR in Japan, highlighted some of the challenges faced during the implementation process, including lack of standardization and compatibility between different systems, difficulty of data migration, and the need for improved communication and cooperation between healthcare providers [5]. Another study provided the significance of standardization, data quality, and the need for technical support. The study also offered recommendations for improving the implementation and adoption of FHIR-based EHR systems [6-7].

Ministry of Health (MoH) manages the EHR system in Indonesia, while the EMR system is independently managed by medical providers, such as hospitals, Puskesmas (community health centers), and private clinics. The PHR system, on the other hand, is provided by the MoH to the citizens of Indonesia [8]. In 2022, the expansion of EMR implementation to encompass all types of healthcare facilities was enacted through Ministry of Health decree no. 24/2022. This regulation is a part of the digital health transformation blueprint released by the Ministry of Health [9]. A significant driver in the adoption of EMR, EHR, and PHR in Indonesia has been the COVID-19 pandemic. The PeduliLindungi app, developed as a tool for tracking, tracing, and monitoring during the pandemic, has become a crucial part of this initiative. This app has been used by over 100 million users, making it interoperable with hundreds of laboratories and 17 telemedicine service providers. Most recently, through the Ministry of Health of the Republic of Indonesia Decree Number HK.01.07/MENKES/1559/2022, health data management is now under the Ministry of Health. Data

from the PeduliLindungi app has been migrated to the SatuSehat platform, as shown in Fig. 1, which will integrate the PHR system and Electronic Medical Record (EMR) system into a single nationwide Electronic Health Record (EHR) system [10]. The SatuSehat Mobile platform enables the public to track COVID-19 vaccinations, immunization records, and medication information from EMRs of various healthcare facilities connected to this platform, utilizing the FHIR HL7 standard. Furthermore, the EMR systems will be able to exchange and share data with ease through the Satushehat platform.

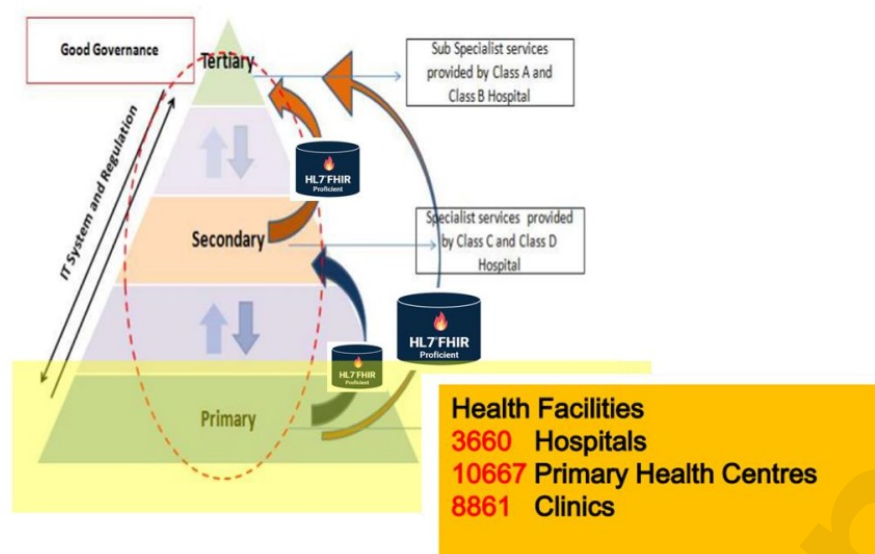
Legal basis for the implementation of the SatuSehat system in Indonesia has been further strengthened with the enactment of the Health Law No. 17/2023. This legislation specifically references the National Health Information System, which is interpreted as a system based on the SatuSehat platform. The forthcoming derivative laws are expected to lay out the structural and operational details, ensuring a coherent and efficient implementation of these systems across the country.

FIGURE 1. SatuSehat platform's architecture. PeduliLindungi app as a PHR is integrated to FHIR server with view only. On the other hand, hospital information system with data from EMR could view/write with other healthcare applications. The FHIR server which is handled by Ministry of Health act as a bridge between healthcare digital instances.



