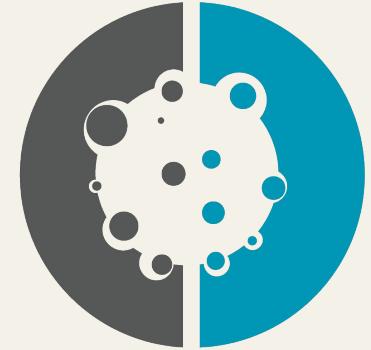


CCDH Quarterly Report

Q4 2020



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CCDH Quarterly Report to Federal Oversight (NIH/NCI and FNL)
Date: January 13, 2021

These slides: bit.ly/ccdh-q4-2020

Outline

- Phase II Timeline
- Developing our Community: Website release, Concierge services, End-to-End Requirements Analysis
- CRDC-H harmonized data model
- Terminological alignment and services for CRDC nodes
- Piloting of tools for annotating data

Phase II Timeline Update

Deliverables

Del.E2f: Pilot Metadata Mapping and Transformation tools
Del.E2e Support Service and Engagement Plan

Ongoing

2a1: Create and maintain a Help desk ✓ Maintenance
2a2: Develop user support documentation and materials (Concierge Services)

Design & Planning

Ongoing

2b1: Metadata Mapping and Transformation tools

Q4 2020

Complete ✓

2b1a: Create web portal v1 ✓ Maintenance
2b1b: Write release notes for web portal v1

Design & Planning

Ongoing

2b1d: Develop an initial comprehensive terminology resource
2b1e: Develop a set of terminology services
2b1f: Develop a terminology/ontology management and delivery platform

Design & Planning

Ongoing

2b1g: Work with nodes to map and transform data

Milestone: Q4 2020

Quarter Deliverables

2b1b: Write release notes for web portal v1 Phase II community development WS

#27 by jmcmurry was closed 25 days ago ⇨ Phase 2 - Quart...

2b1a: Create web portal v1 Phase II community development WS tools WS

#25 by jmcmurry was closed 5 minutes ago ⇨ Phase 2 - Quart...

Provide feedback to the Cancer Data Service (CDS) on Minimum Metadata Requirements for Submission

#17 opened 24 days ago by bburner ⇨ Phase 2 - Quart...

Phase I Retrospective/ Phase II Plan Review

#13 by bburner was closed on Oct 12, 2020 ⇨ Phase 2 - Quart...

Decide on formal implementation language/framework for CRDC-H

#9 by bburner was closed on Oct 4, 2020 ↗ 2 of 2 ⇨ Phase 2 - Quart...

Properties and data types to hold identifiers

#5 by mbrush was closed 25 days ago ⇨ Phase 2 - Quart...

Data Model
Harmonization



github.com/cancerDHC

Terminologies

Implement a tool to manage the permissible value mappings

#26 opened on Dec 2, 2020 by jiaola ⇨ Phase 2 - Quart...

Complete the permissible value mappings for the MVP model

#25 opened on Dec 2, 2020 by jiaola ⇨ Phase 2 - Quart...

Deploy a terminological browser for cancer research

#24 opened on Oct 7, 2020 by jiaola ⇨ Phase 2 - Quart...

Value set and mapping versioning

#20 opened on Aug 5, 2020 by hsolbrig ⇨ Phase 2 - Quart...

Determine mapping environment

#18 by hsolbrig was closed on Dec 2, 2020 ⇨ Phase 2 - Quart...

Begin TCCM implementation

#16 opened on Aug 5, 2020 by hsolbrig ⇨ Phase 2 - Quart...

Complete TCCM Model definition

#15 opened on Aug 5, 2020 by hsolbrig ⇨ Phase 2 - Quart...

Complete the value set modeling support in BiolinkML

#13 opened on Aug 5, 2020 by hsolbrig ⇨ Phase 2 - Quart...

Determine representational model for maps

#12 by hsolbrig was closed on Dec 2, 2020 ⇨ Phase 2 - Quart...

Define the representational model for value sets

#11 opened on Aug 5, 2020 by hsolbrig ⇨ Phase 2 - Quart...

Determine how to represent caDSR "intensional" value sets as FHIR value sets

#10 opened on Aug 5, 2020 by hsolbrig ⇨ Phase 2 - Quart...

