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Prototype for Implementing Data Exchange with The FHIR-HL7 Standard in The Personal Health Record Application

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ABSTRACT

Interoperability between Personal Health Records (PHR) and Electronic Health Records (EHR) is crucial for improving healthcare delivery and patient outcomes. EHRs store clinical data generated by healthcare providers, while PHRs are patient-centric, allowing individuals to access and manage their health information. By enabling these systems to work together, patients and providers gain a unified view of health data, improving care coordination and decision-making. It can be empowers patients to monitor their health, understand their conditions, and actively participate in their care.

This study focuses on developing a prototype for data exchange implementation using the FHIR-HL7 standard in a PHR application. There are many resources in FHIR but in the prototype is tested with selected resources: Patient, Encounter, Observation and Condition. The data flow involves obtaining patient medical records from an EHR system in hospital and displaying them in a mobile device as a Personal Health Record, ensuring secure access via National Identification Number (NIK) matching as Personal Identification Number. The approach includes mapping FHIR resources to relevant data structures, modifying both EHR and PHR applications to support the data exchange process. HAPI FHIR is being used as a portal to provide communication between the apps.

The results demonstrate that patient medical records stored in EHR can be accessed by patients through the PHR apps. Specific FHIR resources enable the exchange of various data types: patient demographics using the Patient resource, diagnoses using the Condition resource and vital signs (e.g., systolic/diastolic blood pressure, weight, height) using the Observation resource. This prototype highlights the feasibility of integrating FHIR-HL7 standards for interoperable health data exchange, enhancing patient engagement and data accessibility.

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1. INTRODUCTION

Monitoring one's health condition is vital for early detection and prevention of diseases, enabling timely interventions and better management of chronic conditions. When patients actively track their health, they are empowered to make informed decisions and adhere to treatment plans, ultimately improving their quality of life. However, in many cases, patient medical records are fragmented across multiple healthcare facilities, leading to incomplete or inconsistent information. This fragmentation can hinder effective care, as providers may lack a holistic view of the patient's health history.

Integrating and consolidating medical records through interoperable systems allows patients and providers to access comprehensive and accurate data. This ensures continuity of care, reduces the risk of redundant tests or conflicting treatments, and fosters collaborative decision-making between patients and healthcare professionals. By centralizing health information, patients can better monitor their conditions, while providers can deliver more personalized and effective care. Interoperability in healthcare systems has become increasingly crucial to ensure seamless data exchange and improve patient care[4]. This study focuses on developing a prototype for implementing data exchange using the FHIR-HL7 standard within a Personal Health Record (PHR) application and Electronic Health Record (EHR).

FHIR is a standard used in health information technology introduced in 2011 by the Standard Development Organization Health Level Seven International (HL7). FHIR is based on previous HL7 standards (HL7 versions 2 and 3 and Clinical Document Architecture) and combines their advantages with established modern web technologies such as a Representational State Transfer (REST) architecture; application programming interface (API), XML, and JSON formats; and authorization tools (Open Authorization). In FHIR, all exchangeable content is defined by distinct basic building blocks—referred to as resources—which define the content and structure of information and can refer to each other using reference mechanisms[1]. A resource is the smallest discrete concept that can be maintained independently and is the smallest possible unit of a transaction. These resources are divided into five major categories: (1) Administrative: location, organization, device, patient, group; (2) Clinical: CarePan, diagnostics, medication, allergy, family history; (3) Financial: billing, payment, support; (4) Infrastructure: conformance, document, message profile; and (5) Workflow: encounter, scheduling, order[9]. Implementing HL7 FHIR for EHR data transmission offers several benefits, for the example: (1) FHIR enables seamless data exchange between disparate healthcare systems, promoting interoperability, (2) FHIR provides standardized data formats and structures, ensuring consistency in data representation, (3) Robust security measures, including authentication and authorization, protect patient data during transmission, (4) FHIR's RESTful architecture allows for efficient data retrieval and updates [11].

