Computable Care Guidelines (CCGs)

What are they... how do they work... and why should we care?

Derek Ritz, P.Eng., CPHIMS-CA
HINF 597 – July 2, 2024
Mandatory apologies...
Computable Care Guidelines (CCGs)

Updating the progress of a long-running HL7-IHE Gemini Project to operationalize care guideline-adherence at scale.

Derek Ritz, P.Eng., CPHIMS-CA
June 3, 2024
Story arc...

- *Super-brief introduction*
- *What* are CCGs, and *why* do we need them?
- *Who* has made progress... and *what* can we learn?
- *Where* are we now, with the *IHE CCG* Profile?
- Q&A
Story arc...

- Super-brief introduction
- What are CCGs, and why do we need them?
- Who has made progress... and what can we learn?
- Where are we now, with the IHE CCG Profile?
- Q&A

...and how do they work?
What are **Computable Care Guidelines (CCGs)**?
Theory of change:
“We want to **maximize** the care delivered in the **GREEN ZONE**.”

Everything that **should** be done
Theory of change:
“We want to maximize the care delivered in the GREEN ZONE.”
Theory of change:
“We want to maximize the care delivered in the GREEN ZONE.”

Everything that was done
Errors of Commission

Errors of Omission

Everything that should be done

The GREEN ZONE
“We want to maximize the care delivered in the **GREEN ZONE.**”

Theory of change:

- Everything that **was** done
- Everything that **should** be done
- Errors of Commission
- Errors of Omission

CCGs give us a way to define what **should** happen in a way that a computer can understand.

We can use our digital health investments to **systematically** increase the “Venn diagram” **overlap.**
CCGs afford us a way to operationalize *feedforward process control* in healthcare.
Feed *what* now?
How digital health impacts upon health.
Health Interventions

Yield

Population Health
Operationalizes

Health Interventions

Digital Health Infrastructure

Population Health

Yield
Operationalizes

Person-centric transactional data

Generate

Yield

Health Interventions

Digital Health Infrastructure

Population Health
Operationalizes

Health Interventions

Digital Health Infrastructure

Population Health

Generate

Person-centric transactional data

Yield

Population-level health metrics
Operationalizes person-centric transactional data to generate population-level health metrics and yield health interventions.

Inform through digital health infrastructure.
Operationalizes

Health Interventions

Digital Health Infrastructure

Population-level health metrics

Person-centric transactional data

Generate

Yield

Inform

Population Health
Operationalizes Person-centric transactional data

Generate Population-level health metrics

Yield Digital Health Infrastructure

Inform Health Interventions
What are potential implications for AI?
What if some “non-indicated” care activities systemically yield better health outcomes?

What if omitting some “indicated” care activities statistically yields identical (or even better) health outcomes?
Key takeaway points...

- We can use digital health to both *meter* the health system – and to exert *process control* upon it.
- Digital health can play an *industrial engineering* role. It can be leveraged to improve *consistency* in execution of the “*health production function*”. This is an example of *feedforward process control*.
- We should leverage digital health in support of *care workflows*. Atomic, person-centric data serves *both* person-centric *care* and population-level *monitoring*.
- *Analytics* can be leveraged to inform *improvements* to the health system *operations*, and/or to the digital health supported *interventions*. This *feedback* loop creates a *Learning Health System*. 
What are Computable Care Guidelines (CCGs)?

Attempt #2 to get Derek to stay focused...
For care guidelines, there are *four levels of knowledge representation*.

- Level 1: Narrative
- Level 2: Semi-structured
- Level 3: Computable
- Level 4: Operationalized
These are *narrative* documents intended for *humans*.
These are **semi-structured** documents.
These are CCGs.
These are digital solutions that **Operationalize** CCGs.
This is the focus of IHE’s Conformance-testable CCG Profile.