Milestone: Q4 2020

Quarter Deliverables

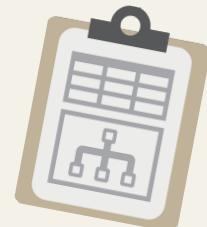
2b1b: Write release notes for web portal v1 Phase II community development WS

#27 by jmcmurry was closed 25 days ago ➔ Phase 2 - Quart...

2b1a: Create web portal v1 Phase II community development WS tools WS

#25 by jmcmurry was closed 5 minutes ago ➔ Phase 2 - Quart...

Tools & Data Quality



github.com/cancerDHC

Investigate an instance where we didn't match a SNOMED term correctly through UMLS
#26 opened on Nov 8, 2020 by gaurav ➔ Phase 2 - Quar...

Check DICOM SNOMED mappings against mappings already in the DICOM standard
#23 opened on Nov 8, 2020 by gaurav ➔ Phase 2 - Quar...

Re-run SNOMED DICOM mappings with new UMLS release
#22 opened on Nov 8, 2020 by gaurav ➔ Phase 2 - Quar...

Test grouping terms in mapping tool via NCImt hierarchy
#20 opened on Oct 13, 2020 by balhoff ➔ Phase 2 - Quar...

Incorporate additional ontologies into DICOM SNOMED to NCIt mapping
#19 by balhoff was closed on Nov 9, 2020 1 of 2 ➔ Phase 2 - Quar...

PDC: Biggest challenge is transforming source data to GDC or PDC data dictionary – tools for data transformation (structured format) will be useful discussion needed
#18 opened on Sep 29, 2020 by lchristopherson ➔ Phase 2 - Quar...

Identify minimum metadata currently used by CRDC nodes
#16 opened on Sep 29, 2020 by gaurav 1 of 4 ➔ Phase 2 - Quar...

Work with CDA to understand/help define their needs for ingesting/accessing the model and terminology support question
#12 opened on Aug 31, 2020 by gaurav ➔ Phase 2 - Quar...

Tools to enable stakeholders to implement CRDC-H (discussion with Seven Bridges, CDA) discussion needed
#11 opened on Aug 31, 2020 by gaurav ➔ Phase 2 - Quar...

Adapt tools currently evaluated as needs are defined discussion needed
#10 by gaurav was closed on Nov 17, 2020 ➔ Phase 2 - Quar...

Discuss adaption and implementation of Metadata Validator with CDS
#9 opened on Aug 31, 2020 by gaurav ➔ Phase 2 - Quar...

Discuss with PDC possible use of CEDAR/other tools for data annotation & approaches/tools for data transformation discussion needed
#8 opened on Aug 31, 2020 by gaurav ➔ Phase 2 - Quar...

Implement boomer workflow for data model harmonization
#5 opened on Aug 1, 2020 by balhoff ➔ Phase 2 - Quar...

Choose a format for publishing mappings
#3 opened on Jun 8, 2020 by gaurav ➔ Phase 2 - Quar...

review of CDS data and think about how it would be used to inform the requirements
#2 by nicolevasilevsky was closed on Dec 9, 2020 ➔ Phase 2 - Quar...

CCDH Reporting

- Weekly → bit.ly/ccdh-weekly-reports
- Monthly → bit.ly/ccdh-monthly-reports
- Quarterly → bit.ly/ccdh-quarterly-reports
- Project Tracker → cancerdhc.github.io



CCDH Reporting

CCDH Project Task Dashboard

Community Development Data Model Harmonization Terminology Tools Operations

cancerdhc.github.io

2021

October

November

December

January

February

March

April

May

June

July

Properties and data types to hold identifiers

Decide on formal implementation language/framework for CRDC-H

Phase I Retrospective/ Phase II Plan Review

Provide feedback to the Cancer Data Service (CDS) on Minimum Metadata Requirements for Submission

Terminological conventions for developing and documenting our model

Update ADM and mappings to include new ICDC Sample properties

Finish refactoring Biospecimen and Administrative entities into the CDM

CDM prototype evaluation and refinement

Establish a Github-based workflow for coordinated model development between

Establish a system (resources, processes, roles) for keeping SSDs, ADM, and C

Bring IDC data model into our pipeline

Evaluate other extant standards for representing cancer data

CDA MVP v0 Deliverables

Follow our progress:
✓ by milestone
✓ by workstream

✓ progress per ticket

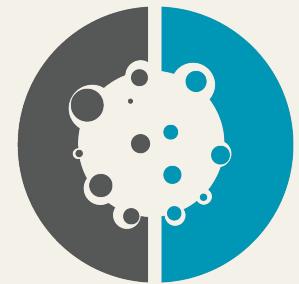


Developing our Community

New CCDH website

Concierge services

End-to-end Requirements Analysis



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New CCDH Website released on 8-Jan-2021