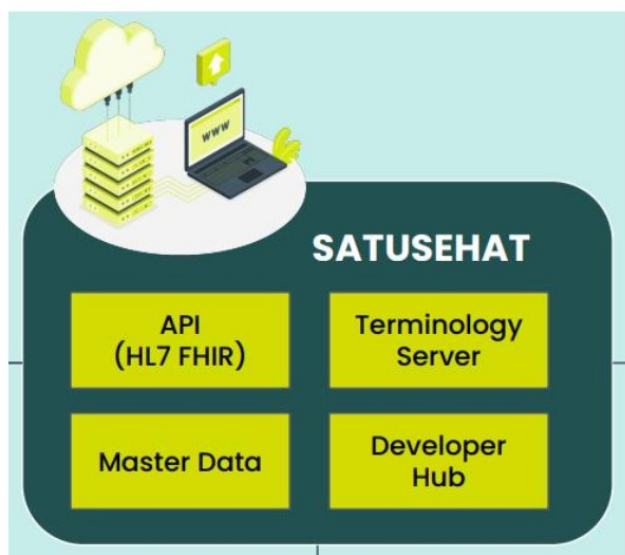
The Satushehat platform represents the cornerstone of Indonesia's nationwide electronic health record (EHR) system [11]. This platform aims to facilitate the exchange and sharing of health data, ultimately leading to better patient care and outcomes. In Indonesia, the Satushehat platform places a strong emphasis on primary healthcare. This is caused by the referral healthcare system in place, where most patients' health data begins with their first visit to a primary healthcare facility such as a Puskesmas or private clinic. These facilities are typically the first point of contact for patients seeking medical attention. If the primary healthcare facilities are unable to provide the necessary treatment or care, the patient will be referred to a higher level of care, such as a hospital. This referral system is depicted in Fig. 2, which shows the progression of patients through different levels of care within the Indonesian healthcare system [12].

FIGURE 2. Indonesia's healthcare tiered referral system. Primary care facilities such as puskesmas or private clinics as the base and entry point of healthcare service. Patient progress/referred to higher level, including secondary or tertiary facilities if needed. This system is implemented with HL7 FHIR between tiers, thorough IT system and regulation.



The Satusihat platform consists of four primary components: the FHIR server, the terminology server, the master data server, and the developer hub as shown in Fig. 3. The FHIR server is responsible for providing a HL7 FHIR Application Programming Interface (API) for health data exchange. The terminology server serves as a database, providing standardized data references for diagnoses using International Classification of Diseases, Tenth Revision (ICD-10), observations using Logical Observation Identifiers Names and Codes (LOINC), and other clinical terms using Systematized Nomenclature of Medicine Clinical Terminology (SNOMED-CT). The master data server is a database that contains the nationwide identification numbers of patients or citizen ID, practitioner data, health facilities data, pharmacies data, financing data, and health service data. The developer hub provides a sandbox environment for developers to test the FHIR API offered by the Ministry of Health. Developers can experiment and test data exchange scenarios, such as immunization, using the provided FHIR API. The developer hub also includes community tools, such as a video sharing platform, a website, and a Telegram group, to provide support and assistance to developers while they test the Satusihat FHIR API [13].

FIGURE 3. Satusihat platform components that consist of FHIR server, terminology server, master data server, and developer hub. FHIR is responsible for healthcare data exchange, terminology server provides diagnoses terminology standardization, master data stores patient and healthcare instances data (practitioners, infrastructures), and developer hub is for support center for developers when utilizing FHIR API.



In order to ensure a successful implementation of the Satusihat platform in Puskesmas and private clinics, it is crucial to identify potential pain points in integrating EMR into the platform from a developer's perspective. Understanding the underlying architecture and structure of the FHIR standard is necessary for effective integration with EHR systems [14]. Another reason for pain points is the lack of resources, as implementing FHIR standards can be resource-intensive, requiring time and expertise. Developers may face constraints in terms of budget and manpower, which can make it difficult to effectively implement the standard [15]. In addition, the lack of support from other stakeholders, including healthcare providers and technical experts, can also pose challenges for developers in implementing FHIR standards [16]. The Indonesian Ministry of Health is currently in the trial phase of the Satusihat platform. The Digital Transformation Office (DTO) of the Ministry of Health conducts workshops and training sessions for EMR system developers and vendors [17]. DTO also provides a website that provides step-by-step tutorials on how to connect and exchange data from EMR systems to the Satusihat platform using the FHIR framework, including the standardized terminologies used for mapping health data to standardized terminologies, such as LOINC for observations, ICD-10 for diagnoses, and SNOMED-CT for other health terminologies. To provide interactive support, DTO also provides a Telegram group that developers can join to ask for support when integrating their EMR systems into the Satusihat platform. Based on the activities in the Telegram group, which mostly involve questions about how to integrate EMR systems into the Satusihat platform, we conclude that there are some pain points when integrating EMR systems into the Satusihat platform. This conclusion came from analysis through the Telegram group including a question and answer sessions with the DTO representative.

