

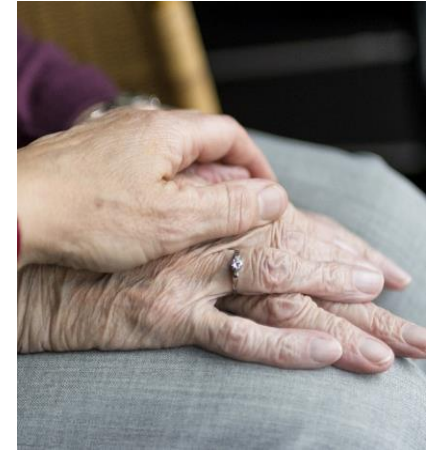
Clinical Decision Support with GDL in C3-cloud

Rong Chen MD PhD, CEO
Cambio CDS

2020/08/28

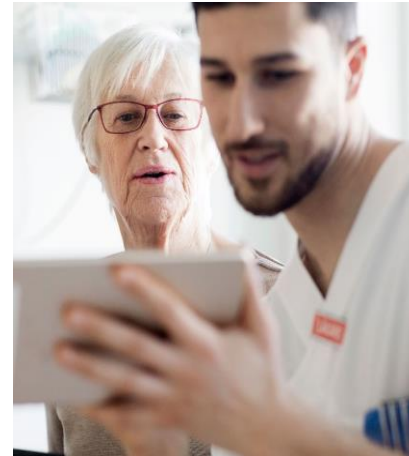


We deliver
integrated
solutions for
regions and
municipalities



Our systems
have around

170,000 users in
several
countries



Our solutions
are based on
regional,
publicly financed
healthcare
systems

Our Customers



170,000 users of our systems



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60+ regions & municipalities use our systems

Enabling Tomorrow's Healthcare

openEHR GDL

<https://specifications.openehr.org/releases/CDS/latest/GDL2.html>

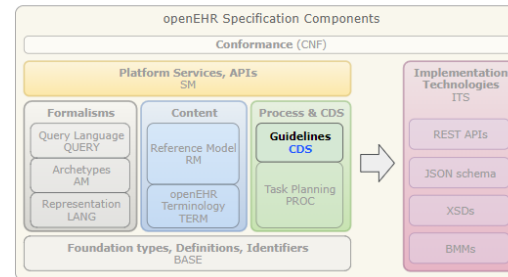
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openEHR

Guideline Definition Language v2 (GDL2)

Issuer: openEHR Specification Program	
Release: CDS latest	Status: TRIAL
Revision: [latest_issue]	Date: [latest_issue_date]
Keywords: decision support, GDL, GDL2, archetype	