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Bringing harmony to cancer data across the CRDC

About CCDH Standards and Tooling Support FAQ Contact Us

The NCI's Center for Cancer Data Harmonization (CCDH) aims to create a national cancer research and care continuum to contribute, access, combine and analyze diverse data of cancer in our country.

The CCDH serves three main roles within the Cancer Research Data Commons (CRDC)

- Facilitate retrospective and prospective data sharing
- Coordinate the community to ensure common standards and harmonized data types and CRDC
- Find agreement across the community and building quality assurance resources

Project Timeline

CCDH High-Level Timeline

The CCDH contract is separated into four phases over three-and-a-half years. Each Workgroup will play a role in the phases as the project progresses.

Phase 1: Planning	Phase 2: Pilot	Phase 3: Production	Phase 4: Operations
October 2019 - March 2020	April 2020 - March 2021	April 2021 - March 2022	April 2022 - March 2023

This phase will focus on planning for community engagement, including engagement with NCI staff and other stakeholders. This includes identifying the use cases driving the interactions between the resources and meet with staff members from the identified nodes.

• Identify priorities of nodes and build CCDH community

• Plan for web portal, concierge services and other support

• Create initial CRDC-H Mapping

• Phase 1 final report

• Write support and engagement plan

• Develop tools related to community mapping, transformation and validation

• Phase 2 final report

• Metadata, model and technology content extraction

• Additional portal development and concierge services

• Phase 3 final report

• Updated production portal

• Continued support, including concierge services and semantic tooling

• Phase 4 final report

• Phase 4 final report

Support

The CCDH is pleased to offer concierge services to support the CRDC nodes. These include:

OFFICE HOURS

Thursdays, 11:30-12pm PT / 1:30-2pm CT / 2:30-3pm ET

Please email centerforcancerdh@gmail.com in advance with specific questions, or walk-ins.

SLACK

Join our Slack workspace.

This will take you to the Slack website, where you'll be prompted to create an account, even if you're already signed in. Follow the prompts and join us on Slack.

EMAIL

Contact us by email at centerforcancerdh@gmail.com.

LIST SERV

Join our list serv [here](#) to receive updates and our quarterly newsletter.

GITHUB

Add a ticket to our GitHub issue tracker.

You will need to sign up for a free GitHub account to post on our public GitHub tracker.



Next up:

- We will capture feedback from the immediate community to iterate on content.
- We will dedicate efforts towards deciding on a content & functionality strategy in the coming months.

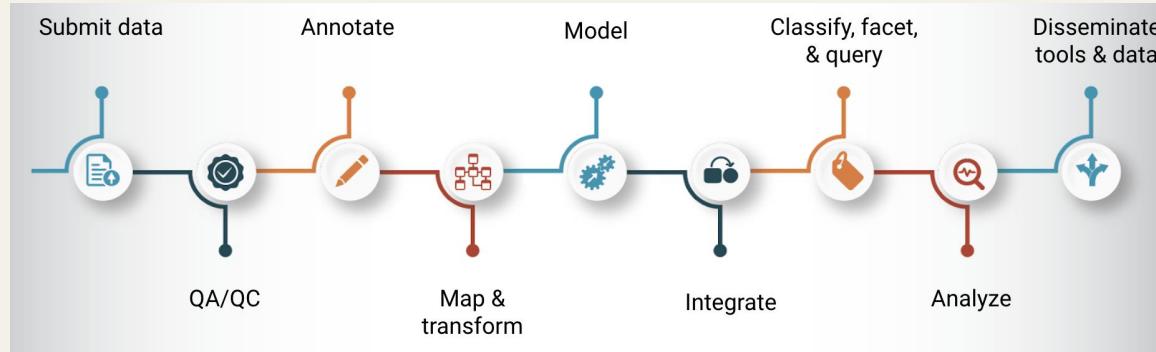
Concierge Services

- User support documentation and materials will include information on the following topics:
 - How to implement CRDC-H
 - Choosing adequate terminologies
 - Tools testing
- Help desk and office hours
- Quarterly CCDH Newsletter