Normative **format** for CCG artefacts

Normative **behaviour** for CCG processors
95 - 95 - 95

HIV Care Guidelines

VCCT Clinic

Pharmacy

Lab
HIV Care Guidelines
If you know what **should** happen, you can treat the **absence** of a signal as a **signal**.
HIV Care Guidelines
Minimum data set
Workflow logic
Reportable indicators
We want **person-centric** care delivery. There may be more than **one** thing to focus on during a care encounter.
Improving the care continuity and care **quality**, especially for co-morbid patients with **multiple chronic conditions (MCC)**, addresses a **big** and **expensive** problem.

In Canada, 73% of persons over 65 years of age suffer from at least one chronic condition, and **30% of Canadians over 35 years of age suffer two or more conditions.** It is estimated the burden of chronic disease represents a cost to the Canadian economy of more than **$190 billion (CAD) annually** and that the direct costs of chronic disease management account for **58% of Canada’s total healthcare spend.**

More than **25% of Americans have MCC**, accounting for more than **65% of U.S. healthcare spending.** Projections suggest numbers of adults aged 65 and older will more than double and numbers of those aged 85 and older will triple by 2050.

Currently an estimated **50 million people in Europe live with multiple chronic conditions** (multimorbidity), and this number will further increase in the next decade. Especially among people aged 65 and over multimorbidity is common with **prevalence rates estimated as high as 65%.**


[https://lthc.thor.org/1cb/21j-21p-21i-21m](https://lthc.thor.org/1cb/21j/21j-21j-21j-21j)


[https://build.fhir.org/ig/HL7/fhir-us-mcc/](https://build.fhir.org/ig/HL7/fhir-us-mcc/)
The care quality problem is an issue everywhere, but it is especially stark in low- and middle-income countries (LMIC).

“Health care in all global settings today suffers from high levels of defects in quality across many domains, and this poor-quality care causes ongoing damage to human health. Hospitalizations in low- and middle-income countries (LMICs) lead to 134 million adverse events each year, and these adverse events contribute to more than 2.5 million deaths annually. More than 830 million people with a diagnosed noncommunicable disease (NCD) are not being treated, and more than 4 million avoidable quality-related deaths each year are attributable to ineffective care for NCDs. In total, between 5.7 and 8.4 million deaths occur annually from poor quality of care in LMICs for the selected set of conditions the committee analyzed... which represents between 10 and 15 percent of the total deaths in LMICs reported by the World Health Organization (WHO) in 2015. For some conditions, deaths due to poor quality contribute to more than half of overall deaths.”

Key takeaway points...

- **CCGs**, at scale, help care delivery networks maximize care delivered in the **GREEN ZONE**.
- To support **scale**, CCGs leverage content typically found in a patient’s **shared** longitudinal electronic health record (**EHR**).
- Digital health solutions that can **ingest** and **operationalize** CCGs are the **antithesis** of “siloed app” care solutions that focus only on a single disease or care pathway.
- Multiple well-formed CCGs can be **concurrently executed** to enable truly **person-centric care** (e.g. care for a woman who is pregnant and HIV+).
- This is a **problem worth solving**!
Who has been making progress on *scaling* computable decision support... and what can we *learn* from their experiences?

IHE’s Quality, Research and Public Health (QRPH) committee conducted a prototyping effort in 2015/16 to see if Business Process Modeling Notation (BPMN) could be used to describe CCGs.

The Patient Care Coordination committee (PCC) defined a FHIR-based Profile for Dynamic Care Planning (DCP) in 2016 (last update 2019).

The IHE CCG Profile work item was approved and launched by QRPH-PCC (jointly) in 2018.
Since 2019, HL7 and IHE are partners on CCG development.

The **CCG Gemini Project** is an HL7-IHE collaboration that has been underway since 2019.

IHE’s role in the partnership is to profile (and simplify) the underlying HL7 specifications in support of implementability and **conformance-testability**.

The HL7 **CPG-on-FHIR IG** is presently completing its 2nd STU ballot. It is based on FHIR R4.
Since 2019, *both* Gemini partners have been active members of a WHO-led CCG initiative: **SMART Guidelines**.

