CDISC Analysis Results Logical Model: Background and Overview

CDISC EU Interchange: April 27, 2023

(Session 5: Track A – Analysis Results Standard)

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Richard Marshall, Principal Data Modeler, CDISC

Meet the Speakers

Bhavin Busa

Title: Principal and Co-founder

Organization: Clymb Clinical

Thought leader in the areas of data standards, programming, analytics, and regulatory submission. Co-Founder of Clymb Clinical. Passionate about leveraging standards and technology to expedite data review, analysis, and submission processes. PHUSE Steering Committee member, co-chair PHUSE US Connect, CDISC Analysis Results Standards Co-Lead and is currently a board member of the CDISC Open-Source Alliance (COSA) team.

Richard Marshall

Title: Principal Data Modeler and API Architect

Organization: CDISC

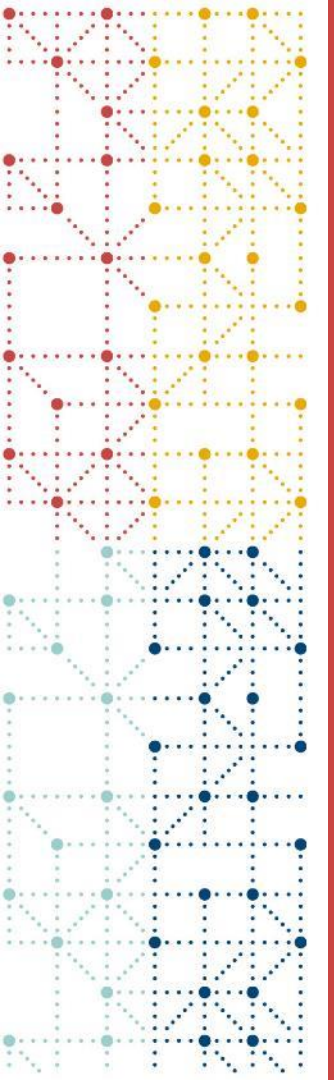
More than 30 years' experience in the pharma industry, specialized in clinical data standards for more than 20 years. Co-founded Accurate Systems Ltd. Past 6 years contracting with CDISC, as both Standards Developer (co-developing three Type 1 Diabetes TAUGs and the Crohn's Disease TAUG, and being the sole developer for the Pediatrics User Guide) and member of the SME panel for the development of the SDTM Tabulate certification program.

He has also developed standard CDASH CRFs for the CRF Portal and played a key role in development and provision of these standard CRFs in both OpenClinica and REDCap. Richard is currently the Principal Data Modeler and API Architect for the Analysis Results Standard (ARS) project.

Disclaimer and Disclosures

- *The views and opinions expressed in this presentation are those of the author(s) and do not necessarily reflect the official policy or position of CDISC.*

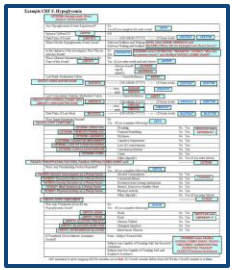
- *I have no real or apparent conflicts of interest to report.*



Agenda

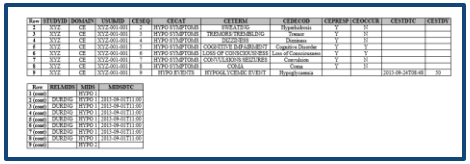
1. Background
2. Use Cases for Analysis Results Standards
3. Analysis Results Key Objectives and Key Results
4. Analysis Results Logical Metamodel
5. ARS Development on GitHub
6. Review Examples
7. Reference implementation
8. ARS Roadmap
9. Q&A

CDISC Foundational Standards



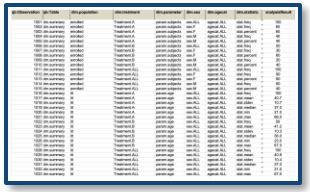
Data Collection

CDASH



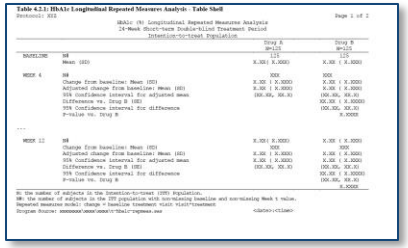
Data Aggregation

SDTM



Analysis

ADaM



Results

???