End-to-end Requirements Analysis (in progress)

Phase 1

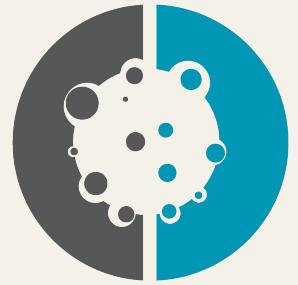
Approach: We performed an assessment of existing documentation from interviews and node presentations (available [here](#)).



Phase 2

- Goals:**
- Understand the commonalities and gaps for the information flow from each node.
 - Answer the questions:
 - What standards are being used?
 - How do we structure the resources?
 - Where are the data being shared?
 - Issue formal recommendations for best practices for data life cycle

CRDC-H Harmonized Data Model

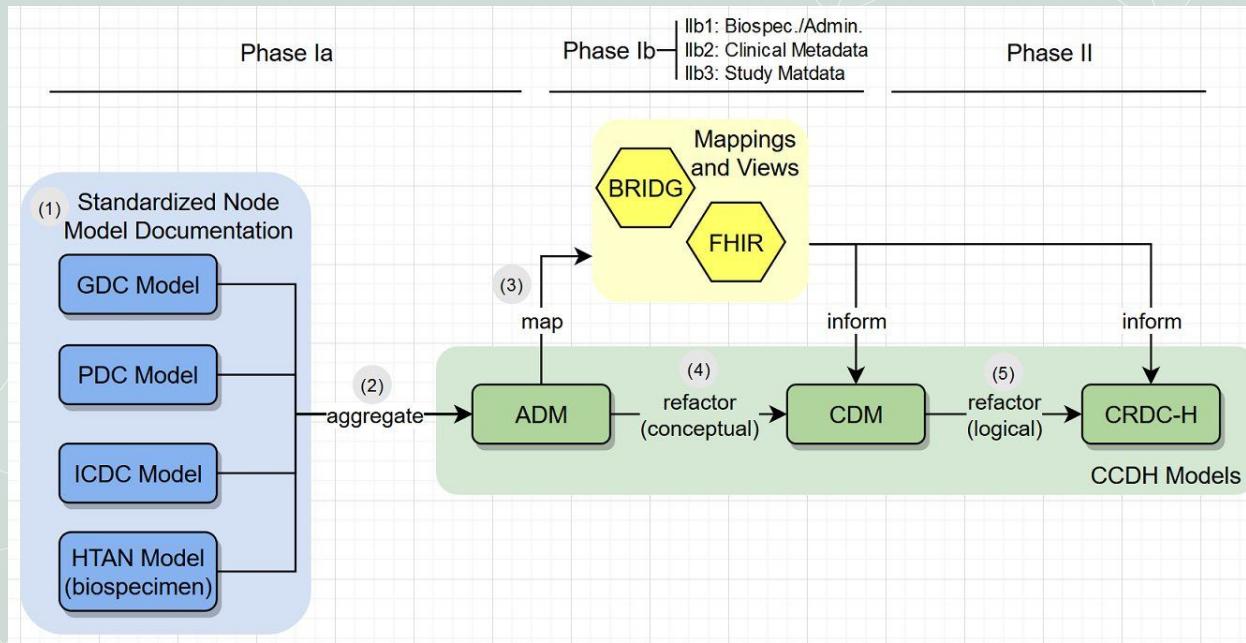


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Data Model Harmonization

Goals:

- Provide a harmonized data model (CRDC-H) to the CRDC community
- Offer data model guidance and support to the CRDC community through office hours and consultation
- Evolve the CRDC-H to address changes in source models and standards



CRDC-H Progress

- Delivery of an initial implementable CRDC-H model scoped to a subset of the biospecimen and administrative subdomains
 - Scoped specifically to support the CDA pilot use case
 - Model represented in LinkML modeling language
- Publication of CRDC-H model documentation
- Implementation and assessment of the CRDC-H model by CDA
- Initiate development of tooling to support a version-controlled model development pipeline for CRDC-H
- Work on CDS Minimum Metadata Model