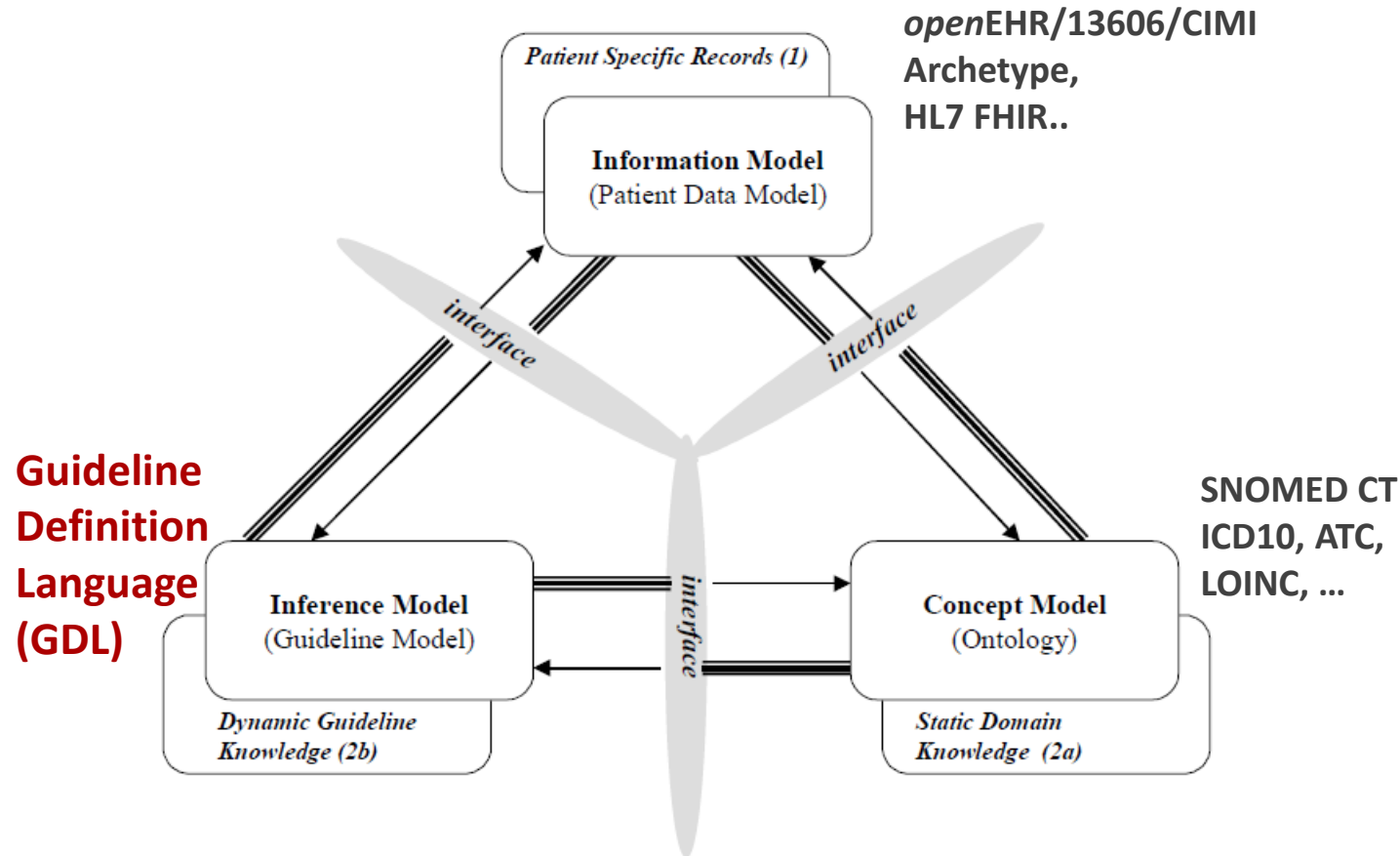


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Support	Issues: Problem Reports Web: specifications.openehr.org

Why GDL?

Around 2012, look for a formal CDS language that meets a list of requirements

- Language and terminology agnostic
- EHR models agnostic
- Modular and reusable
- Expressive enough to represent clinical logic in narrative guidelines



A L Rector PD Johnson S Tu C Wroe and J Rogers (2001) Interface of inference models with concept and medical record models. in S Quaglini, P Barahona and S Andreassen (eds) *Proc Artificial Intelligence in Medicine Europe (AIME-2001)* Springer:314-323

GDL v1 released in 2013

The screenshot shows a web browser window with two tabs: 'CDS Knowledge Manager' and 'openEHR - Releases'. The address bar shows the URL 'www.openehr.org/news_events/releases.php?id=79'. The website header features the 'openEHR' logo with the tagline 'An open domain-driven platform for developing flexible e-health systems'. Navigation links include 'Home', 'Programs', 'Getting Involved', 'Downloads', 'News & Events', and 'About Us'. A search bar with 'Google Custom Search' is also present. The left sidebar lists 'News & Events' with sub-links for 'Industry News', 'Community News', 'Foundation News', 'Events', 'Releases' (highlighted), and 'CKM Activity'. The main content area is titled 'Releases' and features the headline 'Guideline Definition Language (GDL) first release' dated 'March 11, 2013' by 'Rong Chen'. The text announces the availability of GDL design specifications and reference implementation. It highlights synergies between clinical models and CDS rules, and notes that GDL is still in development. A list of links includes 'GDL Specifications (v.90)', 'GDL Editor', 'GDL sample files', and 'GDL Reference Implementation Project'. The page is signed off by 'Rong Chen MD, PhD' on behalf of the Informatics Team at Cambio Healthcare Systems, Sweden.

