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MOTU on FHIR: A preliminary strategy to enable interoperability for retrospective dataset standardization

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MOTU on FHIR: A preliminary strategy to enable interoperability for retrospective dataset standardization

Arcobelli V.A., Moscato S., Marfoglia A., Nardini F., Randi P., Davalli A., Carbonaro A., Palumbo P., Chiari L., and Mellone S.

***Abstract*— We present the application of HL7-FHIR to standardize a retrospective heterogeneous dataset, enhancing human/machine readability and interoperability.**

***Clinical Relevance*— The adopted strategy enables secondary use of clinical data in scientific medical research.**

I. Introduction

In the ever-evolving landscape of digital healthcare, exchanging data effectively and seamlessly across various institutions, processes, and devices has emerged as a critical challenge. However, the current lack of regulatory guidelines and incentives has led to a proliferation of custom data formats and interfaces for short-term gains, hindering interoperability [1]. To address this issue, standardization plays a crucial role in achieving data harmonization, improving the availability, safety [2], [3] and correctness of the information. Moreover, it allows researchers to perform analysis by drawing information from different sources.

In the field of healthcare data interoperability, one noteworthy solution is the Fast Healthcare Interoperability Resources (FHIR), a contemporary HL7 standard that offers an accessible and efficient means of facilitating data exchange while simultaneously striking a balance between standardization and adaptability. FHIR comprises a set of rules and specifications tailored for the purpose of electronic healthcare data exchange. It is deliberately designed to exhibit flexibility and adaptability, enabling its utilization across diverse healthcare settings and with varying healthcare information systems. The adoption of FHIR as a standard for healthcare data exchange bears several notable advantages in the context of prospective data curation and the secondary reuse of real-world data for medical data science, such as cost-effectiveness, increasing quality, and high flexibility of the analysis [4], enabling and supporting continuity of care at all levels of the health system, regardless of the software used.

In this study, we present a preliminary effort to map a database about patients with trans-femoral amputation (the MOTU database) to the FHIR standard, aiming to render it both machine-readable and comprehensible to humans.

II. Materials and Methods

A. MOTU dataset

The MOTU dataset originates from a retrospective observational study [5] conducted at the Italian National Institute for on-the-Job Injuries (INAIL) Prosthesis Center in Budrio, Italy, within the framework of the MOTU project [6]. We included all hospital stays for rehabilitation, occurred between January 2011 and May 2020, of patients aged 18 years or more, with unilateral trans-femoral amputation and patient's signed consent for data usage for research purpose. The aim of the study was to assess the degree of safety against falls of different prosthetic knees, as well as the efficacy of these devices with respect to different balance and mobility outcomes. Part of the MOTU dataset has already been published [7].

The full dataset contains data from 3035 hospital stays, of 1005 patients. The data are organized in five tables: Patients, Hospital stays, Falls, Drugs, and Prosthetic knees. Each patient is associated with an anonymous identifier and is characterized by their age and gender. Each hospital stay is identified by the patient's identifier and the admission date. The hospital stays are further characterized by the discharge date, the reason for the hospitalization, information about the amputation, anthropometric data, the goal of the rehabilitation, whether this goal was achieved at discharge, scores on different questionnaires and instrumented tests about balance, mobility, fall risk, and dependency for activities of daily living assessed at different time points during the rehabilitation path, history of falls, pain, and comorbidities. The table about falls provides details on 147 falls experienced by the patients during their hospitalizations, including the date, whether the patient was wearing the prosthesis during the fall, and any injuries caused by the fall. The table about drugs lists 3035 medicines taken during the hospitalizations, including the trade name of each drug and their Anatomical Therapeutic Chemical (ATC) classification code. The table about prosthetic knees provides information about the manufacturer, the device weight, the maximum patient weight allowed for the device, some design characteristics, and a link to the manufacturer's webpage.