Data Modeling Efforts

Review of v0 modeling

- Complete elements we didn't yet model (e.g. Slide, Project)
- Review and finalize elements in BS/AD model that were provisional (e.g. DataContainers)

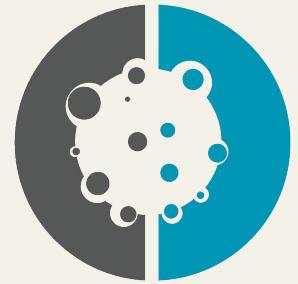
Specimen						
Description	Mappings				Developer Notes	
CDM Entity	CDM Attribute Name	Description	Data Type	Comments	ADM Attribute Mappings	Source Node Attribute Mappings
CDM.Specimen	dimensional_measure	A data container holding information about the one and two dimensional measurements of a specimen.	DataContainer (DimensionalMeasure)	<p>As for all 'DataContainer' objects, we are not yet committing to what type of structure the 'Container' will be here. It may be a complex data type, a nested backbone element, or a FHIR Observation-like object. Our final decision in if and how to encapsulate these ADM properties will depend on additional requirements we collect as work proceeds, and also on the modeling framework we use for our implemented logical model.</p>	<p>Sample.length_of_tumor Sample.width_of_tumor Sample.longest_dimension Sample.shortest_dimension Sample.intermediate_dimension Sample.total_tissue_area Portion.section_thickness_value</p>	<p>GDC.Sample.longest_dimension GDC.Sample.shortest_dimension GDC.Sample.intermediate_dimension PDC.Sample.longest_dimension PDC.Sample.shortest_dimension PDC.Sample.intermediate_dimension ICDC.Sample.length_of_tumor ICDC.Sample.width_of_tumor ICDC.Sample.total_tissue_area HTAN.Biospecimen.SECTION_THICKNESS_VALUE</p>

- Revisit completed modeling given v0 feedback (e.g. from interactions with nodes, CDS, [CDA](#))
- Identify and adhere to consistent modeling principles when possible as we move forward to model other entities/subdomains

Data Modeling Efforts

- Prioritize new elements to model (guided by CDA MVP use case)
 - Includes treatment and diagnostic elements
- Define improved data modeling/harmonization workflow and tooling
 - Process, tools, artifacts for extending, evolving, documenting model, etc. in a principled, rigorous, and semi-automated way
- Support modeling efforts in CRDC repositories (e.g. Clinical Trial Data Commons)

Terminological Alignment and Services for CRDC Nodes



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Summary of our Latest Progress

- Harmonization of permissible values of CRDC nodes data dictionaries
- TCCM terminology service
- BiolinkML/TCCM integration

GDC permissible values

Observations

- True permissible values (e.g., *analyte_type_id*)
 - Some values in GDC dictionary (R, D)
 - Remainder in caDSR, but potentially dated -- NCI working on more current maps

⚙ `analyte_type_id`

A single letter code used to identify a type of molecular analyte.

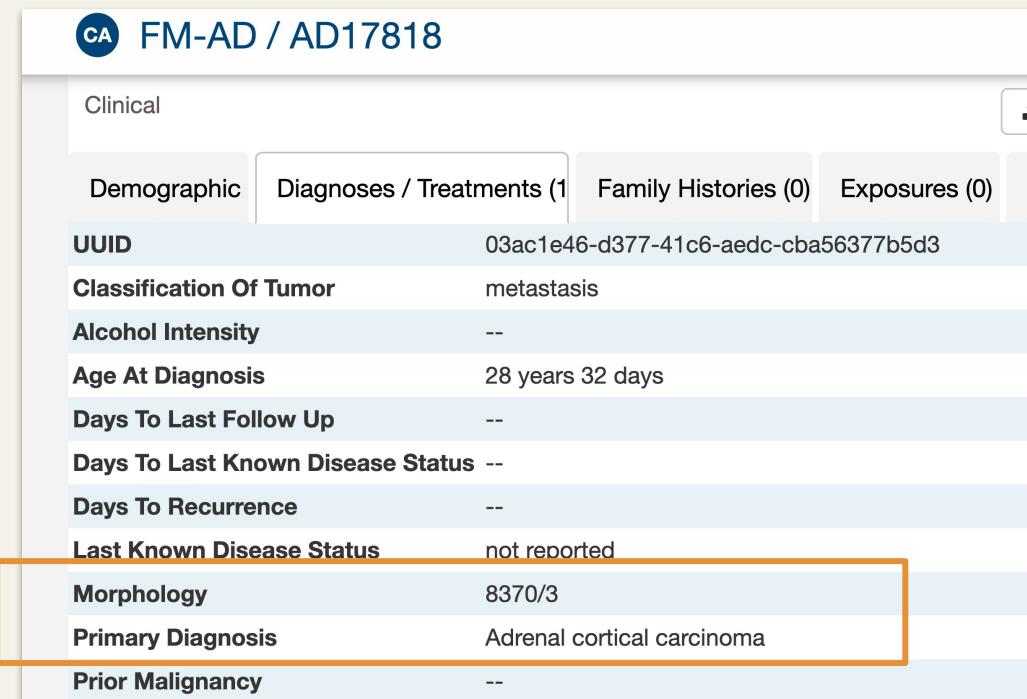
- Enumeration:
 - D
 - E
 - G
 - H
 - R
 - S
 - T
 - W
 - X
 - Y