Objectives

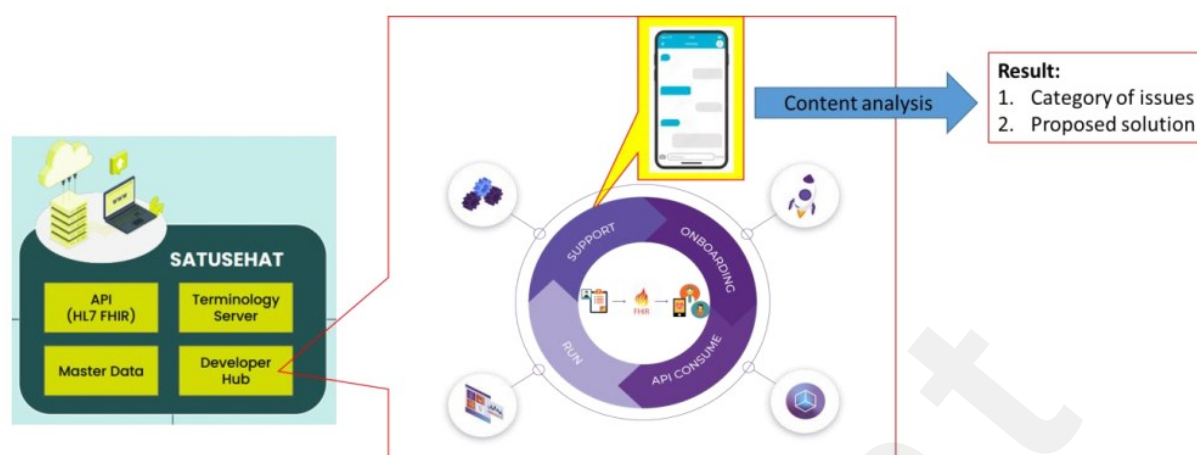
The purpose of this study is to identify the challenges and difficulties encountered by developers that are present in situ during the integration process of electronic medical record (EMR) systems into the Satusihat platform. To accomplish this, we will analyze the communication content in the Telegram group of the Satusihat developer hub, which serves as an interactive community platform for developers. By exploring the pain points communicated by the developers in this forum, we aim to gain a deeper understanding of the barriers and obstacles encountered during the integration process. Once the pain points have been revealed, the study proposes practical approaches that can be used to ensure a successful integration into the Satusihat platform. These approaches are then combined to form an interoperability design of a FHIR-based system for EMR in Puskesmas and private clinics. The study is organized into four sections. The first section introduces the Satusihat platform, related work, and how pain points will be revealed. The second section describes the content analysis

methods used in the study. The third section presents the results, and the fourth section discusses the practical approaches that will be proposed as an interoperability design to ensure a smoother integration into the Satusehat platform.

Methods

In order to uncover the pain points that are addressed in the developer hub, we conducted a content analysis of the Telegram group's contents. We decided to conduct the analysis to the specific telegram group because the group is officially managed by the Digital Transformation Office. It is the most active group that contain developer discussions about EMR integration to the Satusehat platform. Content analysis is a research method used to make inferences by interpreting and coding written, spoken, or visual material [18]. The analysis was conducted at a telegram group that consists of 1067 active members to this day. This study focused on analyzing conversations from December 20, 2022, the date the group was created, until January 29, 2023. The end date was chosen because the amount of extracted data is sufficient to support the experiment, which is content analysis. Extending the time span of chat extraction could potentially enhance the volume of data collected and strengthen the robustness of our conclusions, as the amount of data sampled in an experiment highly depends on the subject of the study [19]. In this instance, our focus was on Telegram as a social network service. A total of 219 chats were chosen during this period. However, we selected only 107 chats related to our research purpose. These chats primarily involved developers discussing issues encountered while integrating their EMR systems with the Satusehat platform using FHIR standards. In our research, we focused on issue-related chats, such as “http server error 500,” “what FHIR profile should be used for chief complaints,” and “SNOMED-CT or LOINC for mapping blood glucose.” We excluded non-issue chats that contained simple responses like “Ok” or “thank you.” To collect the chats, we utilized the Telegram menu to export them into HTML files, which we later transferred to an Excel file. The collected chats later were manually labeled two of the researchers (author and his colleague) who are trained to categorize the data according to agreed and specific rules. The labeler were chosen with taking the research design, the amount of data being analyzed, and the complexity of the coded classification process of the study into account. In addition, the coding process is ensured to be consistent and reliable with involving two researchers including the author and his colleagues with a background in information technology and understanding of the Satusehat platform. This established intercoder reliability in order to achieve valid interpretation of the data [20]. After conducting our content analysis and categorizing the issues, we developed a proposed approach for each issue category as shown in Fig. 4. These proposed approaches may contribute to incorporated into the existing Satusehat platform architecture, potentially resulting in an interoperability design that is less burdensome for developers. By less burdensome, we mean that the design can be easily implemented by novice developers, which are commonly found in private clinics and Puskesmas (community health centers). This design can be referred to as the Fast Healthcare Interoperability Resources (FHIR)-based Satusehat platform interoperability design for private clinics and Puskesmas. By reducing the burden of the interoperability design, the integration of EMR systems into the Satusehat platform in Indonesia will be smoother. It is important to note that there are other factors that can influence the smooth implementation beyond the technical scope this study. For the sake of the study's conciseness, we will only focus on the technical issues from a developer's perspective.

