

# Comparing SDTM and FHIR® for Real World Data from Electronic Health Records for Clinical Trial Submissions

Sarah RIEPENHAUSEN<sup>a,1</sup>, Cornelia MERTENS<sup>a</sup> and Martin DUGAS<sup>a</sup>

<sup>a</sup>*Institute of Medical Informatics, University of Münster*

**Abstract.** Real world data for use in clinical trials is promising. We compared the SDTM for clinical trial data submission with FHIR® for routine documentation. After categorization of variables by relevance, clinically relevant SDTM items were mapped to FHIR®. About 30% in both were seen as clinically relevant. The majority of these SDTM items were mappable to FHIR® Observation resource.

**Keywords.** Real World Data, SDTM, FHIR

## 1. Introduction

The scientific potential of using real world data from electronic health records (EHR) for research e.g. in electronic data capture (EDC) systems is high[1–4]. Redundant diagnostics and documentation cost time and money and may influence patient health. Re-using existing data from routine documentation for research (and vice versa) may benefit trial sponsors, payers of health bills, care teams and patients. Here FHIR® (Fast Healthcare Interoperability Resources) and SDTM (Study Data Tabulation Model) are used as EHR and clinical trial metadata examples, respectively.

FHIR® is under development at HL7® (Health Level 7) for several health care contexts. The latest release on <http://hl7.org/fhir/> is R4 (v4.0.1, R5 preview only) as the first version with normative content, for which HL7® states changes are to be “infrequent and [...] tightly constrained” and forward compatibility is enforced.

CDISC (Clinical Data Interchange Standards Consortium) maintains SDTM. It standardizes data submission of clinical trials to regulatory authorities and is still required by the FDA. The current implementation guide for human clinical trials SDTMIG v3.3 references v1.7. SDTM Terminology is published on <https://datascience.cancer.gov/resources/cancer-vocabulary/cdisc-terminology>.

The (main) aim of these standards is different, but both are concerned with patients’ health data. An overlap was shown previously[5,6]. Here the extent of overlap was investigated with semantic and manual mapping. The focus was on clinically relevant data items.

---

<sup>1</sup> Corresponding Author, Sarah Riepenhausen, Institute of Medical Informatics, University of Münster, Albert-Schweitzer-Campus 1, Gebäude A11, 48149 Münster, Germany; E-mail: [sarah.riepenhausen@uni-muenster.de](mailto:sarah.riepenhausen@uni-muenster.de)

## 2. Methods

This analysis was based on SDTM v1.7 with SDTMIG v3.3 and SDTM Terminology (as of November 2019) and HL7® FHIR® R4 (v4.0.1) resources listed on <http://hl7.org/fhir/>. All items/variables referred by SDTMIG v3.3 and FHIR® R4 were reviewed by two physicians and categorized into clinically relevant, insecure clinical relevance and not-clinically relevant. Disagreement was resolved by discussion between reviewers.

“Clinically relevant” was defined as direct relevance for health care teams, e.g. diagnoses, tests and results, demographics, and family history.

Not-clinically relevant were redundant variables (e.g. synonyms), derivable data items (e.g. study day from dates, standardized from collected results), technical specifications (e.g. FHIR® server) and administrative information (e.g. location of a device, billing). Synonyms and derivable data seem to be for ease of analysis, but offer little to no additional information. Identifiers were seen as technical items for identification purposes to link different data sources.

In between are variables of insecure relevance, i.e. borderline cases. This comprises relevance in rare (constructed) cases or insufficient definition for reliable categorization.

As FHIR® is still under development, maturity of resources was analyzed.

Clinically relevant items were modeled in ODM (CDISC Operational Data Model) and annotated with ODMEdit tool[7] under supervision of the two physicians. Annotation relied mostly on Unified Medical Language System Concept Unique Identifiers (UMLS[8] CUIs) which are used in the Portal of Medical Data Models (MDM Portal, <https://medical-data-models.org/>), supplemented by CUIs from UMLS if necessary. ODM files were semantically analyzed with CDEgenerator[9]. Code-cleaning (uniform CUI coding) was applied to improve matching of codes between different coders.

SDTM items were manually mapped to FHIR® to determine which FHIR® variables can provide data for SDTM by one physician. A direct match with the source specification is “almost no work” except mapping of variables/terminologies. If a profile would have to be defined, there are two options: It is sufficient to implement example ValueSets, extend pre-defined ValueSets or use pre-defined extensions (“Work, but a lot of help”) or more work is necessary with less support from the specification: creation of custom extensions (no place identified, where the information could be found or ValueSets/ Codelists not extensible/mappable) or use of several resources/variables for relevant information for a single SDTM item (for example one codelist in SDTM will have different sources in FHIR® for each codelistitem).