The SMART Guideline initiative is strategic for WHO. Work has progressed on “DAKs” for ANC, HIV, Immunization, and IMCI.

NOTE: WHO does **not** plan to follow the current proposal re: IHE’s CCG Profile.
For conformance-testing, the US ONC requires CDS solutions’ logic to be based on **C-CDA (PS): IHE Health Story Consolidation**.

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### Required Tests

<table>
<thead>
<tr>
<th>(a)(3)(i)</th>
<th>CDS intervention interaction. Interventions provided to a user must occur when a user is interacting with technology.</th>
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<td><strong>Cross Reference Criteria:</strong></td>
<td>$\text{§170.315(a)(3)(i)}$ Preferred language, sex, race, ethnicity, and date of birth.</td>
</tr>
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<td><strong>Standard:</strong></td>
<td>$\text{§170.315(a)(3)(i)}$: C-CDA (PS): IHE Health Story Consolidation.</td>
</tr>
<tr>
<td><strong>IHE Health Story Consolidation:</strong></td>
<td>Release 2.1.1 Draft Standard for Testing.</td>
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*the ONC’s CDS content stipulation is consistent with the content found in the IPS.*
The global equivalent of the US C-CDA is the **International Patient Summary** (IPS). IPS is used for *care continuity* & *CDS* in many countries.

- **Canada** – PS:CA is a profiling of IPS for *domestic* care continuity. It is expected to support CDS (Ontario’s CDS use cases are an active example of this).
- **Denmark** – CDA based PS supporting CDS for COPD, Type-II Diabetes, and heart failure. Moving to FHIR.
- **GravitateHealth** (multi-EU country project) – IPS supporting CDS (especially re: medications).
- **Myanmar, Cambodia, Botswana** – OpenHIE-on-FHIR (IPS) based national HIE efforts targeting to support national CCG initiatives.

[https://international-patient-summary.net/implementations-across-the-globe/](https://international-patient-summary.net/implementations-across-the-globe/)
Key takeaway points...

- HL7 has progressed the CPG-on-FHIR IG; it is the underlying standard for IHE’s CCG Profile.
- WHO has progressed its SMART Guideline effort and has begun publishing Digital Accelerator Kits (DAKs) plus an L3 Antenatal care artefact.
- Conformance-testable implementations in the USA, Denmark and NHS Scotland have adopted common data models based on patient summary specs:
  - C-CDA IHE Health Story Consolidation
  - USCDI (us-core) FHIR profile
  - European PS (precursor to IPS)
  - NHS Shared Care Record (SCR)
- Concurrent execution of multiple CCGs is a must-have requirement to address MCC.
SMART Digital Health

Exploring digital health’s potential role as the foundation of evidence-based, person-centric healthcare delivery.

Derek Ritz, P.Eng., CPHIMS-CA
IHE Netherlands Annual Conference – November 22, 2023
What are the “generic steps” in a typical care encounter?

- Identify the patient
- Fetch the patient’s health story
- Provide guideline-based care
- Update the patient’s health story
This is what the process looks like as a BPMN diagram.
This is what the process looks like as a BPMN diagram.
We're going to focus on this part.

Identify the patient.

Fetch the health story.

Provide care.

Update the health story.
We can express the **CCG-processing logic** using BPMN.

We’re going to focus on this part.
1. Identify the patient
2. Retrieve the patient’s health summary
3. Retrieve the appropriate care plan(s) for the patient
4. **EXECUTE GUIDELINE-BASED CARE**
5. Update the patient’s care plan
6. Update the patient’s health summary

0. Establish the encounter’s context (location, practitioner, organization, available services)
- 15000: Provide Counseling
- 16000: Record Observations
- 17000: Order Tests
- 18000: Conduct Test
- 19000: Record Diagnosis
- 20000: Order Interventions
- 21000: Provide Interventions
- 22000: Order Medications
- 23000: Dispense Medications
- 23500: Administer Medications
- 24000: Establish Monitoring and Follow-up
- 25000: Refer Patient
IPS provides the person-centric *data model* for CCGs.