CDS Knowledge Manager x openEHR - Releases x

www.openehr.org/news_events/releases.php?id=79

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Releases

Guideline Definition Language (GDL) first release

March 11, 2013 | from: Rong Chen

We are pleased to announce the immediate availability of the design specifications of Guideline Definition Language (GDL) and its reference implementation under open source software licenses. GDL is formal language designed to express and to share Clinical Decision Support rules across language and technical barriers by leveraging openEHR designs. CDS rules in GDL format is agnostic to natural languages, reference terminologies and rules engine languages.

There are considerable synergies in the development of clinical models and CDS rules. Semantically well-defined clinical models can provide reliable means of input and output of the rules. On the other hand, experiences from CDS rules development can lead to improvements of the clinical models as well as increased motivations to adopt structured and standardized clinical models. Reusing existing high-quality clinical models in the form of archetypes would hopefully increase the productivity in authoring and maintaining clinical rules.

Please note that GDL is still in development. We aim to submit the GDL specifications for review in openEHR in the near future. We look forward to the community's feedback to further improve the specifications.

Some important links from this release:

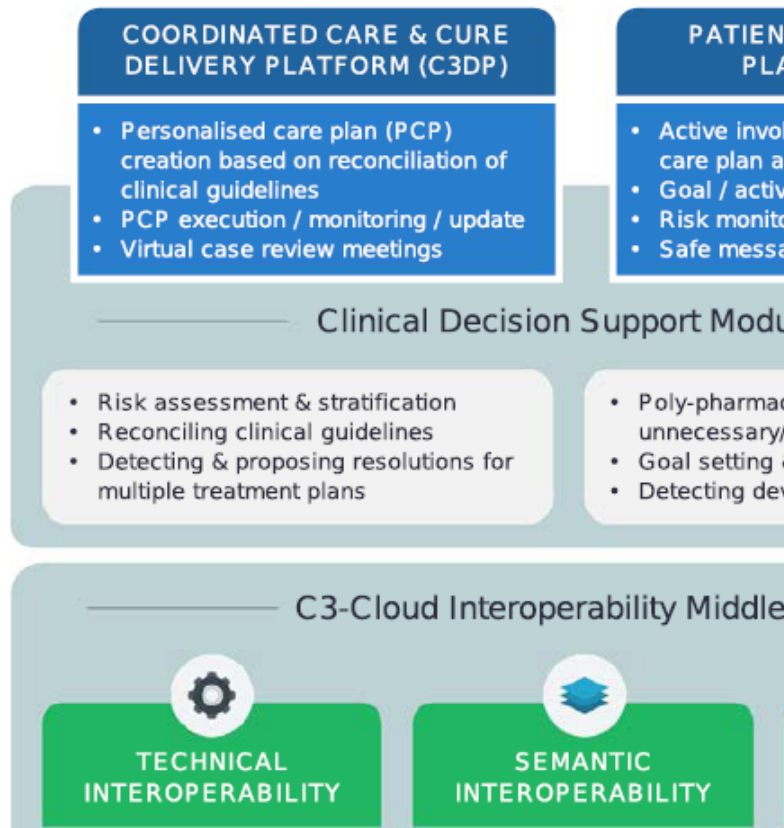
- [GDL Specifications \(v.90\)](#)
- [GDL Editor](#)
- [GDL sample files](#)
- [GDL Reference Implementation Project](#)

Rong Chen MD, PhD
On behalf of the Informatics Team,
Cambio Healthcare Systems, Sweden