## 3. Results

About 30% of variables in both standards were categorized as “clinically relevant”, more than 50% in both were deemed “non-clinically relevant”. Examples of the categorization of both systems can be found in table 1.

Up to about 10% of variable categorizations were initially discordant between the two physicians (FHIR® about 10% vs. SDTM about 4%).

**Table 1.** Categories of relevance to the treating health care team in FHIR® and SDTM with examples and distribution.

Category	FHIR® Examples	Extent	SDTM Examples	Extent
Clinically relevant	Procedure/Condition.code Specimen.collection.bodySite Patient.birthdate	1,112 27.7%	“Topic”: --TRT, --TERM absolute time, excl. data collection: --DTC, --STDTC	624 36.2%
Insecure relevance	Immunization.lotNumber EpisodeOfCare.diagnosis.rank	554 13.8%	Collection timing: MHDTC	204 11.8%
Non-relevant	Practioner.photo Patient.identifier	2,335 58.3%	Synonyms: --MODIFY Relative timing: PRENRTRT	895 51.9%
Total		4,001		1,723

The normative content in FHIR® concerns mostly non-clinically relevant data (over 70% of all variables in normative resources). The extent of normative resources overall is still rather low with 8%.

Semantic mapping resulted in a rather low overlap between SDTM and FHIR® variables (5 after code-cleaning, with 11 concepts). Annotated clinically relevant FHIR® and SDTM variables prior to code-cleaning are available at <https://medical-data-models.org/search?query=fhir> and <https://medical-data-models.org/41546>.

Variables from 32 of the 146 available resources were used for manual mapping, table 2 shows the 5 most frequently used FHIR® resources. Most SDTM items were mapped to FHIR® Observation resource variables. Only few variables were directly mappable, i.e. SDTM Terminology codelist and FHIR® ValueSet were defined (almost) identically, FHIR® variables were fully specified to allow a derivation of data even prior to definition of profiles. About 72% of variables had at least mappable example ValueSets or pre-specified extensions that could be used in FHIR® for the information in SDTM. The target location of the information is clear, it just has to be implemented or extended as proposed. For about 25% it was not completely clear where to find the information in FHIR®. A custom extension is needed. Among these were also variables from SDTM, that would need to be mapped to several FHIR® variables – e.g. SCTEST from the Subject Characteristics Domain in Condition, Observation, and Patient, ... for variables from the Subject Characteristics Domain – and could not be mapped to a single, consistent variable (combination). Also this applies to variables where codelists in SDTM and FHIR® ValueSets are not extensible and not directly mappable.

**Table 2.** The 5 most frequently used resources in manual mapping of clinically relevant SDTM items to FHIR® resources.

Top 5 FHIR® resources	Frequency	Domains that are (partly) mapped to the resource
Observation	438 (70%)	Observation Domains and more
ImagingStudy	97 (16%)	Observation Domains with possible imaging
MedicationAdministration	85 (14%)	Exposure (as collected), Procedure Agents, Concomitant Medication
DiagnosticReport	57 (9%)	Complementing Observation Domain information
AdverseEvent	45 (7%)	Adverse Event, Clinical Event

#### 4. Discussion

Clinically relevant content does not make the majority of elements in both FHIR® and SDTM, for different reasons. SDTM is designed for the needs of data analysis in clinical studies. There are a lot of synonymous variables in SDTM: reported term, dictionary derived term and sponsor-defined term describe the same disease. Tests are given as long form (“Name”) and short form (“Code”). Timing is noted in absolute values and derivable relative values (e.g. Study Day of the Procedure derived from Start Date of Procedure and Start Date of Study Participation). In FHIR® some resources and variables define technical processes or specifications or allow scheduling or billing. These are important for the technical system and to support the workflow of a hospital, but are less important for the health care team.

Semantic mapping identified only a small overlap between SDTM and FHIR®. This is caused by the difference in definition levels; for example a large amount of SDTM variables from different domains can be mapped to observation resource variables. Most information can be mapped manually and to a certain extent via coding, as the Laboratory Domain in SDTM does contain a LBLOINC item for LOINC coding. However, this is only possible if proposed ValueSets are used.

Clinically defined content in FHIR® R4 seems to be rather limited, especially in the diagnostic/observational part. Results from very different sources are covered by DiagnosticReports: Observations with or without associated ImagingStudy, Procedure, MedicationAdministration, ImmunisationAdministration or QuestionnaireResponse, etc. SDTM is more specific, but still not exactly defined. For example, where in FHIR® Observation.code all LOINC codes are suggested as possible values, SDTMTerminology for LBTEST in SDTM only suggests slightly over >1,900 values.