• Medication Summary (R) [ Medication Statement (IPS) | Medication (IPS) ]
• Allergies and Intolerances (R) [ Allergy Intolerance (IPS) ]
• Problem List (R) [ Condition (IPS) ]
• Immunizations (S) [ Immunization (IPS) ]
• History of Procedures (S) [ Procedure (IPS) | Organization (IPS) | Device (performer, observer) ]
• Medical Devices (S) [ Device Use Statement (IPS) | Device (IPS) ]
• Diagnostic Results (S) [ Observation (Results) | DiagnosticReport (IPS) | Organization (IPS) ]
  • Laboratory results [ Observation (Results: laboratory) | Specimen (IPS) | Media observation (Results: laboratory, media) ]
  • Radiology results [ Observation (Results: radiology) | Device (performer, observer) | Imaging Study (IPS) | Practitioner (IPS) ]
  • Pathology results [ Observation (Results: pathology) | Specimen (IPS) | Media observation (Results: laboratory, media) ]
• Vital Signs [ Vital Signs ]
• Past history of illnesses [ Condition (IPS) ]
• Pregnancy (status and history summary) [ Observation (Pregnancy: EDD) | Observation (Pregnancy: outcome) | Observation (Pregnancy: status) ]
• Social History [ Observation (SH: alcohol use) | Observation (SH: tobacco use) ]
• Functional Status (Autonomy / Invalidity) [ Condition (IPS) | Clinical Impression ]
• Plan of care [ Care Plan ]
• Advance Directives [ Consent ]
CCGs must be superimposable. The “metaphor” is the key.
One folder per care guideline (FHIR PlanDefinition resource)

One card per guideline-based recommendation (A PlanDefinition containing a single ActivityDefinition resource based on one of the pre-defined card “types”)

FOLDER NAME - **Condition** for which this CCG is applicable

CARD type

- **Condition** for which the card is applicable
- **Action** that results from “playing the card”
- **Resulting Data** from the action

Metaphor-1: a *folder full of CARDS*
Metaphor-2: an iterative CARD-stack processor
ANC
C: diagnosis = currently pregnant

### Condition

#### Action

#### Resulting Data

<table>
<thead>
<tr>
<th>GUID</th>
<th>Condition</th>
<th>Action</th>
<th>Resulting Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>15000</td>
<td>GUID-1</td>
<td>C: at each encounter; not yet done</td>
<td>A: provide applicable pregnancy counseling</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>RD: Communication resource</td>
</tr>
<tr>
<td>16000</td>
<td>GUID-2</td>
<td>C: at each encounter; not yet done</td>
<td>A: measure BP</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>RD: BP Observation resource</td>
</tr>
<tr>
<td>16000</td>
<td>GUID-3</td>
<td>C: at each encounter; not yet done</td>
<td>A: measure temperature</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>RD: temperature Observation resource</td>
</tr>
<tr>
<td>16000</td>
<td>GUID-4</td>
<td>C: at each encounter; not yet done</td>
<td>A: measure weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>RD: weight Observation resource</td>
</tr>
<tr>
<td>18000</td>
<td>GUID-5</td>
<td>C: at first ANC encounter; not yet done</td>
<td>A: conduct rapid HIV test</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>RD: lab result Observation resource</td>
</tr>
<tr>
<td>22000</td>
<td>GUID-8</td>
<td>C: if BP &gt; target and not BP meds dispensed</td>
<td>A: prescribe BP meds</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>RD: BP MedicationRequest resource</td>
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ANC
C: diagnosis = currently pregnant

Condition
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RD: BP Observation resource