2017-2018

- Cambio won pan-European tender to supply CDS Platform in Scotland National CDS Programme
- Engaged in C3-cloud project due to Swedish customer & research partners
- Original openEHR archetype based approach needs improvement
 - Lessons learned from CDS projects with Swedish regions
 - HL7 FHIR support in the market; UK's GP-connect initiative
 - HL7 SMART App/CDS-hooks initiatives
- GDL2 & 2nd generation of Cambio CDS Platform
 - Completely new GDL2 execution engine & GDL2 Editor
 - On-premise towards Cloud based approach



G.B. Laleci Erturkmen et al. / Computational and Structural Biotechnology Journal 17 (2019) 869–885

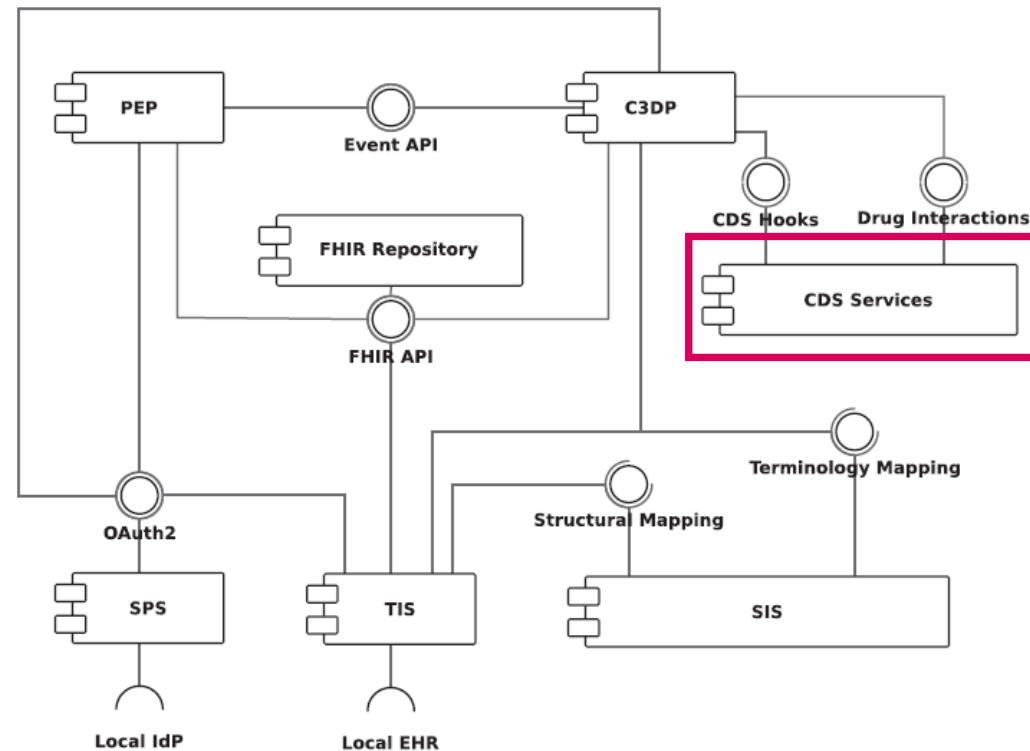
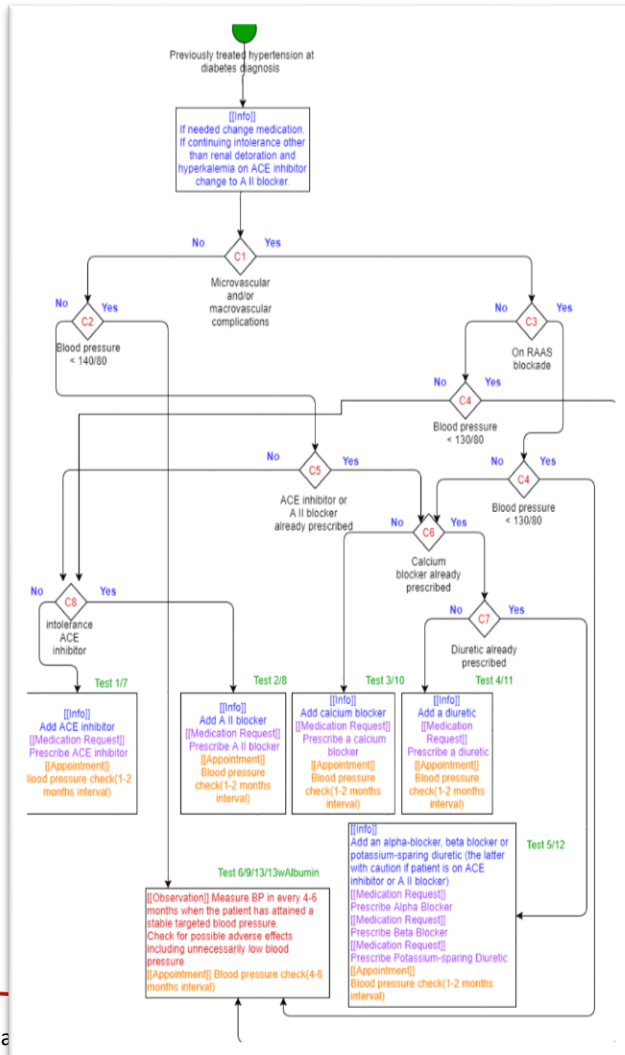