Personal Health Record (PHR), is a platform managed by patients that contains their health information. This includes their medical record number, name, date of birth, blood group, eligibility information, referral, hospital, emergency contacts and other details. The portal allows patients to access laboratory and radiology results, medication information and other reports. They can also request certain services from their healthcare provider and use the portal as a communication channel [2][6][12]. PHR commonly embedded in mobile device so the patient can access it every time and every where. Electronic health records (EHRs) are repositories of patient health information, created by health professionals to capture data related to specific clinical encounters in health facility like hospital, clinic or other primary health care. At a minimum, most EHRs provide three key medical functions: (1) presenting the most-up-to date information on a patient, (2) storing supporting documentation about a patient (such as test results and imaging) and (3) enabling health professionals to input data about a patient's diagnosis and treatment[10]. Electronic medical records are patient medical records in electronic form which include an individual's health information which can be accessed using a computer from a network to provide effective, efficient and integrated health services. According to the Regulation of the Minister of Health of the Republic of Indonesia Number 24 of 2022 concerning medical records, medical records are documents that contain patient identity data, examinations, treatment, procedures and other services that have been provided to patients[3].

By leveraging standardized resources such as Patient, Encounter, Observation, and Condition[5], the prototype aims to enable the integration of data from an Electronic Health Record into the Personal Health Record application. This integration ensures that patients can securely access their medical records through a matching mechanism using the National Identification Number (NIK), fostering better engagement and accessibility in healthcare management. The Master Patient Index (MPI) emerged as a suitable tool for serving as the integration layer for this task. The MPI, with its various functionalities, particularly its role in interoperability via messaging, was identified as a key element in this effort[8]. A PHR must achieve structural interoperability for seamless communication of healthcare data within PHR and between PHR and other external sources such as an EHR[7].

2. METHOD

FHIR (Fast Healthcare Interoperability Resources) is a widely adopted standard for healthcare data exchange due to its flexibility, scalability, and simplicity. It uses RESTful APIs, making it easier to integrate with modern applications and systems. FHIR supports the use of structured resources like Patient, Condition, and Observation, which ensures consistency and interoperability between Electronic Health Records (EHRs) and Personal Health Records (PHRs). The prototype implementation focuses on testing specific FHIR resources, including patient data, vital signs and diagnoses. To facilitate this, a mapping process was conducted to align the variables in the Personal Health Records (PHR) system with the corresponding FHIR resources, as detailed in Table 1 for the vital sign data and Table 2 for the body weight data.

Table 1 Mapping medical record variables in vital sign with FHIR resource: Observation

Medical Record Variable in PHR	Observation	
Name	Path	Value
membervitalsign_sistolik	Observation.code.coding.display	Systolic blood pressure
membervitalsign_diastolik	Observation.code.coding.display	Diastolic blood pressure
membervitalsign_pulse	Observation.code.coding.display	Heart rate
membervitalsign_breath	Observation.code.coding.display	Respiratory rate
membervitalsign_temperature	Observation.code.coding.display	Body temperature
membervitalsign_saturation	Observation.code.coding.display	Oxygen saturation in Arterial blood by Pulse oximetry

Table 2 Mapping medical record variables in body weight with FHIR resource: Observation

Medical Record Variable in PHR	Observation	
Name	Path	Value
memberbmi_weight	Observation.code.coding.display	Body weight
memberbmi_height	Observation.code.coding.display	Body height
memberbmi_result	Observation.code.coding.display	Body mass index (BMI)

The system architecture, illustrated in Figure 1, consists of components: the EHR system, FHIR server, PHR server, and PHR applications. The EHR used is called Bigsirs which was developed to meet the needs of business processes in hospitals that build in web based platform, the FHIR server used is Java-based HAPI FHIR while the PHR application used is NusaCare, a mobile application with a Flutter development framework and the PHR server used is PHP-based using a framework Codeigniter-REST full API. HAPI FHIR is an open-source implementation of the FHIR standard, providing a robust and scalable framework for building interoperability portals. It supports all FHIR resource types and operations, making it an excellent choice for a central data exchange platform. HAPI FHIR simplifies server deployment with tools for validation, transformation, and data storage. Its active community and detailed documentation enhance development and

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troubleshooting. By using HAPI FHIR, organizations can standardize healthcare data exchange, ensure compliance with FHIR specifications, and foster seamless communication between EHRs, PHRs, and other healthcare systems.