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22000
GUID-8
C: if BP > target and not BP meds dispensed
A: prescribe BP meds
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<th>GUID</th>
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| 15000 | HIV       | C: at each encounter; not yet done  
A: provide applicable HIV counseling  
RD: Communication resource |  |
| 16000 | HIV       | C: at each encounter; not yet done  
A: measure BP  
RD: BP Observation resource |  |
| 16000 | HIV       | C: at each encounter; not yet done  
A: measure weight  
RD: weight Observation resource |  |
| 16000 | HIV       | C: at each encounter; not yet done  
A: measure heart rate  
RD: heart rate Observation resource |  |
| 17000 | HIV       | C: if >6mo since last viral load test and no active viral load test order  
A: order viral load test  
RD: ServiceRequest for lab test |  |
| 22000 | HIV       | C: if current date >= last ARV dispense date + coverage period  
A: prescribe ARV  
RD: ARV MedicationRequest resource |  |
| 21000 | HIV       | C: if currently pregnant and not already PMTCT  
A: provide PMTCT  
RD: PMTCT service bundle order |  |
HIV
C: diagnosis = HIV+

15000
GUID-20
C: at each encounter; not yet done
A: provide applicable HIV counseling
RD: Communication resource

16000
GUID-2
C: at each encounter; not yet done
A: measure BP
RD: BP Observation resource

16000
GUID-4
C: at each encounter; not yet done
A: measure weight
RD: weight Observation resource

17000
GUID-24
C: if >6mo since last viral load test and no active viral load test order
A: order viral load test
RD: ServiceRequest for lab test

16000
GUID-22
C: at each encounter; not yet done
A: measure heart rate
RD: heart rate Observation resource

16000
GUID-31
C: if currently pregnant and not already PMTCT
A: provide PMTCT
RD: PMTCT service bundle order
A super-quick illustrative example.
Mosa is pregnant. She presents (4 weeks late) for her 2\textsuperscript{nd} ANC visit. She was given an HIV test at her first visit... she is HIV+. She has been placed on PMTCT and is receiving ARV medications.
Digital Health Solution

CCG Engine

CCGs

Patient's longitudinal health record

REPEAT UNTIL no recommendations returned

Establish care context

Get Patient's health data

Capture user-entered content
Update minimum data set (MDS)

Updated MDS

invoke $apply

CCG Recommendation(s)

Process recommendation(s)
Render relevant user interface

Updated MDS

Update Patient's health record
• Diagnosis of currently pregnant, 2 months ago
• HIV test observation, 2 months ago, HIV+
• PMTCT intervention, 2 months ago
• BP 110/70, 2 months ago
• Weight 50kg, 14 months ago
• Weight 55kg, 2 months ago
• Heart rate 60, 14 months ago
• Heart rate 61, 2 months ago
• Temperature 37C, 14 months ago
• Temperature 37C, 2 months ago
• Pregnancy counseling given, 2 months ago
• ARV dispensed, 2 months ago, 2-month supply
• Viral load ordered, 2 months ago
• Viral load result, 6 weeks ago, 9000 copies
IPS for this subject of care

ANC
C: diagnosis = currently pregnant

HIV
C: diagnosis = HIV+
REPEAT UNTIL no recommendations returned

Establish care context

Get Patient’s health data

Capture user-entered content
Update minimum data set (MDS)

Process recommendation(s)
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CCG Recommendation(s)

Update Patient’s health record

Get Patient’s health data

Establish care context
Pregnancy Counseling: □ □
HIV Counseling: □ □
Blood Pressure: □ mmHg/□ mmHg
Weight: □ kg
Temperature: □ C
Heartrate: □ bpm
Order ARV refill: □ □

Synoptic reporting creates a **virtuous circle**. As CCGs are used, good (coded!) data is created which supports subsequent CCG execution.
Pregnancy Counseling:
HIV Counseling:

Blood Pressure: mmHg/mmHg
Weight: kg
Temperature: °C
Heartrate: bpm

Order ARV refill:

All actions are explicitly recorded... they are either done or not done (with reason code).
CCG Recommendation(s)

Process recommendation(s)
Render relevant user interface

Capture user-entered content
Update minimum data set (MDS)

Get Patient’s health data

Establish care context

REPEAT UNTIL no recommendations returned

Updated MDS
invoke $apply

CCG Recommendation(s)