FIGURE 4. The approach method of the study. Given the developer hub, as the support and assistance forum for developers to test FHIR, the telegram group chat content is extracted. Then, content analysis is conducted that resulted in categorization of issues and proposed solutions for each issues.



Ethical

Considerations

Public telegram group of the Satusihat developer hub contents were utilized for content analysis in this research. There were not any extra compensation given to conduct the analysis since the content itself is public. We acknowledge the ethical concerns that follows while analyzing data that may raise privacy issues. An original study relating to framework that can be used by researchers to consider ethical issues in internet-based research also included how privacy policy and content that were analyzed on specific internet platform should be reviewed. The collected data have to be accessible to public, focused to the content, and not the individual who posted the content [21]. Additionally, taking into account the public nature of the group and also Telegram's privacy policy relating to public chats, we believe that group members implicitly consented to having their data accessible publicly [22]. Following the logics provided in the framework and Telegram's privacy policy, the exemption of additional ethics review is feasible for this study. Institutional Review Board number for the study is KE/FK/0204/EC/2023.

The focus of this study is to analyze the content of the public developer hub, not on the individual who posted in the developer hub. Therefore, anonymization is applied to the data that are collected and presented in this study to ensure group participant's data privacy and confidentiality. According to other literatures, it is stated that waiver of consent could be requested when no identifying information is presented. Also, permission of further use of the data is permitted if the data is freely available on public forum [23]. Considering aforementioned points, acquiring consents was not necessary for this research. However, it is important to get consents in general for research using data from people. In our case, it wasn't possible to getting informed consents due to the scope of our research.

Results

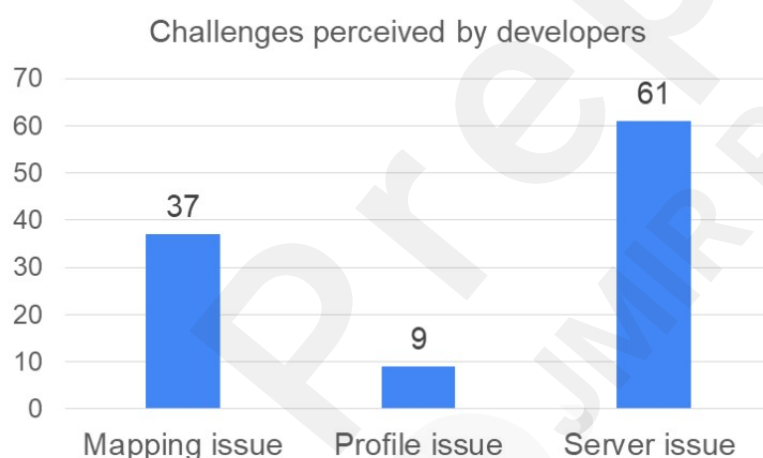
The results of our study are divided into two sections for clarity and organization. The first section outlines the pain points and issues with the Satusihat platform, which were identified through content analysis of the Satusihat Social Networking Service (SNS) Telegram group messages. These pain points include issues with the Fast Healthcare Interoperability Resources (FHIR) server, difficulties in selecting the appropriate FHIR profile, and challenges in mapping electronic medical record (EMR) data into standardized data formats like Systematized Nomenclature of Medicine Clinical Terminology (SNOMED-CT) terminology [24]. Implementing and maintaining a FHIR server may be challenging due to the interoperability, security concerns, and scalability. Selecting the appropriate FHIR profile gives difficulties in aligning with specific use cases, balancing flexibility

and considering long-term maintenance. Mapping EMR data into standardized data formats like SNOMED-CT could be challenging due to data complexity, granularity, updates, and achieving semantic interoperability. The second section of our study presents proposed designs that aim to address the pain points identified in the first section. We believe that the proposed designs will help overcome the challenges that may arise during the implementation of the Satusihat platform in primary healthcare settings, such as Puskesmas and private clinics. These proposed designs include a federated architecture for the FHIR server to ensure reliable and distributed server load management, a FHIR writer and viewer system inspired by the successful Standardized Structured Medical Record Information eXchange (SS-MIX) system in Japan [25], and a FHIR conversion framework that integrates with our FHIR writer and FHIR viewer system.