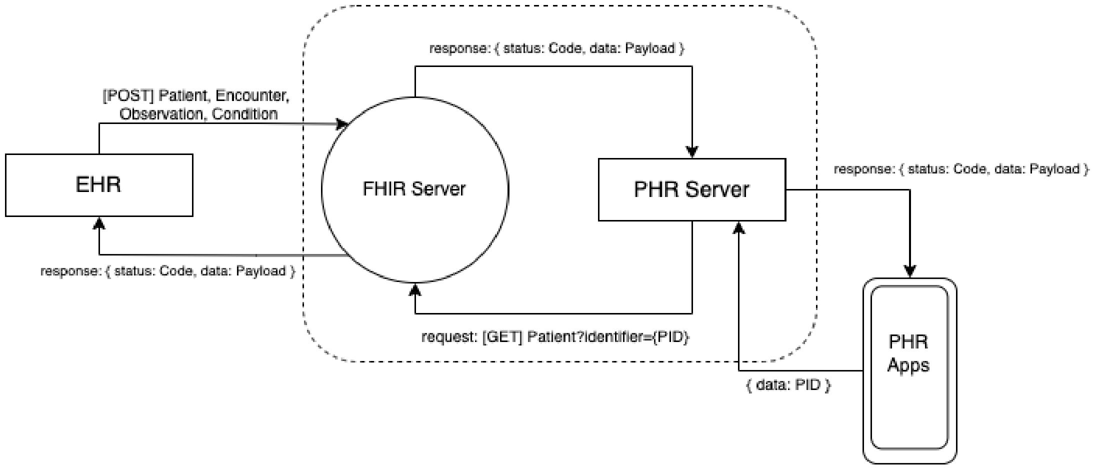

Figure 1 The interoperability system architecture of PHR and EHR

The diagram illustrates the data exchange process between an Electronic Health Record (EHR) system, a FHIR server, a Personal Health Record (PHR) server, and a PHR application. The EHR system sends medical record data, including Patient, Encounter, Observation, and Condition resources, to the FHIR server via a POST request. The FHIR server processes this data and returns a response containing the status code and payload. The data exchange can be happened with network connection such as internet or local area network (LAN) using http protocol.

To retrieve specific patient data, the PHR server sends a GET request to the FHIR server using the patient identifier (PID). The FHIR server responds with the requested data, which the PHR server forwards to the PHR application. This enables the application to display the patient's health information. Each interaction includes a response containing status codes and data payloads.

The data flow process involves obtaining data from the EHR system as follows in Figure 2. The flowchart outlines the process of retrieving patient health data using FHIR resources. It starts by initializing the *fhir_server_base_url* and *member_id*. Member_id is an unique ID from PHR application. The system invokes the *visit_get(member_id)* function to check for visits related to the specified member ID. A request is then sent to the FHIR server to retrieve the patient data using the patient identifier (PID) through the endpoint /Patient?identifier using curl with GET method http request.

If no visits are found, the system returns a status code of 201 with a message indicating "data not found." If visits are identified, a request is made to fetch encounter data using the endpoint /Encounter?subject=Patient/<resource_id> with GET http method to get uuid of Encounter resources. Based on the retrieved encounter uuid, subsequent GET requests are made to fetch diagnostic information and vital signs using the endpoints /Condition?encounter=<resource_id> and /Observation?encounter=<resource_id>, respectively. The resource_id is uuid from the encounter.

The retrieved data is then subjected to variable mapping, converting it into the desired structure like shown in Table 1. Finally, the process concludes by returning a status code of 200 with the payload containing the requested health data.

