

# Towards a Clinically Meaningful Model to Structure the Development of Interoperable Order Sets, Applicable to the Point of Care in Any EMR

Mobin YASINI<sup>a,1</sup> Dennis RAUSCH<sup>a</sup>, Lise MARIN<sup>a</sup>, Ingrid HOCHHEIM<sup>a</sup>, Navinder SINGH DHILLON<sup>a</sup>, and Michael DAHLWEID<sup>a</sup>

<sup>a</sup>*Dedalus Research Lab, Italy*

ORCID ID: Mobin YASINI <https://orcid.org/0000-0002-9281-8875>

**Abstract.** Standardized order sets are a pragmatic type of clinical decision support that can improve adherence to clinical guidelines with a list of recommended orders related to a specific clinical context. We developed a structure facilitating the creation of order sets and making them interoperable, to increase their usability. Various orders contained in electronic medical records in different hospitals were identified and included in different categories of orderable items. Clear definitions were provided for each category. A mapping to FHIR resources was performed to relate these clinically meaningful categories to FHIR standards to assure interoperability. We used this structure to implement the relevant user interface in the Clinical Knowledge Platform. The use of standard medical terminologies and the integration of clinical information models like FHIR resources are key factors for creating reusable decision support systems. The content authors should be provided with a clinically meaningful system to use in a non-ambiguous context.

**Keywords.** Medical Record, Standing Orders, Electronic Prescribing

## 1. Introduction

One of the potentials of digitalizing medical records is the ability to implement clinical decision support systems (CDSS) that could help healthcare providers in a variety of decisions and patient care tasks [1]. CDSS are software applications designed to assist health care professionals in decision making throughout the care process. When used at the point of ordering, CDSS can integrate evidence-based clinical guidelines with computerized physician order entry systems (CPOE) [2].

Order sets are clinical tools that deliver guidance by providing a list of recommended orderable items applicable in a specific clinical context. A clinical context is a combination of various conditions including disease, symptoms, comorbidities, stage of the problem, stage of the care, demographic patient characteristics, etc.[3] that define the applicability of an order set. Orderable items could be of various types (medication, lab test, imaging, procedure, etc.) and each type could have various attributes (timing, count,

---

<sup>1</sup> Corresponding Author: Mobin Yasini, Dedalus France, 22 Avenue Galilée, 92350 Le Plessis-Robinson, France; E-mail: [mobin.yasini@dedalus.eu](mailto:mobin.yasini@dedalus.eu)

frequency, etc.). Standardized order sets can positively influence adherence to evidence-based guidelines and could be used to ensure appropriate orders are being made by health professionals and therefore reduce errors [4].

Despite ongoing development and promising potentials of CDSS in general, lack of interoperability renders many CDSS as cumbersome stand-alone systems that cannot communicate effectively with other systems [1] or may be used only in the EMRs for which they had been developed. This makes the applicability of CDSS including order sets limited to local use. Interoperability enables better workflows and reduces ambiguity among systems and could be used in various areas. For example, interoperable EMRs allow the electronic sharing of patient information between different systems and healthcare providers, improving the ease with which doctors can provide care to their patients. Interoperable CDSS could disseminate the knowledge that they represent in various systems and institutions and reduces the implementation costs through their reusability. The use of standardized formalisms for knowledge representation, like terminologies as well as the integration of semantically enriched clinical information models, contributes to the development of interoperable CDSS [5,6].

We have already presented the Clinical Knowledge Platform (CKP) as an ecosystem in which clinicians could create and share interoperable order sets [3]. In this paper, we present the method that we used to define various orderable items and the relevant attributes specific to each orderable item in a clinically meaningful manner. This provides clinicians with an easily understandable platform with necessary items that enables them to create interoperable order sets.

## 2. Methods

We need to provide the order set authors with a tool that empowers them to find the orderable items easily and rapidly, together with the relevant attributes. For that purpose, a working group including health professionals and experts in information technology (IT) and clinical informatics was created.

**Defining the classification of orderable items:** In order to identify the various clinically meaningful categories of orderable items, the health professionals of the working group have studied a set of 325 medical records selected randomly in different general hospitals in France and Germany. Medical records were first randomly assigned to two groups. The first group, the study group, containing two thirds of these records, was used to structure the categories of orderable items. The remaining third was used to validate the categories obtained. The orders of each medical record in the study group were listed. These orders were then analyzed to identify the categories to which they belong. Whenever an order could not be included in a category already created, a new category was added. The categories of orders found in the medical records were therefore enumerated incrementally, as they were discovered. A clear clinical definition was assigned to each category of orderable items to define the meaning and functionalities of each category.

**Defining the attributes of each category:** We then analyzed the orders of each category, to identify the various attributes that a category could include. For example, an order for the prescription of a drug may have attributes such as pharmaceutical form, route of administration, duration of administration, frequency, etc.