Pain Points

Based on content analysis of the Satusihat Social Networking Service (SNS) Telegram group messages, we identified three main types of issues faced by developers: server issues, profile issues, and mapping issues as illustrated in Fig. 5. Among the three categories, server issues had the highest population with 61 chats, followed by mapping issues with 37 identified chats and then profile issues with 9 chats. Our data collection method allowed us to focus on the issues and concerns that developers faced when integrating their EMR systems with Satusihat platform using FHIR standards.

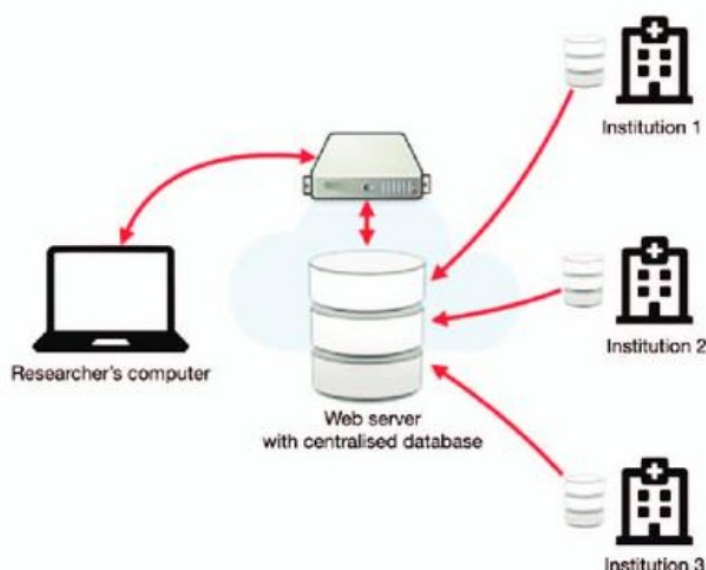
FIGURE 5. Most prominent pain points perceived by developers when testing FHIR from the Telegram group (developer hub).



Proposed Design

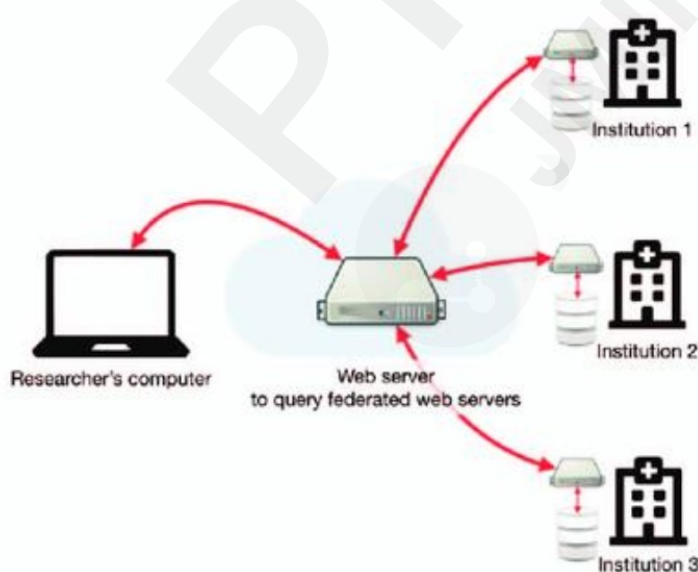
The Satusihat platform is built on a centralized architecture, which is illustrated in Fig. 6. To ensure authentication, the platform uses an OAuth server [26]. Once a user is authenticated, they can access the FHIR resources available on the platform through the FHIR API. However, based on the developers' perspective, connecting to the Satusihat platform can be challenging. We have identified this issue as a server issue. Sometimes, the Satusihat platform server fails to respond to the user's request, resulting in errors such as HTTP Error 401 – Unauthorized, HTTP status 403 – Forbidden, HTTP status 404 - Not Found, and HTTP status 500 - Internal Server Error [27].

FIGURE 6. Satusihat current architecture. The platform was build on centralized architecture and database [28]. Authenticated institutions or individuals is able to access the FHIR eresources in the central database. Writer identifies this as the root of server issue stated in developer hub.