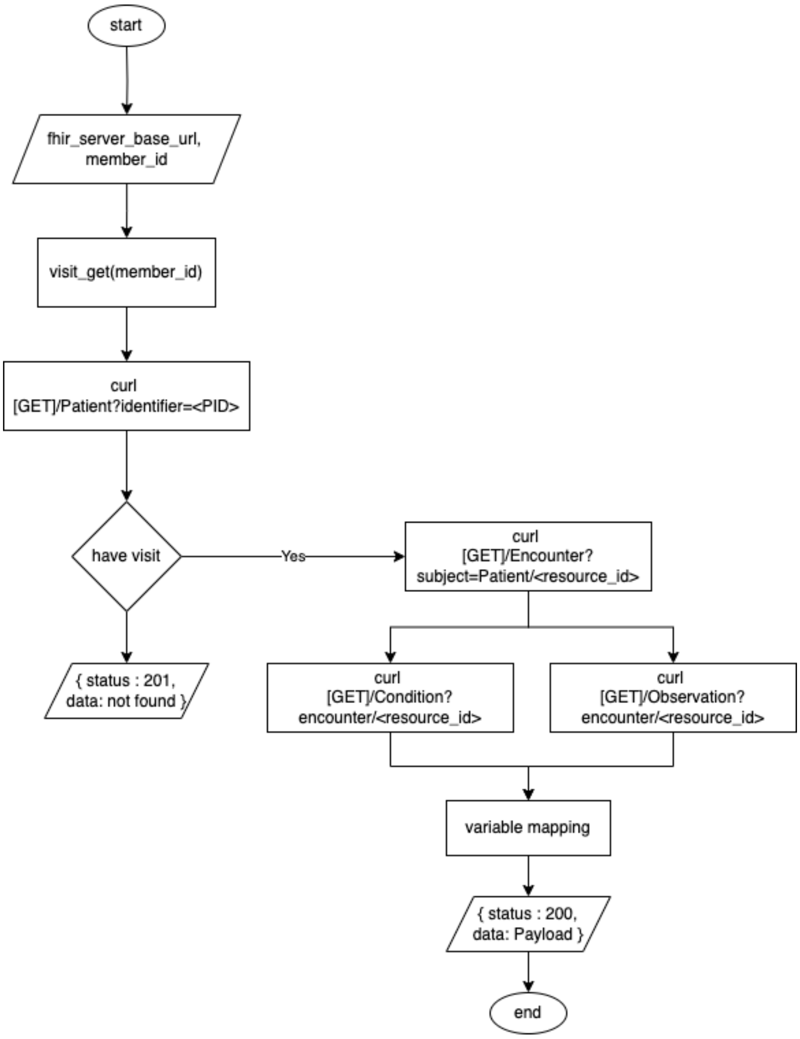

Figure 2 Flow chart how to get data from FHIR server and map to PHR

After determining the resources and mapping variables, then developing a data exchange architecture, then creating a detailed data access flow mechanism. The next step is to modify each application so that data exchange simulations can be carried out. A Master Patient Index (MPI) was utilized to match patient records using the National Identification Number (NIK) as Patient Identifiers (PIDs), ensuring accurate and secure retrieval of patient information. This approach establishes a structured framework for testing and implementing FHIR-based data exchange.

3. RESULTS AND DISCUSSIONS

The implementation of the prototype demonstrates that patient medical records stored in the EHR can be accessed seamlessly by patients through the PHR. Using the FHIR-HL7 standard, patient demographic data can be exchanged effectively using the **Patient** resource, ensuring accurate and secure data sharing. Additionally, diagnostic information is successfully exchanged using the **Condition** resource, enabling better continuity of care. Vital sign data, including systolic and diastolic blood pressure, body weight, and height, are also exchanged efficiently using the **Observation** resource. These results highlight the effectiveness of leveraging FHIR-HL7 resources to achieve interoperable health data exchange and improve patient access to personal health information.

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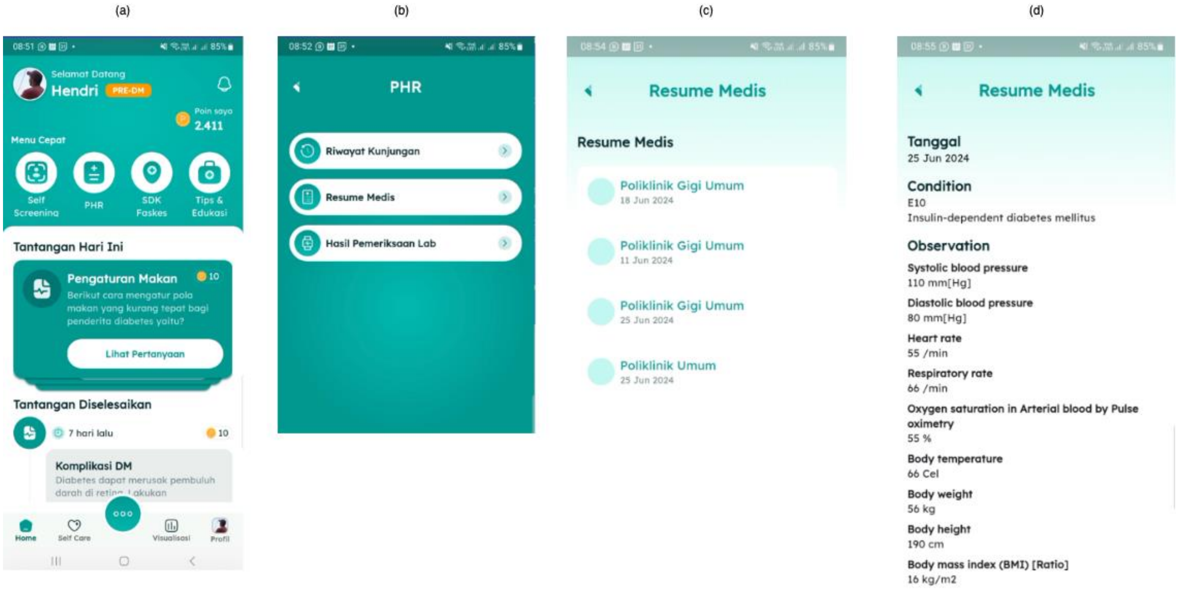