[^ Less Values](#)

GDC permissible values

Observations (continued)

- Code/Label tuples (e.g., *primary_diagnosis* and *morphology*, *analyte_type* and *analyte_type_id*)
 - Implicit dependency -- code determines label
 - Commitment to a particular code system ("8370/3" is ICD-O-M)



Clinical			
Demographic	Diagnoses / Treatments (1)	Family Histories (0)	Exposures (0)
UUID	03ac1e46-d377-41c6-aedc-cba56377b5d3		
Classification Of Tumor	metastasis		
Alcohol Intensity	--		
Age At Diagnosis	28 years 32 days		
Days To Last Follow Up	--		
Days To Last Known Disease Status	--		
Days To Recurrence	--		
Last Known Disease Status	not reported		
Morphology	8370/3		
Primary Diagnosis	Adrenal cortical carcinoma		
Prior Malignancy	--		

GDC permissible values

Observations (continued)

- Label only (*disease_type*)
 - Still committed to ICD-O, but label is identity
 - Brittle -- “Leukemia, NOS” vs. “Leukaemia, NOS”

CA FM-AD / AD17818

Add a

Summary

Case UUID	ec455d41-48c7-4fce-8f52-d4c715bd559a
Case ID	AD17818
Project	FM-AD
Project Name	Foundation Medicine Adult Cancer Clinical Dataset (FM-AD)
Disease Type	Adenomas and Adenocarcinomas
Program	FM
Primary Site	Adrenal gland

FILES

5

ANNOTAT

0

GDC permissible values

Observations (continued)

- “Flavors of Null” - Unknown, Not Reported, Not Applicable ...
 - “Not Reported” is *not* a type of measurement -- permissible value re-used for multiple purposes

CMI-MBC / MBCProject_4424			
Demographic	Diagnoses / Treatments (1)	Family Histories (0)	Exposur
UUID	24c9e56c-447e-4365-9df1-51c77906232c		
Classification Of Tumor	--		
Alcohol Intensity	--		
Age At Diagnosis	--		
Days To Last Follow Up	--		
Days To Last Known Disease Status	--		
Days To Recurrence	--		
Last Known Disease Status	--		
Morphology	Not Reported		
Primary Diagnosis	Not Reported		
Prior Malignancy	--		
Synchronous Malignancy	--		
Progression Or Recurrence	--		
Site Of Resection Of Biopsy	Not Reported		
Tissue Or Organ Of Origin	Breast, NOS		
Tumor Grade	--		
Tumor Stage	--		

GDC permissible values

Observations (continued)

- Data vs. code semantics
 - “Yes”, “No” in answers to questions (e.g., *Diagnosis.ann_arbor_b_symptoms*, *ann_arbor_b_symptoms_described*)
 - Generic stage identifiers from particular staging systems

• Enumeration:	
◦ <i>ann_arbor_b_symptoms</i>	Text term to signify whether lymphoma B-symptoms are present as noted in the patient's medical record.
◦ <i>ann_arbor_b_symptoms_described</i>	Text describing the specific lymphoma B-symptoms present.
• Enumeration:	
	◦ Yes
	◦ No
	◦ Unknown
	◦ Not Reported
• Enumeration:	
	◦ Fever
	◦ Night Sweats
	◦ Other
	◦ Weight Loss