Fig. 2. High level system architecture.

From decision trees to GDL guidelines



```
},
"gt0296": {
  "id": "gt0296",
  "priority": 12,
  "when": [
    "$gt0012|latestEgfrValue|<45,mL/min/{1.73_m2}",
    "$gt0052|Empagliflozin|!=null",
    "$gt0074|Triple therapy|==local::1|True|"
  ],
  "cards": [
    {
      "summary": "{gt9017.term}",
      "detail": "{gt9018.term}",
      "indicator": "info",
      "source": {
        "label": "NICE diabetes guideline Chapter 1.6.25-1.6.31 [48, pp. 22-24].",
        "url": "https://www.nice.org.uk/guidance/ng28",
        "label_reference": "$ref[3].label",
        "url_reference": "$ref[3].url1"
      },
      "suggestions": [
        {
          "uuid": "973687e4-e42c-4f9f-aaed-9114fb6d4ca9",
          "label": "{gt0681.term}",
          "actions": [
            {
              "type": "delete",
              "description": "{gt0683.term}",
              "resource_template": {
                "template_id": "gt0517",
                "assignments": [
                  "$gt0518='Empagliflozin'",
                  "$gt0519='A108K03'",
                  "$gt9000=($currentTime)"
                ]
              }
            }
          ]
        }
      ]
    }
  ]
}
```

Challenges

- Delay of the GDL2 editor and initial quality issues
- Lack of training material for the partners
- Complex guidelines, unseen in other projects
 - Diabetes glucose management guideline is over 27k lines

DescriptionDefinitionsPreconditionsDefault actionsOutput templatesRule listTerminologyBindingReferencesGDLHTMLExecutionTest

Name:CKD Guideline CVD Prevention and Treatment Servi

Author Details

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Organisation:AP-HP - LIMICS

Authored date:14/01/20

Authorship lifecycle:Author draft

Copyright:© LIMICS

Keywords:

+C3-Cloud

Chronic Kidney Disease

Renal Failure

CVD prevention

CVD treatment

Contributors:

+Jacques BOUAUD

Brigitte SEROUSSI

Catherine DUCLOS

Description:

This guideline service deals with the prevention and treatment of cardiovascular disease in patient with chronic kidney disease.It implements the flowchart '5.4.9. Cardiovascular disease prevention and treatment' of deliverable D7.1 of the C3Cloud project.This flowchart is based on the NICE CKD guideline CG182, Chapter 1.6.16, [60, p. 33-34]. This CDSM accounts for DM-RF reconciliation rules specified in deliverable D7.2 of the C3Cloud project.