To overcome this issue, we propose a federated server architecture instead of a centralized server architecture [28], as shown in Fig. 7. In this approach, the FHIR resources are stored in local or regional servers that are subordinate to the central server. Periodically, the central server inquiries about the FHIR resources and copies them to the central server. This approach ensures high reliability for both the central and local/regional servers, resulting in a more robust exchange of FHIR resources. By implementing the federated server architecture, the exchange of FHIR resources will be more reliable, making it easier for authenticated users to post, get, put, and patch the FHIR resources from the Satusehat platform.

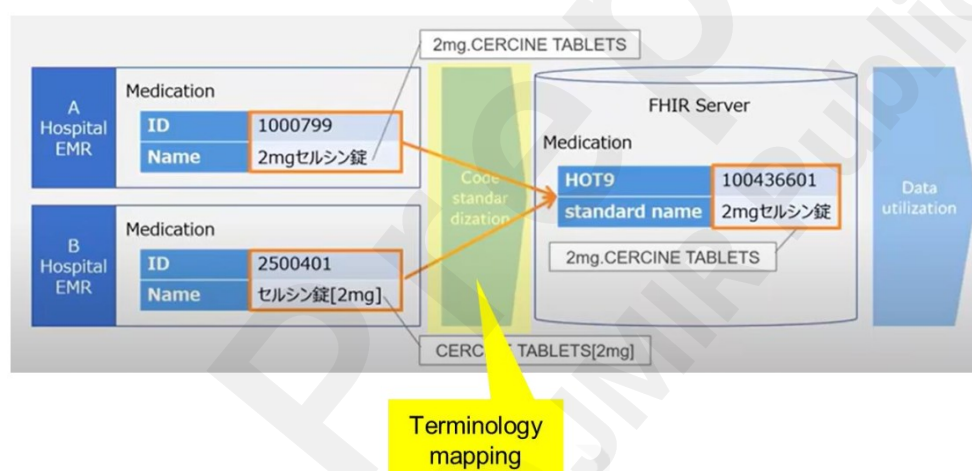
FIGURE 7. Our proposed solution: Satusehat with federated architecture [28]. Central server periodically fetch and add FHIR resources that are stored in local servers with the aim to enhance reliability and robustness of the platform.



The issue of mapping is a significant challenge faced by developers working on the Satusehat platform. Healthcare facilities in Indonesia use various local terminologies, which are often in Indonesian or local tribal languages, such as

Javanese. In contrast, standardized terminologies such as International Classification of Diseases, Tenth Revision (ICD-10) for diagnosis and International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9 CM) for medical procedures are in non Indonesian languages, such as English [29]. This presents a significant challenge in mapping the various local terminologies with their many variations into a single standardized terminology in English. We believe that this issue is not unique to Indonesia but also affects other countries whose national language is not English, such as Japan, Taiwan, and Thailand [30]. To overcome this challenge, we propose an approach that is similar to the one used in Japan. The Japanese approach utilizes the FHIR conversion framework [31]. In this approach, the conversion is only done on the terminology code and not on the terminology text. The written terminology still uses the local language, such as Japanese, but the code follows the standardized code. This approach reduces the complexity of the mapping task significantly. The FHIR conversion framework is illustrated in Fig. 8. By implementing this approach, we can ensure that the Satusehat platform can handle the mapping of various local terminologies into standardized terminologies in a more efficient and effective way.

FIGURE 8. FHIR conversion framework to address mapping issues [26]. Japanese terminology for medication data, in the name attribute (2mg CERCINE TABLETS) is preserved in hospital EMR to ensure readability. The corresponding standardized code (such as ICD-10) is mapped into the FHIR server with terminology mapping.