GDC permissible values

Approaches

- True permissible values (e.g., *analyte_type_id*)
 - Define in BiolinkML Enums
 - Determine code systems and code sets for value meaning maps
- Code/Label tuples (e.g., *primary_diagnosis* and *morphology*, *analyte_type* and *analyte_type_id*)
 - Are the codes sensible as permissible values (labels clearly are not)
 - Automate code → label lookup (do this for all permissible values)
 - Decide whether and which particular code system should define the values themselves
- Label only (*disease_type*)
 - Determine code system and codes to use (e.g., ICD-O-M category ontology)

GDC permissible values

Approaches (continued)

- “Flavors of Null” - Unknown, Not Reported, Not Applicable ...
 - Determine approach and philosophy advised by FHIR model
- Data vs. code semantics
 - Have to extend ontology to include specific assertions about specific symptoms (*ann_arbor_b_symptoms_present* as a concept, *ajcc_pathologic_stage_1* vs. *stage_1*)
 - Look at focusing on the ability to create atomic “factoids” -- statements that can stand on their own. Goal is to be able to decompose data sets into relevant factoids and then join ala. Linked Data paradigm.

GDC Model

- Need a rule language for validation (value and missing reason can't both be present).
 - Where do we go with this and how far do we go?
 - Can we leverage an existing language (e.g., FHIR Constraint Language) w/o committing to FHIR?
- Need to maintain and complete the data element semantic bindings -- the ontology based meanings associated with the actual data elements (i.e., fields)

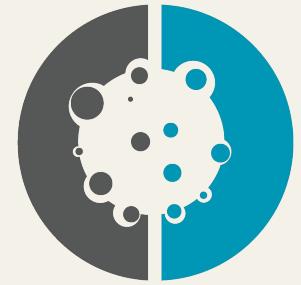
Harmonization of Permissible Values

- Worked on harmonization of some properties in GDC/PDC (e.g., *disease_type*, *analyte_type*)
- Collected existing GDC-NCIt mappings from EVS for the MVP CDM
- Programmatically collected NCIt-MONDO term mappings from the UberGraph RDF triplestore.
- Mapped disease type to MONDO terms. Curated existing mappings and added new mappings.
- Collaborated with CDA on value harmonization
- Established SSSOM as the format for mapping

TCCM (Terminology Core Common Model)

- Modeling
 - Continued to work on representing the TCCM model using BiolinkML.
 - Proposed RDF representation of ontologies (e.g., HPO) using SKOS
 - Worked on a 11179-based model in BiolinkML to represent enumerated value-based code sets
- Service Prototyping
 - Created prototype of a Python programming interface
 - Scripted programs to extract minimal entity reference for concepts from OWL-based ontologies.
 - Prototyped a REST API for delivering the entity references

Piloting of Tools for Annotating Data



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Piloting of Tools for Annotating Data

Exploration of tools and pilot testing of formats for annotating data with the CRDC-H model

- Continued work with pilot harmonization of data from Imaging Data Commons (IDC) datasets

Piloting of Tools for Annotating Data Tool summaries

Overview summaries of selected tools and formats explored during data harmonization pilots:

- CEDAR Workbench
- Ptolemy.V
- Portable Format for Biomedical Data (PFB)

Piloting of Tools for Annotating Data

Tool summaries

CEDAR Workbench

- [Document](#)
- CEDAR is built around a data model for describing templates, fields, and instances using JSON-LD (i.e. RDF) and JSON Schema
- Pros
 - design forms to collect data according a particular model (e.g., CRDC-H)
 - connection to caDSR data elements
- Cons
 - not yet deployable locally (outside of Bioportal group)
 - forms may be best suited to project level metadata; perhaps not for handling large row-oriented dataset

Piloting of Tools for Annotating Data

Tool summaries

Ptolemy.V

- [Document](#)
- Interactive web interface for mapping CSV dataset to a standardizd model
- Pros
 - nice support for workflow: “look at the distribution of values in a column, search for related terms, and then map the values to permissible values in the term”
- Cons
 - not open-source
 - needs richer output format (e.g., including identifiers, perhaps by adopting something like CEDAR instance format)

Piloting of Tools for Annotating Data

Tool summaries

Portable Format for Biomedical Data (PFB)

- [Document](#)
- PFB allows data to be transmitted side-by-side with metadata describing field formats, possible values, and other information in an Apache Avro Object Container File.
- Pros
 - In-file metadata and schema
 - In use by some data commons projects (e.g., Biodata Catalyst)
- Cons
 - Binary format; not as compatible with semantic web standards as JSON-LD

While we anticipate that most CCDH harmonized data will be stored in RDF (as LinkML instances), we think that PFB will be a valuable format for exchanging semantically-rich biomedical data.