**Mapping to FHIR:** CKP uses FHIR resources and standard interrelated multi-terminology servers [3] to assure interoperability. FHIR resources for orderable items

were investigated by the working group to map the relevant resources to the founded categories. Then, the attributes for each category were discussed and linked to the relevant FHIR content.

Developing the order set designer in the CKP: The categories of orderable items and the relevant attributes were then used to develop the user interface in the CKP environment. Various catalogs of orderable items were tagged to the relevant categories and implemented in the CKP database. The content creator could search for orderable items and assemble the desired order set.

### 3. Results

13 clinically meaningful categories and 40 attributes were identified for orderable items. All the categories of orderable items found in the medical records, together with the mappings to FHIR resources and the definitions are represented in table 1.

**Table 1.** Categories of orderable items, definitions, and mapping to FHIR resources

Orderable category	Definition	FHIR correspondence
Imaging/nuclear medicine	Medical imaging refers to several different technologies that are used to view the human body in order to diagnose, monitor, or treat medical conditions. It includes radiography, CT, Fluoroscopy, Mammography, MRI, Ultrasound. Nuclear medicine uses radioactive material inside the body to see how organs or tissue are functioning (for diagnosis) or to target and destroy damaged or diseased organs or tissue (for treatment).	ServiceRequest
Medication/ vaccination/ Blood & Blood derivatives	A substance that is taken into or placed on the body for a specific medical purpose (cure a disease, treat a medical condition, relieve symptoms, prevent disease, etc.), Ordering vaccines and whole blood and blood components including RBC, Platelets, Plasma, Packed cells, etc. are also categorized in this group	Medication Request
Microbiology, lab tests, genetics & pathology	A medical procedure that involves testing a sample of blood, urine, or other substance or tissue from the body. These tests can help determine a diagnosis, plan treatment, check to see if treatment is working, or monitor the disease over time	ServiceRequest
Nutrition & Diet	Oral diets (including general diets such as general Healthy diet, or therapeutic diets such as consistent carbohydrate, 2-gram Sodium, or fluid restricted), oral nutrition supplements (such as nutritionally complete pre-packed drinks), enteral nutrition (tube feedings) and infant formula which govern the distribution of food and nutritional products used to feed patients within an in-patient setting.	NutritionOrder
Consultation	Asking the opinion of another specialist consultation and assessments about the patient	ServiceRequest Appointment
Nursing	Any activity that is motivated by the intention to provide Nursing care (care procedures, positioning, feeding, washing, shaving, talking to the patient etc.)	ServiceRequest
Lines & drains	Any activity that results in placing, removal or maintenance of Lines & Drains (urinary catheter, NG tube, airway, probes, etc.)	ServiceRequest
Tracking notification	A request to convey information, e.g., the physician or a CDS system proposes that an alert be sent to a responsible provider, the CDS system proposes that the public health agency be notified about a reportable condition.	Communication Request
Surgery	A medical act that is performed for the purpose of structurally altering the human body by incision or destruction of tissues as a part of the practice of medicine. It includes operations, but also activities like installing an ilizarov frame, pacemaker implants, etc.	ServiceRequest

Allied care	Allied care includes anything not done by physicians or nurses (physiotherapy, speech, behavioral, etc.)	ServiceRequest
Devices, gear, prostheses	Ordering a tool, device, prosthesis to be applied for the patient including mattresses, braces, ilizarov frame, pacemaker, etc.	DeviceRequest SupplyRequest
Wound care	Specific procedures for wounds (bandage, debridement, etc.)	ServiceRequest
Procedure	Other types of acts used to diagnose, measure, or treat problems such as disease or injury. It includes radiotherapy, tracheotomy, ECG, EEG, pacemaker check, endoscopy, biopsies, LP, PFT, etc.	ServiceRequest

Each attribute could be related to one or more categories. For example, an attribute like the day of the week which, if provided, specifies that the action happens only on the specified day, is related to all categories of orderable items. However, the attribute route of administration is related only to medication and nutrition categories. We mapped each category to the relevant HL7 FHIR resource. Various categories were mapped to service request resource which is not necessarily understood by clinicians.

These categories were developed from two thirds of the studied medical records and were validated on the remaining third. The validation showed that the data model was able to represent all the orders contained in the remaining third of the medical records.

Figure 1 shows some superposed screenshots of the implementation in the CKP.

The figure displays two overlapping screenshots of a software interface for configuring medication requests. The top screenshot shows a sidebar menu with categories like 'Medication request', 'Nutrition and diet', 'Imaging/Procedure Medication', 'Dress/linen', and 'Nursing'. The main area is titled 'Medication request' and contains various configuration fields: 'Dosage' (Single, Bulk), 'Maximum dosage' (Single, Bulk), 'Route of administration' (with a search field), 'Administration method' (with a search field), and 'Body site' (with a search field). The bottom screenshot shows a 'Timing' configuration section with options for 'Select from Catalogue' or 'Custom', 'Frequency' (Single, Range), 'Period' (Single, Range), 'Duration' (with search fields), 'Activity Duration' (Single, Range), 'Count' (Single, Range), and 'Day(s) of the Week' (with a 'Select day' dropdown and checkboxes for 'each time' and 'when').