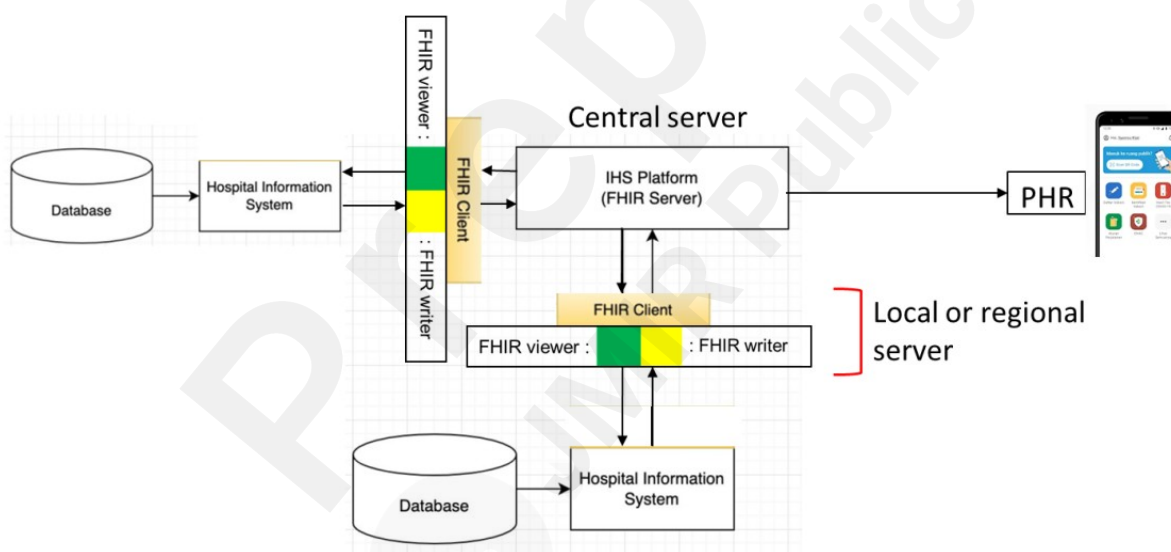
In addition, automating the code conversion process is much simpler than the text conversion process because the variations in code are relatively small. This approach not only reduces the workload for developers but also ensures the accuracy and consistency of the mapping process. The last issue concerns the challenge of selecting and applying the correct FHIR profiles to EMR data. While there is an Implementation Guide (IG) available to guide users in selecting the appropriate profiles for specific use cases, such as outpatient medical resumes and immunization records, manually selecting and applying the profiles can still be difficult. To address this issue, we propose a solution that involves feeding EMR data into a system that automatically selects the correct FHIR profile and builds the content of that profile based on the input data. Similar approaches have been implemented in countries that have standardized their health data using Health Level Seven (HL7) standards, such as Japan's use of HL7 V 2.5 to standardize various health data into a storage system called the Standardized Structured Medical Record Information Exchange (SS-MIX) [29]. The SS-MIX system has been successful in facilitating Health Information Exchange in Japan. Since both SS-MIX and FHIR are from HL7, we

believe it would be feasible to adopt the SS-MIX system and modify it to use HL7 FHIR structures instead of HL7 V 2.5 structures. This is a practical solution as there are already open structures and guidelines available to implement SS-MIX. We simply need to modify the structure to use HL7 FHIR data.

Discussion

Server issue, mapping issue, and profile issue are identified as the most frequent problems that developers faced when integrating electronic medical record (EMR) and Satusihat with Fast Healthcare Interoperability Resources (FHIR) protocol. The proposed design for an interoperable FHIR-based Satusihat platform tailored to the needs of Puskesmas (community health centers) and private clinics is depicted in Fig. 9, which illustrates the combined approaches that have led to a more reliable and user-friendly platform. The design integrates several key features, including a federated architecture that distributes the data, a data mapping system that ensures consistency across diverse healthcare terminologies, and an automated selection and implementation of appropriate FHIR profiles for EMR data.

FIGURE 9. Our proposed design for FHIR-based Satusihat platform. It consist of federated architecture between central server and Hospital Information System in local or regional server as FHIR client, local terminology system mapping, dan automated FHIR profile selection.



To address the mapping and profile issues related to data, we propose a FHIR writer and viewer system that combines the FHIR conversion framework and the Standardized Structured Medical Record Information eXchange (SS-MIX) system. This system can be deployed on both local and regional servers to ensure accessibility for healthcare facilities such as Puskesmas, hospitals, and private clinics. To use this system, Hospital Information Systems or EMR systems feed data into the FHIR writer subsystem. The FHIR writer then converts the local code into standardized code and selects the appropriate profile to be inserted with the standardized data. The FHIR profile, filled with standardized data, is then stored or prepared in the local or regional server and is ready to be queried by a central server. If healthcare facilities want to view patient data from their own facilities, their EMR system can make a request to the local or regional server to view the patient data. If the data is not available in the local or regional server, the server continues the request to the central server to retrieve the data using FHIR Application Programming Interface (API). In this way, the local or

