Using a Rule-Based Approach for Building Dynamic Questionnaires in a FHIR-first Patient Chatbot Application

Alex Pavlushkin - Beda Software
Who am I?

- Alex Pavlushkin
- Full stack developer in Beda Software
- Help e-health startups and medical organisations create web and mobile apps using FHIR-first approach
- 10+ years of experience in health informatics
- MD
Use case

- Mobile app
- Captures data from patients using set of questionnaires
- Limited amount of questions
- Trade-off between brevity and fullness
Use case

- Mobile app
- Captures data from patients using set of questionnaires
- Limited amount of questions
- Trade-off between brevity and fullness

Need to

- Capture more useful data
- Without overburden existing forms
- Conditional logic
Example

- Patient has arterial hypertension
Example

- Patient has arterial hypertension
- Ask the patient additional questions

What related complications have you had?

What hypotensive medications do you take?
Example

- Patient has arterial hypertension
- Ask the patient additional questions
- Use conversational UI

What related complications have you had?

What hypotensive medications do you take?
Solution

Flexible
Rule-driven
Based on medical ontology

Supportable
Low code
Solution

FHIR-first app

- The app built on top of FHIR
- FHIR API is a main API
- FHIR is an app framework
- Extend app in FHIR way

FHIR API

- Patient John Doe
- Questionnaire Check-in form
- QuestionnaireResponse
- Condition
- Observation
- MedicationStatement

Extract

- Structured Data Capture FHIR IG
- John’s check-in data
- Arterial hypertension
- Arterial Blood Pressure 145/90 mmHg
- Amiodarone

Condition

- Arterial hypertension
- Observation
- MedicationStatement
Medical Terminology

- SNOMED CT
Medical Terminology

- SNOMED CT
- Why?
Medical Terminology

• SNOMED CT
• Why?
  • Implicit ECL value sets

ECL query
<< 64572001 : 363698007 = 113257007

<table>
<thead>
<tr>
<th>Concept</th>
<th>Preferred Term</th>
<th>Id</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obstructive shock (disorder)</td>
<td>Obstructive shock</td>
<td>16472761000119108</td>
</tr>
<tr>
<td>Disorder of cardiovascular system co-occurrent and due to Marfan syndrome (disorder)</td>
<td>Disorder of cardiovascular system co-occurrent and due to Marfan syndrome</td>
<td>16055691000119106</td>
</tr>
<tr>
<td>Hypotension following procedure (disorder)</td>
<td>Hypotension following procedure</td>
<td>16055431000119108</td>
</tr>
<tr>
<td>Hypotension during surgery (disorder)</td>
<td>Hypotension during surgery</td>
<td>10901000087102</td>
</tr>
<tr>
<td>Post-surgical refractory hypotension (disorder)</td>
<td>Refractory hypotension</td>
<td>7431000175109</td>
</tr>
<tr>
<td>Aneurysm due to traumatic injury (disorder)</td>
<td>Aneurysm due to traumatic injury</td>
<td>869506001</td>
</tr>
<tr>
<td>Cardiac syncope (disorder)</td>
<td>Cardiac syncope</td>
<td>788677005</td>
</tr>
<tr>
<td>Lamin A/C related cardiocutaneous porgenia syndrome (disorder)</td>
<td>LMNA-related cardiocutaneous porgenia syndrome</td>
<td>773420004</td>
</tr>
<tr>
<td>Brachydactyly, mesomelia, intellectual disability, heart defect syndrome (disorder)</td>
<td>Brachydactyly, mesomelia, intellectual disability, heart defect syndrome</td>
<td>765761009</td>
</tr>
<tr>
<td>Title</td>
<td>Description</td>
<td>Status</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------------------------------------------------------------------------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>NZ Child development</td>
<td>Initially generated from ECL. ( &lt; 58265001</td>
<td>Heart disease</td>
</tr>
<tr>
<td></td>
<td>( &lt; 8722008</td>
<td>Aortic valve disorder</td>
</tr>
</tbody>
</table>
Medical Terminology

- SNOMED CT
- Why?
  - Implicit ECL value sets
  - Relationships between concepts - subsumption operations

- Hypertensive disorder
- Secondary hypertension
- Benign essential hypertension
- Hypertension in chronic kidney disease due to type 1 diabetes mellitus
- Hypertensive crisis
- Renal hypertension

Apply a rule
Medical Terminology

• SNOMED CT
• Why?
  • Implicit ECL value sets
  • Relationships between concepts - subsumption operations
  • Multilanguage and patient friendly terms support
Medical Terminology