Table 4.2.2: HbA1c Longitudinal Repeated Measures Analysis Results Metadata

Metadata Field	Metadata
DISPLAY IDENTIFIER	Table 4.2.1/Figure 4.2.1
DISPLAY NAME	Mean Change from Baseline in HbA1c (Percent) Longitudinal Repeated Measures Analysis, 24-Week Short-term Double-blind Treatment Period, Intention-to-treat Population
RESULT IDENTIFIER	Treatment difference results (LSMean, confidence interval, p-value)
PARAM	HbA1c (%)
PARAMCD	HBA1C
ANALYSIS VARIABLE	CHG (Change from baseline)
ANALYSIS REASON	SPECIFIED IN SAP
ANALYSIS PURPOSE	PRIMARY OUTCOME MEASURE
ANALYSIS DATASET	ADHBA1C

ARM for Define.XML

Use Cases for Analysis Results Standards

- Use Case 01:

  As an analyst, I need a technical specifications to prospectively specify analysis results metadata for data displays to facilitate and automate the planning and production of results

- Use Case 02:

  As an analyst, I need a structure to represent analysis results and qualifying metadata to support traceability, reproducibility, reusability and quality

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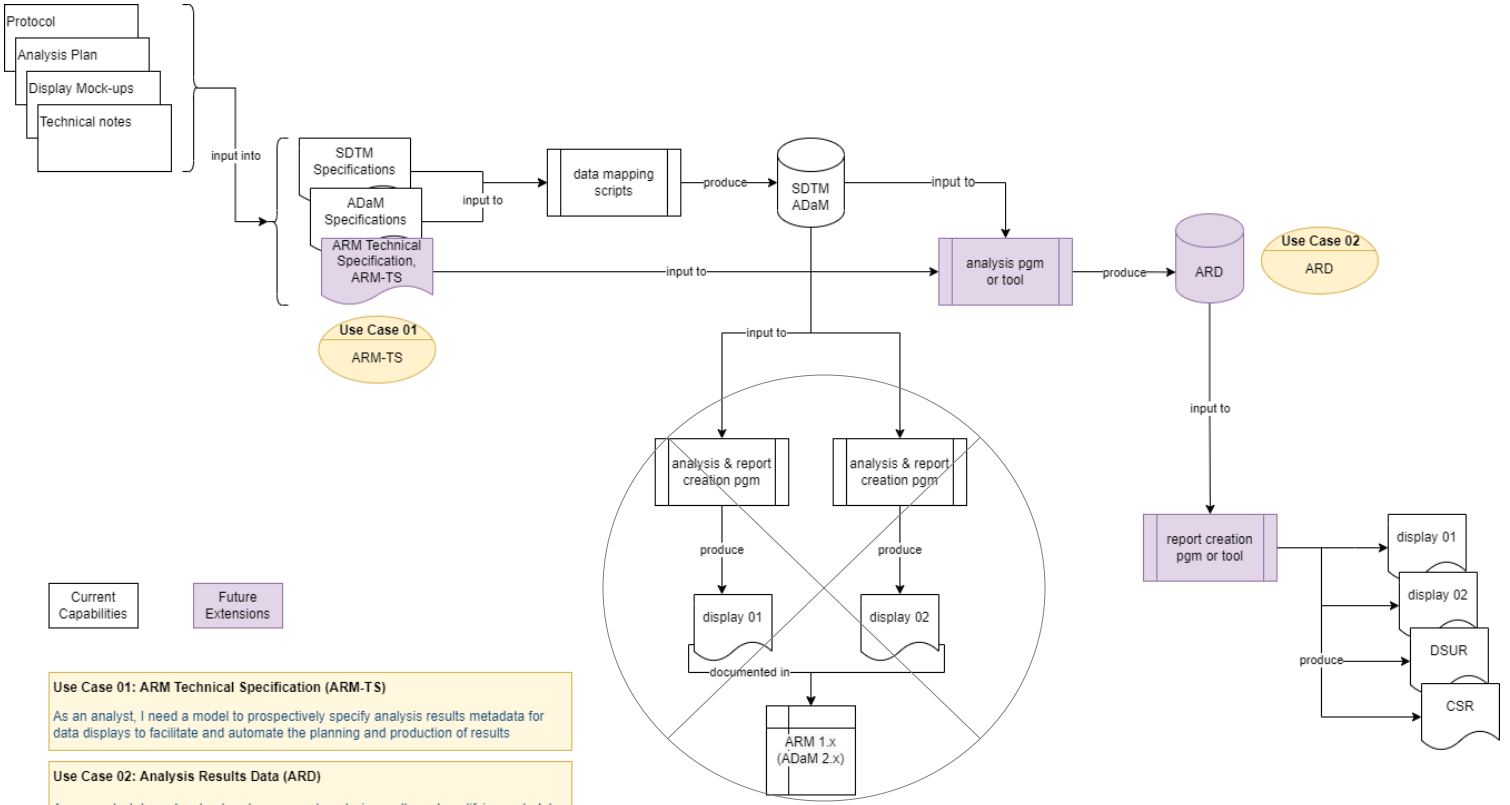
Workflow with Future Extensions