Piloting of Tools for Annotating Data Annotated Data Formats

- **Goals**
 - Publish them in a way that encourages reuse
 - Share standardized concept identifiers rather than study-specific terminology
 - Add provenance information
 - “Self-describing and self-contained”
- **Support**
 - Validation of datasets according to the model
 - Moving structured data throughout CRDC

Piloting of Tools for Annotating Data Annotated Data Formats

- CSV without validation
- JSON-LD with validation using SHACL/ShEx
 - these “RDF shape” specifications could either describe the data file, or be exported from a LinkML model (e.g., CRDC-H) to be used for validation
- JSON-LD with validation using JSON Schema (= CEDAR Instance format)
 - JSON Schema could also be exported from a LinkML model
- JSON in Avro without validation (= Portable Format for Biomedical Data, PFB)

Exports to these formats from a CSV file have been implemented in our development tool `csv2caDSR` (<https://github.com/cancerDHC/csv2caDSR>)

Piloting of Tools for Annotating Data

Summary results

	CSV	JSON-LD + SHACL/ShEx	JSON-LD + JSON Schema (CEDAR)	JSON in Avro (PFB)
Provenance metadata	Sidecar	RDF-based	Included	In additional Avro schemas
Column-level metadata	Doable	RDF-based	<i>Not sure</i>	By extending the PFB schemas
Row-level metadata	Sidecar	RDF-based	By adding additional fields	By extending our schemas
Datum-level metadata	Hard to do	RDF-based	<i>Not sure</i>	<i>Not sure</i>
Self-contained	No	Yes	No	Yes
Self-describing	No	Yes	Yes	Yes
Convert from CSV	Roll our own	Roll our own	Roll our own	Roll our own
Convert to CSV	Tautology	Hard	Roll our own	Yes (pypfb)
Validate against model	Roll our own	SHACL/ShEx	JSON Schema	Roll our own
Interface for viewing	Yes	???	Yes, but only individual records	Yes
Interface for editing	Yes	No	Yes, but only individual records	Yes
Interface for editing model	No	No	Yes	Yes
Interface for submitting forms	Yes	No	Yes	No

Acknowledgments

CRDC Nodes

CDS: Cancer Data Services

GDC: Genomic Data Commons

ICDC: Integrated Canine Data Commons

IDC: Imaging Data Commons

PDC: Proteomics Data Commons

DCF: Data Commons Framework - Infrastructure

Collaborators

Broad Institute FireCloud

CIDC: Cancer Immunology Data Commons

Gabriella Miller Kids First Data Resource Center

HTAN: Human Tumor Atlas Network

ISB: Institute for Systems Biology (Cloud)

Center for Biomedical Informatics & Information Technology

- Allen Dearry
- Sherri de Coronado
- Erika Kim
- Denise Warzel
- Melissa Cook

Samvit Solutions

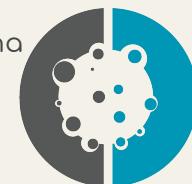
- Smita Hastak
- Wendy Ver Hoef
- Charles Yaghmour

Frederick National Laboratory for Cancer Research

- Todd Pihl
- Resham Kulkarni

Cancer Data Aggregator

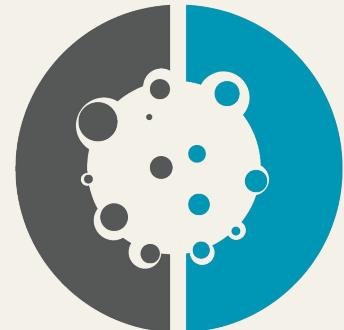
- Brian O'Connor
- Alex Baumann
- David Pot
- Jack DiGiovanna
- Annie Kuan



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Questions & Answers

These slides:
bit.ly/ccdh-q4-2020



CCDH Quarterly Report to Federal Oversight (NIH/NCI and FNL)
Date: January 13, 2021

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