Purpose:

To determine the drug treatment to prevent or treat cardiovascular disease.

Use:

Misuse:

Implementation notes [2019/06/03 JB]

- All rules implemented

- Use of additional specific FHIR profile to have a local placeholder for a boolean variable (FHIR-STU3- Observation.ckd-referral-variable.v0)

- One reconciliation rule added: R4.5.DMRF10.

- Execution in GDL2 editor works

References:

Chronic kidney disease in adults: assessment and management - Clinical guideline [CG182] - Published date: July 2014 - Last updated: January 2015

<https://www.nice.org.uk/guidance/cg182/chapter/1-Recommendations#referral-criteria>

Cardiovascular disease: risk assessment and reduction, including lipid modification - Clinical guideline [CG181] - Published date: July 2014 - Last updated: September 2016

<https://www.nice.org.uk/guidance/cg181/chapter/1-Recommendations#lipid-modification-therapy-for-the-primary-and-secondary-prevention-of-cvd-2>

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CAMBIO

File

Configuration

Help

English

GDL 2 Editor

CAMBIO
CLINICAL DECISION SUPPORT

Description

Definitions

Preconditions

Default actions

Output templates

Rule list

Terminology

Binding

References

GDL

HTML

Execution

Test

Guideline definitions

Archetype instantiation

Element instantiation

Constant Comparison

IS_A Comparison

Function Predicate

Element Existence

Attribute Comparison

INPUT Definition entities

Input

FHIR-STU3-Condition.problem_diagnosis.v0

<> cT coding[0] as CKD

With Element cT coding[0] is_a CKDcode

Input

FHIR-STU3-Condition.problem_diagnosis.v0

<> cT coding[0] as CVD

With Element cT coding[0] is_a CVDcode

Input

FHIR-STU3-Condition.problem_diagnosis.v0

<> cT coding[0] as NonValvularAF

With Element cT coding[0] is_a NonValvularAFcode

Input

FHIR-STU3-Condition.problem_diagnosis.v0

<> cT coding[0] as AF

With Element cT coding[0] is_a AFcode

Input

FHIR-STU3-Condition.problem_diagnosis.v0

<> cT coding[0] as priorStroke

With Element cT coding[0] is_a priorStrokecode

Input

FHIR-STU3-Condition.problem_diagnosis.v0

<> cT coding[0] as priorTransientIschemicAttack

With Element cT coding[0] is_a priorTransientIschemicAttackcode

Input

FHIR-STU3-Condition.problem_diagnosis.v0

<> cT coding[0] as Hypertension

With Element cT coding[0] is_a Hypertensioncode

Input

FHIR-STU3-Condition.problem_diagnosis.v0

<> cT coding[0] as Diabetes

With Element cT coding[0] is_a Diabetescode

Input

FHIR-STU3-Condition.problem_diagnosis.v0

<> cT coding[0] as SymptomaticHF

With Element cT coding[0] is_a SymptomaticHFcode

Input

FHIR-STU3-Observation.estimated_glomerular_filtration_rate.v0

<> cT coding[0] as eGFR

With Element cT coding[0] is_a eGFRcode

OUTPUT Definition entities

Output

FHIR-STU3-Observation.ckd-referral-variable.v0

<> cT valueCode as OneOfRiskFactors

DescriptionDefinitionsPreconditionsDefault actionsOutput templatesRule listTerminologyBindingReferencesGDLHTMLExecutionTest