Use Case 01: ARM Technical Specification (ARM-TS)

As an analyst, I need a model to prospectively specify analysis results metadata for data displays to facilitate and automate the planning and production of results

Use Case 02: Analysis Results Data (ARD)

As an analyst, I need a structure to represent analysis results and qualifying metadata to support traceability, reproducibility, reusability and quality

Analysis Results Key Objectives

- Use analysis results metadata to drive the automation of results
- Support storage, access, processing and reproducibility of results
- Improved navigation and reusability of analyses and results
- Traceability to Protocol/SAP and to input ADaM data

Initial Analysis Results Standards Key Results

Develop a technical specification to prospectively leverage Analysis Results Metadata to drive automation

Develop a structure to represent Analysis Results as data

Illustrate and exercise with a set of common data displays

Concepts Team Consulted Published Layouts

- PH
- JP
- Re
- Su

Scatterplot and Shift Table Summary of Absolute Lab values – Lab Test 1 Minimum Baseline vs Minimum Post-baseline

Treatment
T1 (N = xxx)
T2 (N = xxx)
PL (N = xxx)

N = number of su
of subjects in ea
using the referer
demographics.

3.14安全性の解析（バイタルサイン、身体的所見及び安全性に関連する

Table summary of vital signs by visit

<Prameter> BDS.PARAM
<Visit> BDS.AVISIT
n
Mean (SD) BDS.AVAL
Median
Min - Max

上記例は、絶対値の集計の場合。
バイタルサインのベースラインからの変化量を集計する必要がある場合
る場合は BDS.PCHG を使用する

Table 3. Laboratory Abnormalities that Worsened from Baseline to Grade 3 or 4 Occurring in ≥1% of Patients with dMMR Endometrial Cancer Receiving Product in Study

Laboratory Test	Product N = 104	
	All Grades[a] %	Grade 3 or 4[a] %
Hematology		
Decreased lymphocytes	37	9
Decreased leukocytes	21	2.9
Chemistry		
Decreased albumin	30	2.9
Increased creatinine	27	2.9
Increased alkaline phosphatase	25	2.9
Increased aspartate aminotransferase	16	1.9
Increased alanine aminotransferase	15	2.9
Electrolytes		
Decreased sodium	26	4.8
Increased calcium	15	1.9
Decreased potassium	15	1.9

[a] Consists of new onset of laboratory abnormality or worsening of baseline laboratory abnormality.

Demographics Analysis Results and Metadata

Display Template | Title | Analysis Set

Table 2. Baseline Demographic and Clinical Characteristics, Safety Population, Pooled Analyses (or Trial X)

Characteristic (Analysis Group)	Drug Name Dosage X N = XXX	Drug Name Dosage Y N = XXX	Placebo N = XXX	Active Control N = XXX	Total Population N = XXX
Sex, n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Male	n (%)	n (%)	n (%)	n (%)	n (%)
Female	n (%)	n (%)	n (%)	n (%)	n (%)
Age, years	**X.X (Y.Y)**	**X.X (Y.Y)**	**X.X (Y.Y)**	**X.X (Y.Y)**	**X.X (Y.Y)**
Mean (SD)	X.X (Y.Y)	X.X (Y.Y)	X.X (Y.Y)	X.X (Y.Y)	X.X (Y.Y)
Median (min, max)	X.X (Y.Y, Z.Z)	X.X (Y.Y, Z.Z)	X.X (Y.Y, Z.Z)	X.X (Y.Y, Z.Z)	X.X (Y.Y, Z.Z)
Age groups (years), n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
≥17 to <65	n (%)	n (%)	n (%)	n (%)	n (%)
≥65	n (%)	n (%)	n (%)	n (%)	n (%)
≥65 to <75	n (%)	n (%)	n (%)	n (%)	n (%)
≥75	n (%)	n (%)	n (%)	n (%)	n (%)
Race, n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
American Indian or Alaska Native Asian	n (%)	n (%)	n (%)	n (%)	n (%)
Black or African American	n (%)	n (%)	n (%)	n (%)	n (%)
Native Hawaiian or Other Pacific Islander	n (%)	n (%)	n (%)	n (%)	n (%)
White	n (%)	n (%)	n (%)	n (%)	n (%)
Other	n (%)	n (%)	n (%)	n (%)	n (%)