regional server acts as a FHIR client, and the central server acts as a FHIR server in terms of the client-server connection [30]. Our proposed FHIR writer and viewer system provides a standardized approach to data mapping and FHIR profile selection, ensuring consistency and ease of use for healthcare facilities. It also allows for efficient querying of patient data across multiple facilities, increasing the interoperability and accessibility of healthcare data. The issue of server architecture is a critical consideration in developing an efficient and reliable health information system. In particular, the ability to handle large volumes of data and ensure seamless data exchange across different healthcare providers is crucial. The approach to addressing this challenge lies in the use of federated architecture. Federated architecture offers a scalable and flexible solution to server issues by distributing the load across multiple servers [31]. This ensures that the server load is manageable even during peak periods, such as when there is an automatic processing of EMR data. By spreading the load, federated architecture also enhances the reliability of the system, making it more robust and resilient. Moreover, federated architecture is an ideal solution for countries like Indonesia, which has a vast archipelago with numerous islands separated by sea. With federated architecture, health facilities in remote areas can be connected to a centralized health information system, enabling the efficient exchange of health data and improving patient care. To fully leverage the benefits of federated architecture, an automated FHIR writer/viewer system can be implemented. This system enables the automatic conversion of local codes to standardized codes, the selection of appropriate FHIR profiles, and the storage and retrieval of patient data from local and regional servers. The system can be easily deployed and customized to suit the specific needs of Puskesmas, private clinics, and hospitals. By using this approach, healthcare providers can efficiently access patient data, resulting in improved healthcare outcomes for patients. Although our proposed design is based on a small amount of chats in the Satusihat telegram group, we recognize that this group is the most interactive channel for developers seeking support in integrating their EMR systems into the Satusihat platform. Therefore, despite the limited data, we believe that most of the issues related to integrating EMR systems into Satusihat using the FHIR framework have been recorded in the Satusihat telegram group. By analyzing and addressing these issues, we were able to develop a design that effectively addresses the common challenges faced by developers. We also recognize that ongoing monitoring and analysis of the Satusihat telegram group will be critical for identifying and addressing new issues that arise as the platform continues to evolve. Our proposed design for the FHIR-based Satusihat platform can be a valuable solution for other countries facing similar challenges in implementing health information exchange systems. While we drew inspiration from the design of Japan's health information exchange system, which shares similar characteristics with Indonesia, such as a non-English language and multiple islands, our approach is adaptable and scalable to meet the needs of other countries. By collaborating and sharing knowledge, countries facing similar issues can learn from each other to enhance the implementation of FHIR-based platforms like Satusihat. This approach could foster the development of a regional-level health information exchange system in ASEAN countries or even beyond, incorporating other Asian countries such as Japan, Taiwan, and India, which have already implemented health information exchange systems [35]. By working together, we are able to create a more efficient and effective health information exchange system that benefits all participating countries.

Limitations

The content analysis in the study were limited into specific timeframe (December 20, 2022 - January 29, 2023) and a small size sample of 107 chats. It was originated from the developer hub's telegram group that was managed by the Digital Transformation Office (DTO) of Indonesia Ministry of Health. The telegram also only addresses the technical pain points from developers perspective to integrate their EMR to Satusihat platform. Also, the proposed approaches based on the identified pain points also have not been implemented to the existing Satusihat platform.

Future Works

After gaining an understanding of the challenges faced by the Satusihat platform and proposing an interoperability design for the platform, our next step is to develop a FHIR writer/viewer system that is tailored to the Satusihat platform. To accomplish this, we plan to collaborate with an EMR system developer for the purpose of collecting EMR data. This data will be used to train and test the FHIR writer/viewer system, to determine whether the EMR data can be standardized based on the FHIR-based Satusihat platform and whether it can be viewed back by the same EMR system. We are also interested in collaborating with researchers from Japan, whose approach to building the SS-MIX system has inspired our proposed design. By working together, we aim to create an FHIR-compliant version of SS-MIX that can not only be used in the Satusihat platform in Indonesia but also has the potential to be implemented in Japan. With this joint collaboration, the FHIR-based SS-MIX can facilitate cross-country border Health Information Exchange (HIE) by ensuring interoperability and seamless exchange of healthcare data between the two countries.

Conclusion

For ensuring successful implementation of the Satusihat platform, this paper proposes content analysis as a way to identify pain points that are faced by developers during development

Analyzing Satu Sehat developers' discussions on social networking system, we have identified three top pain points about Satusihat platform: server issues, data mapping, and difficulties managing user profiles. We have showed how using federated server architecture, a Fast Healthcare Interoperability Resources (FHIR) writer and FHIR viewer, and FHIR conversion framework could address the mentioned issues. The proposed architecture for solving pain points gives several suggestion as a blueprint on how to reduce developer workload when committing integration, increasing the robustness of the resources exchange, ensure accuracy and consistency on mapping and also profiling process. All of this will further help the advancement of Satusihat platform implementation in Puskesmas (community health centers) and private clinics in Indonesia.

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Conflicts of Interest

None declared.

Data availability

The data sets generated during and/or analyzed during this study are not publicly available due to the Satusihat privacy policy but are available from the corresponding author on reasonable request.

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Supplementary Files

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