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Interdisciplinary Teams in Health Informatics: Using FHIR Standards to Share Computable Knowledge

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Abstract. The use and shareability of Clinical Quality Language (CQL) artefacts is an important aspect in enabling the exchange and interoperability of clinical data to support both clinical decisions and research in the medical informatics field. This paper, while basing on use cases and synthetic data, developed purposeful CQL reusable libraries to showcase the possibilities of multidisciplinary teams and how CQLs could be best used to support clinical decision making.

Keywords. Clinical Quality Language (CQL), CQL artefacts, Healthcare data, Interoperability, FHIR, computable knowledge

1. Introduction

Creating and sharing computable knowledge, in other words executable knowledge in healthcare is a complex and challenging [1]. To develop computable knowledge, we require data and knowledge, which are formatted in a sequential format, understandable by a computer. As computable knowledge infers that it is not just data, but we require knowledge to produce it. This knowledge can be healthcare based such as causes of a health condition or effectiveness of medication [2] but it also requires engineers and developers, overall organised interdisciplinary teams [3].

The National Institute for Health and Care Excellence (NICE) is trying to increase the level of programmable capabilities of the Clinical Practice Guidelines (CPG), by adding structured and standardised clinical codes to its guidelines [4]. CPGs are meant to express best practices in healthcare and are commonly presented as narrative documents communicating care processes, decision making, and clinical case knowledge. The NICE initiative is clearly related with programming technologies that would enable those codes to be used.

Two of the main strategical objectives of Health Level Seven International (HL7) [5], SNOMED International [6] and Health Data Research UK (HDRUK) [7] are

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international and national interoperability as well as using data and analytics. To achieve this they provide standards and healthcare domain-specific languages (DSL) such as Fast Healthcare Interoperability Resources (FHIR) [8] and Clinical Quality Language (CQL) [9]. Those are used to describe a CPG, and provide a standardized, shareable, computable artefact that leaves little room for misinterpretation or ambiguity. This is one of the reasons why countries like Germany [10] and the UK are working towards adopting FHIR as the framework for healthcare data interoperability [11].

Computable knowledge artefacts are notoriously un-sharable and often hidden behind corporate walls. Developing libraries of structured, tested, meaningful and sharable computable knowledge artefacts and to enhance the Learning Health System, can improve the benefits of innovation and the decision making of clinicians.

This paper aims to showcase how fit to purpose use cases and synthetic data are used to develop purposeful CQL re-usable libraries.

2. Methods

We developed and verified seven use cases in order to create educational tutorials for computable knowledge, as was described in detail in a previous publication [1].

Four use cases were developed with focus on Type 2 Diabetes (T2D) diagnosis based on Type 2 Diabetes diagnostic NICE guidelines [12]. The other three developed use cases focus on prescribing direct oral anticoagulants (DOAC) in patients with Non-Valvular Atrial Fibrillation (AF) and for the treatment and prevention of venous thromboembolism (VTE) [13]. The T2D use cases were inspired by case studies aimed at training clinicians [14] and the DOAC related use cases were inspired by use cases published previously in the Hospitalist [15]. The intention behind creating these use cases for diagnoses and prescription was to showcase that FHIR standards and CQL are able to be used in both of these categories.

A FHIR server was setup, relevant to the use cases resources were created. This resulted into “Condition” and “Observation” FHIR resources which were coded using SNOMED CT and LOINC code systems [16] respectively, while the UCUM [17] standard was used for the value units.

Based on the Condition and Observation FHIR resources, CQL libraries were created to reflect the use cases and population. The CQLs were then tested using Postman as a REST client application, which successfully returned the desired population results.

3. Results

The developed CQL artefacts, use cases and the rest of the resources of this publication are freely available at the GitHub repository [18]. A healthcare professional verified the use cases and the artefacts for medical accuracy, a programmer developed the FHIR server and the CQL libraries and a health informatician was responsible for the coordination and communication.

The T2D use cases were discussing generic elements of the diagnosis and their rationale is modeled in Figure 1. The use cases about the DOAC prescription’s rationale are modelled in Figure 2. The CQL artefacts were created and tested based on Blaze FHIR server. Figure 3 shows code snippets from use case 2 CQL that was created.