Result Group | Result Variable | Where Clause | Result Statistics

Source: [include Applicant source, datasets and/or software tools used].
[1] Difference is shown between [treatment arms] (e.g., difference is shown between Drug Name dosage X vs. placebo).
Abbreviations: N, number of patients in treatment arm; n, number of patients with given characteristic; SD, standard deviation

Footnote | Abbreviations | Legend

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Analysis Results and Associated Metadata Example

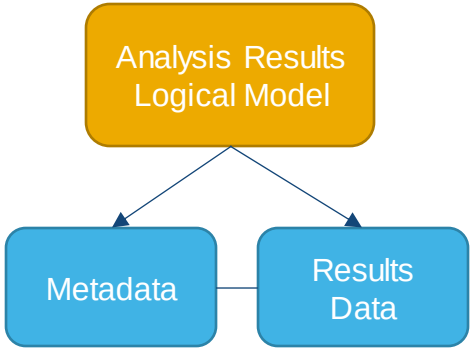
Identifiers		Analysis Group			Result Variable			Results Statistic		
Name	Title	Dataset	Variable	Value	Variable	Value	Label	Value	Name	Label
Table 2	Baseline Demographics and Clinical Characteristics, Safety Population	ADSL	TR01X	Drug Name Dosage X	SEX	M	Male	53	Count	n
Table 2	Baseline Demographics and Clinical Characteristics, Safety Population	ADSL	TR01X	Drug Name Dosage X	SEX	M	Male	61.6	Percent	%
Table 2	Baseline Demographics and Clinical Characteristics, Safety Population	ADSL	TR01X	Drug Name Dosage X	SEX	F	Female	33	Count	n
Table 2	Baseline Demographics and Clinical Characteristics, Safety Population	ADSL	TR01X	Drug Name Dosage X	SEX	F	Female	38.4	Percent	%

Analysis Results Metadata

Analysis Results Data

Moving Towards a Logical Model

- Logical model will incorporate the elements for both analysis results and associated metadata:
  - Analysis Results Metadata Technical Specification (ARM-TS), to support automation, traceability, and creation of data displays
  - Analysis Results Data (ARD) structure, to support reuse, reproducibility, and traceability of results data
- Model definition and documentation
- Illustrate and exercise with a common safety displays
  - Vital signs
  - Demographics
  - Adverse Events



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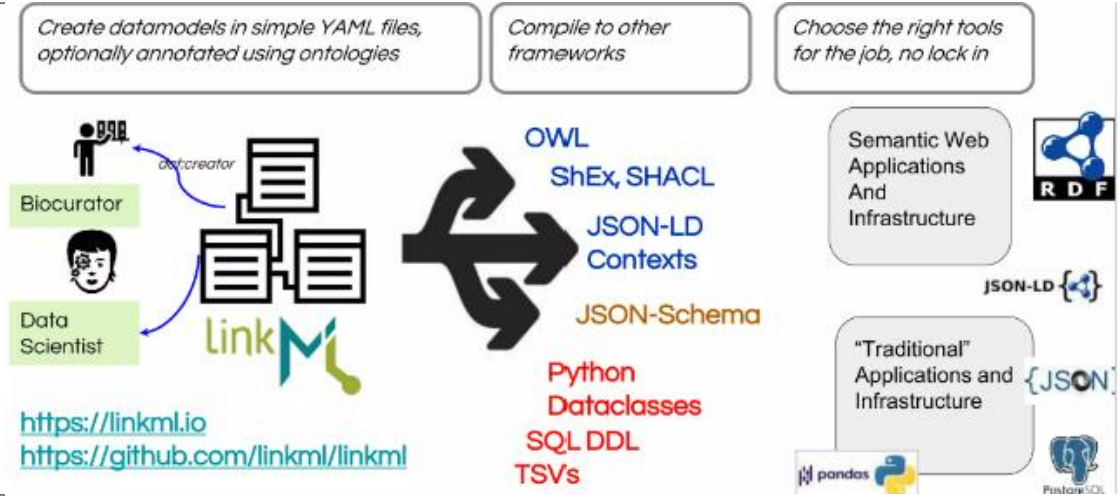
Using LinkML to Create Analysis Results Model