Figure 3 Interface of PHR application. (a) Home page (b) PHR menu (c) User visits (d) interface medical record from specific visit

Figure 3 depicts the various screens or views of a PHR application. The image is divided into four parts, as described by the labels (a), (b), (c), and (d) as follows: (a) Home Page: This section shows the initial screen that users see when they open the PHR application. The home page typically provides an overview of the user's health data, important notifications, and quick access to various features of the application. (b) PHR Menu: This part displays the menu of the PHR application, where users can navigate to different sections of their health records. The menu might include options like medical history and lab results, allowing users to easily manage and access their health information. (c) User Visits: This section represents the screen where users can view their past visits or appointments with healthcare providers. It may show a list of all medical visits, including dates, healthcare providers, and visit types (e.g., routine check-up, specialist consultation, etc.). (d) Interface Medical Record from Specific Visit: This part shows the detailed medical record from a particular visit. It may include information such as the diagnosis, vital sign, body weight, lab results, and notes from the healthcare provider, giving users access to specific details related to their past visit.

The following is an example of a payload from a Condition resource obtained from the FHIR Server. The payload contains information about the resource type, unique ID, update time, clinical status, category of condition and value of the resource which is represented by the path *resource.code.coding.code* and *display*

Response Body


```
{
  "resourceType": "Bundle",
  "id": "2123cf69-5764-406f-b425-978c7b0b4805",
  "meta": {
    "lastUpdated": "2024-12-27T01:32:24.200+00:00"
  },
  "type": "searchset",
  "total": 2,
  "link": [ {
    "relation": "self",
    "url": "http://fhir.sisfomedika.co.id/fhir/Condition?encounter=50634faf-bb06-
  } ],
  "entry": [ {
    "fullUrl": "http://fhir.sisfomedika.co.id/fhir/Condition/4cc74785-527b-47db-a
    "resource": {
      "resourceType": "Condition",
      "id": "4cc74785-527b-47db-a832-ce053b38ae72",
      "meta": {
        "versionId": "1",
        "lastUpdated": "2024-06-27T09:40:12.162+00:00",
        "source": "#pcUnnwvN1eSqqI0x"
      },
      "clinicalStatus": {
        "coding": [ {
          "system": "http://terminology.hl7.org/CodeSystem/condition-clinical",
          "code": "active",
          "display": "Active"
        } ]
      },
      "category": [ {
        "coding": [ {
          "system": "http://terminology.hl7.org/CodeSystem/condition-category",
          "code": "encounter-diagnosis",
          "display": "Encounter Diagnosis"
        } ]
      } ],
      "code": {
        "coding": [ {
          "system": "http://hl7.org/fhir/sid/icd-10",
          "code": "E10",
          "display": "Insulin-dependent diabetes mellitus"
        } ]
      },
```


Figure 4 FHIR Resource: Condition

4. CONCLUSION (10 PT)

FHIR serves as a reliable standard for healthcare data exchange, particularly for managing patient medical records. In this implementation, the Patient resource is utilized to exchange patient demographic data. The Observation resource facilitates the sharing of vital signs, such as blood pressure, weight, and height, while the Condition resource enables the exchange of diagnostic information. These findings underline the potential of FHIR as an effective framework for interoperable health data exchange, supporting improved access and continuity of patient care.