Using terminologies (e.g. LOINC for Observation) as the only definition of content looks like an externalization of complexity – in contrast to Grahame Grieve’s statement “that’s not the intent at all”[10]. With many similar codes in SNOMED CT or LOINC, a constraint would be needed for harmonized data collection, that preferably is not (completely) left to the user. There are few proposals for more defined medical content on the FHIR® website, for instance an example profile for vital signs. More such profiles from an official source are needed to achieve a more harmonized data collection across (future) users of FHIR® from our perspective.

An official (dynamic) mapping is under progress extending prior work (e.g. [6,11,12]). Our approach has limitations: We did not map the complete SDTM: Only variables that are mentioned in SDTMIG v3.3 were used. There are further SDTM implementation guides (e.g. for Pharmacogenomics and Genetic Biomarkers or Devices), likely with more clinically relevant variables. Furthermore, SDTM is extensible (e.g. endocrine system findings or custom domains) with items not mentioned in SDTMIG v3.3.

The FHIR® standard is still work in progress; only a small proportion of content is normative yet.

This work was focused on resources. Pre-specified profile suggestions were not used for categorization and mapping except to check overall usage. We did not use simplifier.net, where user profiles and extensions are published, as we wanted to concentrate on the specification details and not user interpretations. Usability of either standard was not assessed.

## 5. Conclusion

According to our analysis, the FHIR® standard would benefit from more clinically defined content to standardize data collection. Mapping to SDTM is possible with limitations. Creation of SDTM conforming profiles could support re-use of real world data in clinical trial studies.

## References

- [1] Jorm L. Routinely collected data as a strategic resource for research: priorities for methods and workforce. *Public Health Res Pr.* [Internet] 2015;25(4).
- [2] Corrao G, Cantarutti A. Building reliable evidence from real-world data: Needs, methods, cautiousness and recommendations. *Pulmonary Pharmacology & Therapeutics.* 2018 Dec 1;53:61–7.
- [3] Martin-Sanchez FJ, Aguiar-Pulido V, Lopez-Campos GH, Peek N, Sacchi L. Secondary Use and Analysis of Big Data Collected for Patient Care. *Yearb Med Inform.* 2017 Aug;26(1):28–37.
- [4] Nordo AH, Levaux HP, Becnel LB, Galvez J, Rao P, Stem K, Prakash E, Kush RD. Use of EHRs data for clinical research: Historical progress and current applications. *Learning Health Systems.* 2019;3(1):e10076.
- [5] Clinical Research Sponsor Laboratory Semantics in FHIR, Available at: <http://hl7.org/fhir/uv/cdisc-lab/terminology.html>, Accessed December 17, 2020.
- [6] Zopf R, Abolafia J, Hill C, Reddy B. Use of Fast Healthcare Interoperability Resources (FHIR) in the Generation of Real World Evidence (RWE), PhUSE Annual Conference, Edinburgh, Scotland, 2017.
- [7] Dugas M, Meidt A, Neuhaus P, Storck M, Varghese J. ODMedit: uniform semantic annotation for data integration in medicine based on a public metadata repository. *BMC Medical Research Methodology.* 2016 Jun 1;16(1):65.
- [8] Bodenreider O. The Unified Medical Language System (UMLS): integrating biomedical terminology. *Nucleic Acids Res.* 2004 Jan 1;32(Database issue):D267–70.
- [9] Varghese J, Fujarski M, Hegselmann S, Neuhaus P, Dugas M. CDEGenerator: an online platform to learn from existing data models to build model registries. *Clin Epidemiol.* 2018 Aug 10;10:961–70.
- [10] Grieve G. #FHIR and confusion about the 80/20 rule. Health Intersections Pty Ltd. 2014, Available at: <http://www.healthintersections.com.au/?p=1924>, Accessed September 8, 2020.
- [11] Aerts J. Towards a Single Data Exchange Standard for Use in Healthcare and in Clinical Research. *Stud Health Technol Inform.* 2018;248:55–63.
- [12] Healthcare Innovation. FHIR-to-CDISC Project Seeks to Facilitate Use of EHR data in Clinical Research 2020, Available at: <https://www.hcinnovationgroup.com/interoperability-hie/standards/news/21137358/fhirtocdisc-project-seeks-to-facilitate-use-of-ehr-data-in-clinical-research>, Accessed January 14, 2021