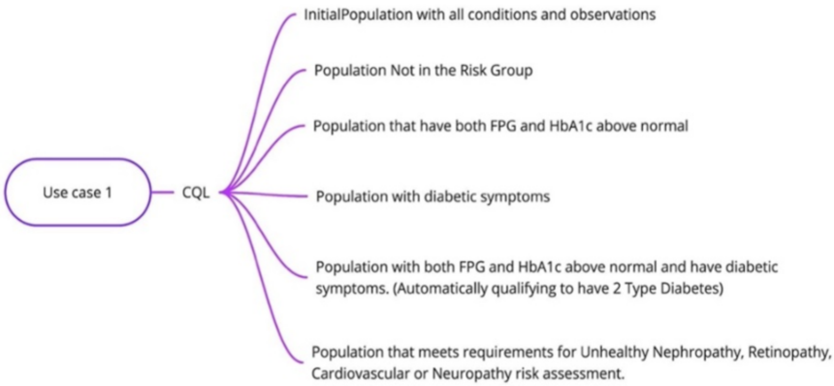

Figure 1. Model of use case 1 (T2D) CQL and population measures that it can query.

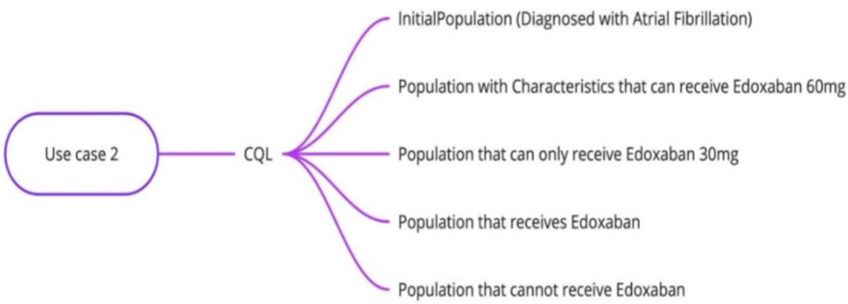

Figure 2. Model of use case 2 (DOAC) CQL and population measures that it can query.

```
//Define Population to exclude from edoxaban 60mg prescription but include in edoxaban 30mg 1 tablet per day prescription
define Thirty_mg_Edoxaban_Prescription:
exists InitialPopulation and
exists ([Observation: Code '35591-7' from LOINC] O where O.value as Quantity >= 30 'mL/min' and O.value as Quantity <=50 'mL/min')

//Define Population to exclude from Edoxaban Prescription
define NO_Edoxaban_Prescription:
not exists "Sixty_mg_Edoxaban_Prescription" or
not exists "Thirty_mg_Edoxaban_Prescription"

//Define Population that can receive Edoxaban.
define Edoxaban_Prescription:
"Thirty_mg_Edoxaban_Prescription" or "Sixty_mg_Edoxaban_Prescription"
```

Figure 3. Model of use case 2 CQL and population measures that it can query.

Further details on the relationship between the use cases and the artefacts can be viewed at our GitHub repository [18]. As a result, reports of type “subject-list” were created. These unlike the “population measure” reports which only list the patient reference id, besides the patient reference ids, of the queried population, they provide detailed information on the patient.

4. Discussion and Conclusion

This paper presents CQL artefacts that work on FHIR servers based on T2D diagnosis and the prescription of DOACs. Working with CQLs requires a Fast Healthcare Interoperability Resources (FHIR) [8] server which supports the CQL modules. Currently not every FHIR servers is capable of this. It is our belief and argued in the literature [19] that the FHIR servers able to support CQL are both too expensive for research and educational teams to afford or they are just not fully supporting all possible CQL queries.

Clinical quality language [9] was initially developed as a quality indicator in US, outside of HL7 standards but soon was incorporated into HL7 only on 2019. Identifying quality indicators evolved into something that can be used for healthcare decision support. In US there are a lot of defined sets of computable knowledge associated with CQL but are not part of it yet, around conditions and procedures that US uses for monitoring. We are working on developing those phenotypes and use them for decision support purposes rather than quality control purposes.

The novelty of CQL presented a problem in our use cases, where we were unable to make references to "*Family Member History*" conditions. This however is a limitation from the FHIR server we used, as it is still in development. We hope that this will be fixed in future revisions, and we will be able to incorporate "*Family Member History*" when diagnosing a patient in our future CQL development.

Overall, the creation of CQL artefacts was a complicated procedure. To correctly diagnose and prescribe, literature on diagnosis and prescription were consulted constantly in order to know the exact conditions under which the described use case phenotypes existed. This highlighted that to correctly model CQL artefacts, interdisciplinary teams are needed of which domain clinicians (medics) need to be part of. Clinical Information Modelling [10] requires highly competent teams that are able to educate all members on interoperability and sharing of resources.

To test and use the CQL artefacts developed for this paper, prior knowledge and the use of SNOMED CT and LOINC code systems are required. This also signifies that developers educated on medical informatics should be part of the interdisciplinary teams when developing CQL artefacts.