To enhance the implementation of interoperable health data exchange, we recommend to addressing security issues related to authentication and consent is critical. Robust authentication mechanisms should be employed to ensure that only authorized users can access sensitive health data, with secure processes such as multi-factor authentication and encrypted communication channels. Additionally, patient consent must be explicitly obtained and managed, adhering to privacy regulations and providing patients with control over their data access and sharing preferences. Furthermore, extending the system's capabilities to include prescription history would provide a more comprehensive view of patient health records, supporting better clinical decision-making and personalized care. These recommendations aim to improve both the security and functionality of the health data exchange system.

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CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Author1: Conceptualization, Methodology, Backend software engineer, Project administration. **Author2**: Frontend software developer, Design UI/UX. **Author3**: Frontend software developer, infrastructure provider.

DECLARATION OF COMPETING INTERESTS

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

[1] Vorisek, Carina & Lehne, Moritz & Klopfenstein, Sophie & Bartschke, Alexander & Haese, Thomas & Thun, Sylvia. (2021). Fast Healthcare Interoperability Resources (FHIR) for Interoperability in Health Research: A Systematic Review (Preprint). JMIR Medical Informatics. 10. 10.2196/35724.

[2] Alanazi, A.; Alanazi, M.; Aldosari, B. Personal Health Record (PHR) Experience and Recommendations for a Transformation in Saudi Arabia. *J. Pers. Med.* **2023**, *13*, 1275. https://doi.org/10.3390/jpm13081275.

[3] Nurrahma AN, Larasati TA, Kurniati I, Pramesona BA. Electronic medical records in first level health facilities. Rev Prim Care Prac and Educ. 2023; 6(2): 22-26.

[4] Torab-Miandoab, A., Samad-Soltani, T., Jodati, A. *et al.* Interoperability of heterogeneous health information systems: a systematic literature review. *BMC Med Inform Decis Mak* 23, 18 (2023). https://doi.org/10.1186/s12911-023-02115-5.

[5] Kiourtis, Athanasios & Mavrogiorgou, Argyro & Menychtas, Andreas & Maglogiannis, Ilias & Kyriazis, Dimosthenis. (2019). Structurally Mapping Healthcare Data to HL7 FHIR through Ontology Alignment. Journal of Medical Systems. 43. 10.1007/s10916-019-1183-y.

[6] Jones DA, Shipman JP, Plaut DA, Selden CR. Characteristics of personal health records: findings of the Medical Library Association/National Library of Medicine Joint Electronic Personal Health Record Task Force. J Med Libr Assoc. 2010 Jul;98(3):243-9. doi: 10.3163/1536-5050.98.3.013. PMID: 20648259; PMCID: PMC2900995.

[7] Saripalle, R., Runyan, C., Russell, M. Using HL7 FHIR to achieve interoperability in patient health record. Journal of Biomedical Informatics. 2019, https://doi.org/10.1016/j.jbi.2019.103188.

[8] P. Jayathissa, R. Hewapathirana, HAPI-FHIR Server Implementation to Enhancing Interoperability among Primary Care Health Information Systems in Sri Lanka: Review of the Technical Use Case, 2024.

[9] Ayaz M, Pasha M, Alzahrani M, Budiarto R, Stiawan D The Fast Health Interoperability Resources (FHIR) Standard: Systematic Literature Review of Implementations, Applications, Challenges and Opportunities JMIR Med Inform 2021;9(7):e21929 URL: https://medinform.jmir.org/2021/7/e21929 DOI: 10.2196/21929.

[10] Janssen A, Kay J, Talic S, Pusic M, Birnbaum RJ, Cavalcanti R, Gasevic D, Shaw T. Electronic Health Records That Support Health Professional Reflective Practice: a Missed Opportunity in Digital Health. J Healthc Inform Res. 2023 Jan 20;6(4):375-384. doi: 10.1007/s41666-022-00123-0. PMID: 36744083; PMCID: PMC9892400.

[11] https://www.capminds.com/blog/hl7-fhir-ehr-data-transmission-9-easy-steps-to-implement/ accessed in Dec, 26 2024

[12] Sarwal D, Gupta V. Personal Health Record. [Updated 2024 Sep 10]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK557757/.