B. Conversion strategy and tool selection

In order to achieve a declarative, modular and maintainable transformation pipeline, we chose templating as the conversion strategy. Specifically, we utilized the HL7 FHIR Mapping Language [8], a mapping language specification which we used to convert data from custom formats to the FHIR model. Finally, we chose the Matchbox[9], as a FHIR templating engine implementation, due to its versatile features, including offline transformation, standalone microservice

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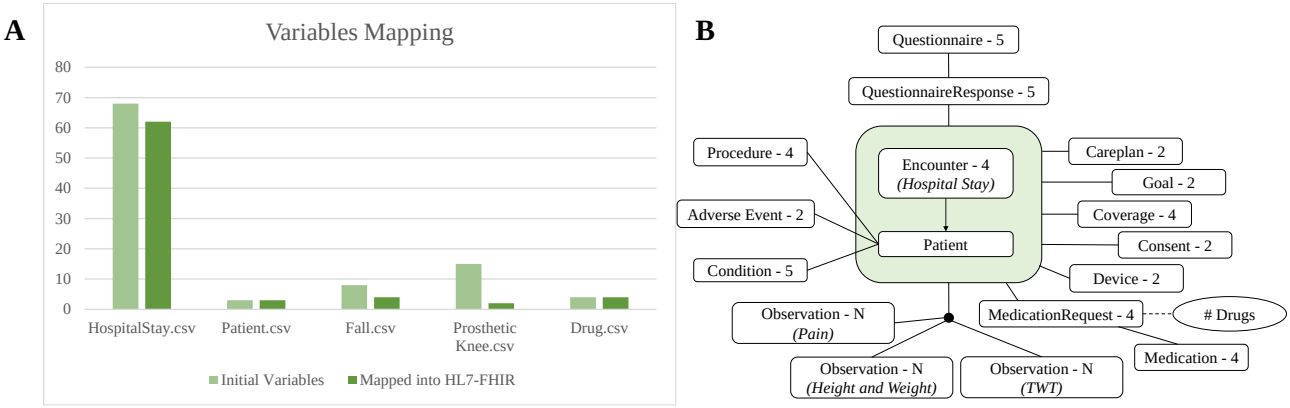

Figure 1. A) Number of variables in the starting dataset and number of variables mapped into HL7-FHIR standard. B) HL7-FHIR resources to map the dataset, with the maturity level specified

deployment, and seamless integration as a Java library. These capabilities empower our project to readily accommodate future evolutions and changing requirements.

C. Resources mapping

Two HL7 FHIR R4 experts independently mapped MOTU database variables into suitable FHIR resources, then together resolved any possible discrepancies, and established the final resource mapping with appropriate coding systems and using a modular template approach with MatchBox. We also implemented a FHIR server operation (# Drug in Figure 1B) to track the number of drug intake during hospital stays.

III. Results

From the initial set of 98 variables in the MOTU dataset, we successfully mapped a total of 75 variables (77% of the dataset) into FHIR resources (Fig 1.A). This mapping involved the use of 15 distinct resources and a FHIR-server operation, as illustrated in Fig 1.B. To accurately reproduce the instances of the MOTU dataset as hospital stays, and the relationships between the variables, we established references between the resources and the patient-hospital stay coupling.

IV. Discussion and Conclusion

We successfully mapped the MOTU dataset into the FHIR data standard, achieving a relevant mapping percentage. The adopted methodology can be generalized to any retrospective dataset, as the scalability of this method is ensured by the templating managed on MatchBox by implementing a modular approach and being adaptable to different, and more complex, sources of information. There is potential for further enhancement through additional analysis, particularly concerning the table related to prosthetic knees, where only 2 out of 15 resources were mapped. MOTU dataset converted to FHIR improves accessibility and readability, making data easily readable by both humans and machines. In the presented study, a team of four highly proficient experts invested substantial effort, which included participation in 13 discussion meetings lasting approximately 2 hours each, engagement in 4 brainstorming sessions spanning around 6 hours each and dedicating approximately 40 hours to individual work per team member. This collaborative effort resulted in each individual investing a total of 90 working hours, highlighting the importance of early adoption of data standardization for retrospective studies. Next stages will focus on: i) conducting further analysis on the prosthetic knee table, ii) validating the dataset in FHIR server, and iii) developing a modular working pipeline that can be applied to other datasets and prospective studies.

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