Update Patient’s health record

Digital Health Solution

CCG Engine

CCGs

Patient’s longitudinal health record
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<td>RD: BP medication order resource</td>
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Order BP meds: ☐ ☐
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<tr>
<td>22000</td>
<td></td>
<td>C: if current date &gt;= last ARV dispense date + coverage period</td>
<td>RD: ARV med order resource</td>
</tr>
</tbody>
</table>

IPS for this subject of care

BP meds ordered, now
Establish care context

Get Patient’s health data

Capture user-entered content
Update minimum data set (MDS)

Process recommendation(s)
Render relevant user interface

Update Patient’s health record

REPEAT UNTIL no recommendations returned

Updated MDS

invoke $apply

CCG Recommendation(s)
No cards evaluated TRUE. We’re DONE!

<table>
<thead>
<tr>
<th>GUID</th>
<th>C: at each encounter; not yet done</th>
<th>A: measure weight</th>
<th>RD: weight Observation resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>16000</td>
<td>C: if current date &gt;= last ARV dispense date + coverage period</td>
<td>A: prescribe ARV</td>
<td>RD: ARV med order resource</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GUID</th>
<th>C: at each encounter; not yet done</th>
<th>A: provide applicable HIV counseling</th>
<th>RD: Communication resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>22000</td>
<td>C: if BP&gt;target and not BP meds dispensed</td>
<td>A: prescribe BP meds</td>
<td>RD: BP medication order resource</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GUID</th>
<th>C: if &gt;6mo since last viral load test and no active viral load test order</th>
<th>A: order viral load test</th>
<th>RD: ServiceRequest for lab test</th>
</tr>
</thead>
<tbody>
<tr>
<td>17000</td>
<td>C: at first ANC encounter; not yet done</td>
<td>A: conduct rapid HIV test</td>
<td>RD: lab result Observation resource</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GUID</th>
<th>C: at each encounter; not yet done</th>
<th>A: provide applicable pregnancy counseling</th>
<th>RD: Communication resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>15000</td>
<td>C: at each encounter; not yet done</td>
<td>A: provide applicable pregnancy counseling</td>
<td>RD: Communication resource</td>
</tr>
<tr>
<td>16000</td>
<td>C: at each encounter; not yet done</td>
<td>A: measure temperature</td>
<td>RD: temperature Observation resource</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GUID</th>
<th>C: at each encounter; not yet done</th>
<th>A: provide applicable HIV counseling</th>
<th>RD: Communication resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>15000</td>
<td>C: at each encounter; not yet done</td>
<td>A: provide applicable HIV counseling</td>
<td>RD: Communication resource</td>
</tr>
<tr>
<td>16000</td>
<td>C: at each encounter; not yet done</td>
<td>A: measure BP</td>
<td>RD: BP Observation resource</td>
</tr>
</tbody>
</table>

| IPS for this subject of care | No cards evaluated TRUE. We’re DONE! |
Patient’s longitudinal health record

Get Patient’s health data

Establish care context

Capture user-entered content
Update minimum data set (MDS)

Process recommendation(s)
Render relevant user interface

Updated MDS

invoke $apply

CCG Recommendation(s)

Update Patient’s health record

REPEAT UNTIL no recommendations returned

Digital Health Solution

CCG Engine

CCGs
Each guideline-based encounter is part of a long-running care path.
Important simplifications...

The encounter context must be established prior to CCG execution (location, provider, date & time, etc.)

CCG condition statements must be defined in terms of the IHE mCSD (context) and IHE IPS (clinical) data content models

CCG actions must be defined in terms of one of the pre-defined “CARD” types

Reportable indicators must be defined in terms of the pre-defined card type's resulting data
Key takeaway points...

- A normative behaviour for CCG processors establishes a patient-safe way to concurrently execute multiple CCGs.
- Simplifications on the underlying HL7 specification enable CCGs to be broadly scaled in regulated markets where conformance-testing is mandatory.
- The IHE CCG Profile is intended to support the mainstreaming of CCGs, and so it is tied to the patient summary data specification that will be most readily available within the care delivery network.