**Figure 1.** When the category is selected to medication request, the relevant attributes are automatically presented to the user. The attributes are also allocated to some groups to provide the user with a better usability.

While creating an order set, the user could directly search the orderable item or find it by choosing the relevant category of orderable items. Then, according to the category to which the orderable item belongs, the relevant attributes will be displayed to the user to specify the exact application of the orderable item in question.

#### 4. Discussion

In this study, we have proposed 13 clinically meaningful categories of orderable items together with clear definitions and relevant attributes specific to each item. The content providers and clinicians could therefore create various order sets in the CKP. Using FHIR resources and mapping clinical concepts to standard terminologies in the CKP makes these order sets interoperable and allow them to be shared with various systems.

Our approach to the use of standardized formalisms for knowledge representation as terminologies as well as the integration of semantically enriched clinical information

models like FHIR resources, corroborates with the results of other studies that consider these issues as key factors for reusable CDSS [5]. Standardized order sets are shown to be associated with reduced hospital stays, decreased adverse patient effects, lower risk of mortality and increased cost-effectiveness [6–8].

Only health professionals were involved in the phase of defining the categories because the output had to be clinically meaningful. General hospitals were selected because all specialties had to be covered. However, in most hospitals, the orders are already organized by categories that may have a bias on the categories of orderable items that are used while developing an order set. The working group has merged some of the categories (like imaging and nuclear medicine). This was to improve the user experience while searching for orderable items. FHIR resources are complex, not clinically meaningful and include many attributes which are not necessarily understandable by clinicians. That's why we have mapped our categories to FHIR and gathered only functional attributes that are useful in our use case, instead of using original FHIR terms.

Further optimization of this structure, by other users than the developer team, including content providers, is required to confirm its generic nature. A quantitative evaluation of the impact of the interface in terms of the ease and intuitiveness to which physicians and content providers could create order sets would be of considerable interest. If the results of the evaluations are promising, recommended order items (within the categories) would be proposed as standards to be used for recommendations. CKP including the standardized and interoperable order sets can pave the way to other possible applications for improving the quality of medical practice. These applications may be based on various clinical contexts in which a physician prescribes or makes orders that are needed to be in accordance with the recommendations. The orderable categories can be also used to standardize clinical pathways, which involve a series of orders over time. Clinical pathways play a crucial role in patient care and standardizing them, like order sets, could lead to enhanced efficiency and better quality of care.

## References

- [1] Sutton RT, Pincock D, Baumgart DC, Sadowski DC, et al. An overview of clinical decision support systems: benefits, risks, and strategies for success. *NPJ digital medicine*. 2020 Feb 6;3(1):17.
- [2] Forseen SE, Corey AS. Clinical decision support and acute low back pain: evidence-based order sets. *Journal of the American College of Radiology*. 2012 Oct 1;9(10):704-12.
- [3] Dahlweid M, Rausch D, Hinske C, Darmoni S, Grosjean J, Santi J, Marin L, Yasini M. Clinical Knowledge Platform (CKP): A Collaborative Ecosystem to Share Interoperable Clinical Forms, Viewers, and Order Sets with Various EMRs. In *Digital Professionalism in Health and Care: Developing the Workforce, Building the Future 2022 Aug 1* (pp. 117-121). IOS Press.
- [4] Ansari S, Fung K, MacNeil SD, Nichols AC, Yoo J, Sowerby LJ. The use of standardized order sets to improve adherence to evidence-based postoperative management in major head and neck surgery. *European annals of otorhinolaryngology, head and neck diseases*. 2018 Sep 1;135(5):S107-11.
- [5] Wulff A, Haarbrandt B, et al. An interoperable clinical decision-support system for early detection of SIRS in pediatric intensive care using openEHR. *Artificial Intelligence in Medicine*. 2018;89:10-23.
- [6] Kijirichareanchai K, Ngamruengphong S, Rakvit A, Nugent K, Parupudi S. The utilization of standardized order sets using AASLD guidelines for patients with suspected cirrhosis and acute gastrointestinal bleeding. *Quality Management in Healthcare*. 2013 Apr 1;22(2):146-51.
- [7] Fleming NS, Ogola G, Ballard DJ. Implementing a standardized order set for community-acquired pneumonia: impact on mortality and cost. *The Joint Commission Journal on Quality and Patient Safety*. 2009 Aug 1;35(8):414-AP5.
- [8] Zeidan AM, Streiff MB, Lau BD, Ahmed SR, Kraus PS, Hobson DB, Carolan H, Lambrianidi C, Horn PB, Shermock KM, Tinoco G. Impact of a venous thromboembolism prophylaxis "smart order set": improved compliance, fewer events. *American journal of hematology*. 2013 Jul;88(7):545-9..