4.1. Limitations and future work

Since we did not use all possible code systems for conditions e.g., ICD-10-GM and the different UCUM units for measurements, our artefacts are limited to work with specific code systems and units of measure. This implies that the share-ability of the artefacts besides the complexity in its development is also limited by code systems and unit of measure standards. This however, presents opportunities for future work, which can incorporate all possible code systems in our artefacts to enable cross-border share-ability of CQL artefacts where one does not need to have prior knowledge of the code system the receiver uses to code conditions or observations. This applies to units too especially in cases where an observation value can be stored with more than one unit, for example mg/dL and mg/L.

Overall, we showed that CQL provides a great opportunity for clinical decision support and not just for quality control purposes. And it is through this opportunity that health informaticians and clinicians can be taught how to develop decision support systems based on clinical rules and syntaxes used in CQLs.

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References

[1] Andrikopoulou E, Scott P. Experiences of Creating Computable Knowledge Tutorials Using HL7 Clinical Quality Language. Vol. 298, Studies in Health Technology and Informatics. 2022.
[2] Wyatt J, Scott P. Computable knowledge is the enemy of disease. Vol. 27, BMJ health & care informatics. England; 2020.
[3] Scott P. Computable knowledge Part 2 of 2: learning from the HDR UK collaborathon – make it FAIR! [Internet]. 2021 [cited 2022 Jun 30]. Available from: https://www.hdruk.ac.uk/news/computable-knowledge-part-2-of-2-learning-from-the-hdr-uk-collaborathon-make-it-fair/
[4] Mitchell A. A NICE perspective on computable biomedical knowledge. BMJ Heal Care Informatics [Internet]. 2020 Jul 1 [cited 2022 Dec 15];27(2):e100126. Available from: https://informatics.bmj.com/content/27/2/e100126
[5] HL7 International. About Health Level Seven International [Internet]. 2022. [cited 2023 Jan 4]. Available from: https://www.hl7.org/about/index.cfm?ref=nav
[6] NHS Digital. SNOMED CT [Internet]. NHS Digital. 2022 [cited 2022 Jun 30]. Available from: https://digital.nhs.uk/services/terminology-and-classifications/snomed-ct
[7] Health Data Research UK. Our Strategy [Internet]. 2022. [cited 2023 Jan 4]. Available from: https://www.hdruk.ac.uk/about-us/our-strategy/
[8] HL7.org. FHIR Specification [Internet]. [cited 2022 Jun 30]. Available from: https://hl7.org/fhir/
[9] HL7 International. Clinical Quality Language (CQL) [Internet]. [cited 2022 Jun 30]. Available from: https://cql.hl7.org/
[10] Haarbrandt B, Schreiweis B, Rey S, Sax U, Scheithauer S, Rienhoff O, et al. HiGHmed – An Open Platform Approach to Enhance Care and Research across Institutional Boundaries. Methods Inf Med. 2018 Jul 17;57(S 01):e66–81
[11] Scott PJ, Heitmann KU. Team Competencies and Educational Threshold Concepts for Clinical Information Modelling. Stud Health Technol Inform. 2018;255:252–6.
[12] NICE. When should I suspect type 2 diabetes in an adult? [Internet]. Clinical Knowledge Summaries. 2022 [cited 2022 Jun 30]. Available from: https://cks.nice.org.uk/topics/diabetes-type-2/diagnosis/diagnosis-in-adults/
[13] NHS Greater Glasgow and Clyde Medicines Information Service. DOAC Prescribing in Patients with Non-Valvular AF and for the treatment and prevention of VTE Frequently Asked Questions. Vol. 7. 2018.
[14] Diabetes & Primary Care. Making a diagnosis of type 2 diabetes [Internet]. [cited 2022 Dec 8]. Available from: https://diabetesonthenet.com/cpd-module/making-a-diagnosis-of-type-2-diabetes/
[15] Chadha J, Viquez-Beita K. Can I use DOAC in a patient with renal disease? [Internet]. The Hospitalist. 2022 [cited 2022 Dec 8]. Available from: https://www.the-hospitalist.org/hospitalist/article/31587/renal-genitourinary/can-i-use-doac-in-a-patient-with-renal-disease/
[16] LOINC. Home [Internet]. 2022 [cited 2023 Jan 4]. Available from: https://loinc.org/
[17] National Library of Medicine. Unified Code for Units of Measure. In: Definitions [Internet]. 2020 [cited 2023 Jan 4]. Available from: https://ucum.nlm.nih.gov/
[18] Andrikopoulou E, Anywar M. CzarMich/Kiel-Portsmouth-Collaboration [Internet]. 2023 [cited 2023 Jan 4]. Available from: https://github.com/CzarMich/Kiel-Portsmouth-Collaboration
[19] Li M, Cai H, Zhi Y, Fu Z, Duan H, Lu X. A configurable method for clinical quality measurement through electronic health records based on openEHR and CQL. BMC Med Inform Decis Mak. 2022 Feb;22(1):37.