• SNOMED CT

• Why?
  • Implicit ECL value sets
  • Relationships between concepts - subsumption operations
  • Multilanguage and patient friendly terms support

• Snowstorm Terminology Server
Medical Rule

Custom FHIR resource

```
Update MedicalRule

id: df38df9b-230e-491a-97e0-a89d2e389300
resourceType: MedicalRule
name: Hypertension
sourceQuery:
  id: Source
type: batch
entry:
  - request:
      url: $snowstorm
      method: POST
      resource:
        ecl: '<<< 38341003 | Hypertensive disorder, systemic arterial (disorder) |'
        resourceType: SnowstormRequest
resourceType: Bundle
matchExpression:
  language: text/fhirpath
  expression: '%Source.entry[0].resource.expansion.contains.where(code=%Coding.code)!-{}'
related:
  - id: 3d80844e-e463-4caa-928d-63b7aa259d74
type: condition
```
Medical Rule

Match sections

List of SNOMED codes

```
Update MedicalRule

1. id: df38df9b-230e-491a-97e0-a89d2e389300
2. resourceType: MedicalRule
3. name: Hypertension
4. sourceQuery:
   - id: Source
     type: batch
     entry:
       - request:
           url: $snowstorm
           method: POST
           resource:
             ecl: '<< 38341003 | Hypertensive disorder, systemic arterial (disorder) |'
             resourceType: SnowstormRequest
     resourceType: Bundle
5. matchExpression:
   language: text/fhirpath
   expression: '(%Source.entry[0].resource.expansion.contains.where(code=%Coding.code))~{}'
6. related:
   - id: 3d80844e-e463-4caa-928d-63b7aa259d74
     type: condition
```
Medical Rule

Match sections

List of SNOMED codes
Medical Rule

Match sections

List of SNOMED codes
Update MedicalRule

```yaml
id: df38df9b-230e-491a-97e0-a89d2e389300
resourceType: MedicalRule
name: Hypertension
sourceQuery:
  id: Source
type: batch
entry:
  - request:
    url: $snowstorm
    method: POST
    resource:
      ecr: `{<< 38341003 | Hypertensive disorder, systemic arterial (disorder) |}'
      resourceType: SnowstormRequest
    resourceType: Bundle
matchExpression:
  language: text/fhirpath
  expression: `%Source.entry[0].resource.expansion.contains.where(code=%Coding.code)!-{}'
related:
  - id: 3d80844e-e463-4caa-928d-63b7aa259d74
type: condition
```
Medical Rule

- id: 3d80844e-e463-4ca9-928d-63b7aa259d74
  type: condition
  title: Complications
  question: What complications do you have?
  repeats: true
  mandatory: true
  subquestions:
  - linkId: status
  - linkId: severity
  - linkId: body-site
    disabled: true
  - linkId: onset
  - linkId: note
  - linkId: attachment
    disabled: true
  answerValueSet: 01ae90b-51c4-4742-9ef3-9e415e6bbca0
  - id: 14a86bc0-449b-4c3e-955c-09c5e70fba43
    type: medication
    title: Medications
    question: What hypotensive medications do you take?
    repeats: true
    mandatory: true
Let’s create a rule
Code evaluation process

Event → Patient’s medical data → SNOMED codes → Condition Medication → MedicalRuleMatchRequest → Matching process → MedicalRuleMatch → Show suggested questions → No matches
Patient answers related questions
Results for the client

Working Solution

89
Rules created

Flexible
Can handle diverse use cases
to retrieve information from a patient

Universal
Rules can work with all kind of FHIR resources
Including external ones

No code
Any physician with basic SNOMED knowledge
can create rules
Further enhancements

Improve value sets quality
SNOMED ECL is not perfect for all medical areas
Sometimes it is challenging to create a good implicit ECL value set
Need better ways to build and maintain value sets

Improve tooling
It is challenging to maintain plethora of rules
Need better tools to debug and test it

Reduce matching time
The more FHIR resources in the database
And the more rules lead to delay
before new questions appear
How to go deeper

Snowstorm Terminology
https://github.com/IHTSDO/snowstorm

Aidbox Terminology
https://docs.aidbox.app/modules-1/terminology

Custom FHIR resources
https://docs.aidbox.app/modules-1/custom-resources/getting-started-with-custom-resources

ECL queries
https://confluence.ihtsdotools.org/display/DOCECL

Implicit Value Sets
Contact

Whoa App
Speaker’s Gallery

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