R4.4-Card 3 check AF specific guidelines

Condition types

? Element Existence

◇ Constant Comparison

□ Element Comparison

{ } Attribute Comparison

? Variable Comparison

≡ IS_A Comparison

▼ Or Operator

! Not Operator

🔥 Rule Fired

Rule conditions

? Input cT CKD exists - +

? Input cT AF exists - +

🔥 R4.3-Card 2 apixaban not fired - +

? Input cT ApixabanMedication does not exist - +

ActionsCards

Card entities

📄 Create Card

📄 Source

📄 Link

💬 Suggestion

⚙️ Action Create

⚙️ Action Delete

⚙️ Action Update

Rule Cards

📄 Card -

T summary : Check NICE guideline on atrial fibrillation management

T detail : In this situation of Chronic Kidney Disease and Atrial Fibrillation, check NICE guideline on the diagnosis and management of atrial fibrillation [CG180]

cT indicator : info

Guideline Rules

+ Add new Rule

🔥 R4.1-Card 1 antiplatelet drugs -

🔥 R4.2a-OneOfRiskFactors = prior stroke -

🔥 R4.2b-OneOfRiskFactors = prior trans. isch. attack -

🔥 R4.2c-OneOfRiskFactors = age>=75 -

🔥 R4.2d-OneOfRiskFactors = hypertension -

🔥 R4.2e-OneOfRiskFactors = diabetes mellitus -

🔥 R4.2f-OneOfRiskFactors = symptomatic HF -

🔥 R4.3-Card 2 apixaban -

🔥 R4.4-Card 3 check AF specific guidelines -

🔥 R4.5.DMRF10. Card 5 atorvastatin 20 mg -

🔥 R4.5-Card 4 check CVD prevention guidelines -

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CAMBIO

+ −		
Local term	Codes	Uri
gt0010 — NonValvularAFcode	49436004	
gt0022 — Hypertensioncode	38341003	
gt0013 — AFcode	49436004	
gt0007 — CVDcode	49601007	
gt0019 — priorTransientIschemicAttackcode	266257000	
gt0004 — CKDcode	425369003, 431855005, 431856006, 433144002, 431857002, 433146000	
gt0016 — priorStrokecode	230690007	
gt0104 — Diabetescode	73211009, 46635009, 44054006	
gt0028 — SymptomaticHFcode	84114007, 42343007, 698594003	

Refresh

Input

CKD

ICD-10-UK # N19 # CKDcode

CVD

CIE-10-CM-ES # I23 # CVDcode

NonValvularAF

READ2 # G5730 # NonValvularAFcode

AF

READ2 # G5730 # AFcode

priorStroke

CIE-10-CM-ES # I63 # priorStrokecode

priorTransientIschemicAttack

ICD-10-UK # G45 # priorTransientIschemicAttackcode

Hypertension

ICD-10-SE # I10 # Hypertensioncode

Diabetes

CIE-10-CM-ES # E10 # Diabetescode

SymptomaticHF

ICD-10-SE # I110 # SymptomaticHFcode

eGFRObservation

NPU # EGFRKRE # eGRFcode

eGFRValue

56 mL/min/{1.73_m2}

eGFReffectiveDateTime

2020-08-27T22:17Z

birthDate

1950-08-27T22:17Z

AntiplateletMedication

ApixabanMedication

AtorvastatinMedication

Output

Execution results

```
{
  "Cards": [
    {
      "Summary": "Check NICE guideline on atrial fibrillation management",
      "Detail": "In this situation of Chronic Kidney Disease and Atrial Fibrillation, check NICE guideline",
      "Indicator": "info",
      "Source": null,
      "Suggestions": [],
      "Links": []
    }
  ]
}
```

Debug execution

1

Guideline Fixture

Test Case Id:

Add test fixture

1

Results

- 23 GDL2 guidelines (>500 rules)
- Congestive heart failure, chronic kidney disease, depression, type-2 diabetes and hypertension
- 3 languages: English, Spanish and Swedish
- Several reference terminologies
 - ATC, ICD-10 (SE/ES/UK), READ2, NPU, DBP, LOINC, SNOMED-CT
- 6+ authors from 3 organizations (Cambio, University of Warwick, Inserm)
- Open sourced at github, <https://github.com/C3-Cloud-eu/gdl2-cds-services>

Special thanks to colleagues at SRDC, Univ. of Warwick, Inserm