- LinkML is a general-purpose modeling language that can be used with linked data, JSON, and other formalisms

LinkML Landscape



Reference: https://www.slideshare.net/cmungall/linkml-intro-july-2022pptx

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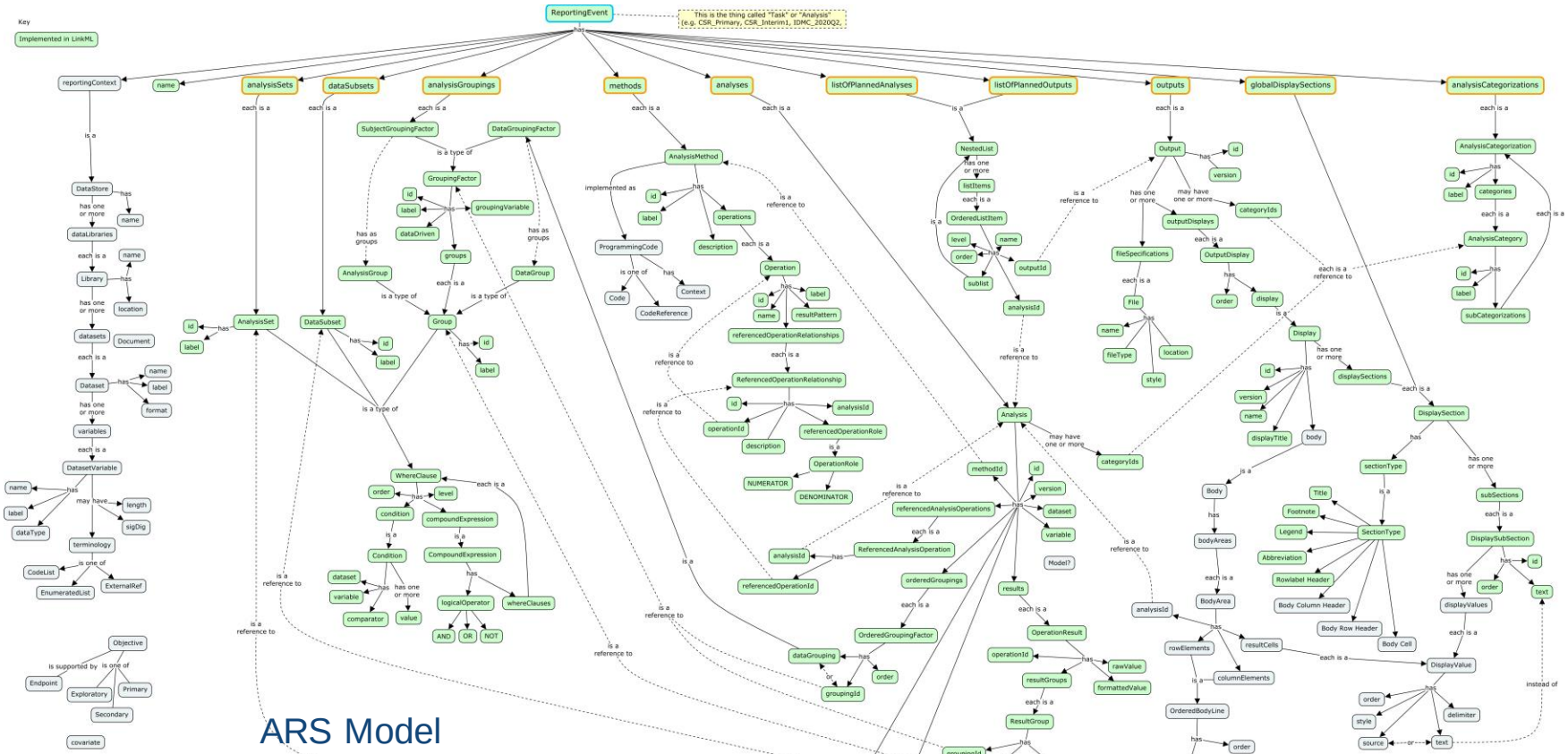
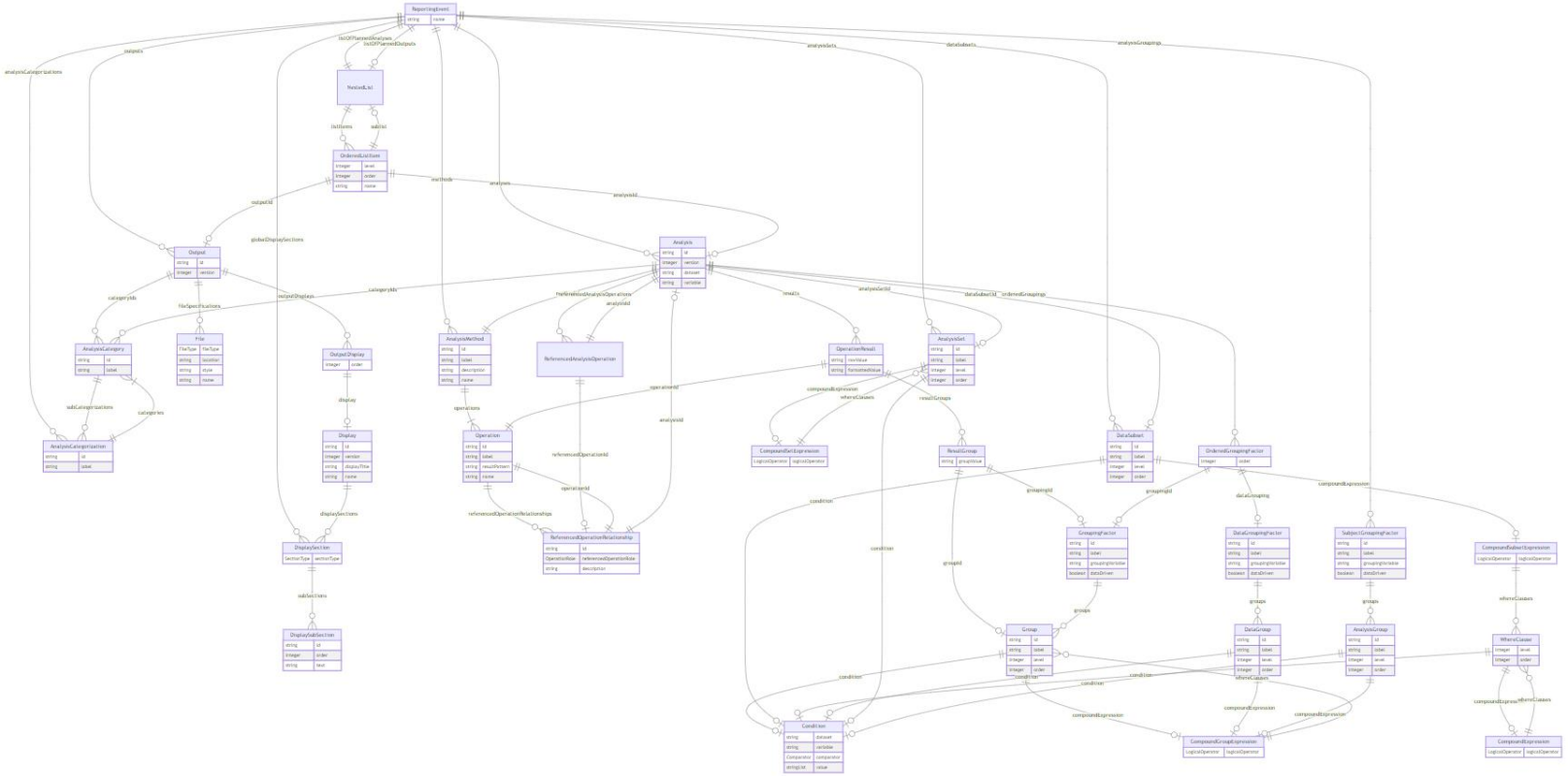
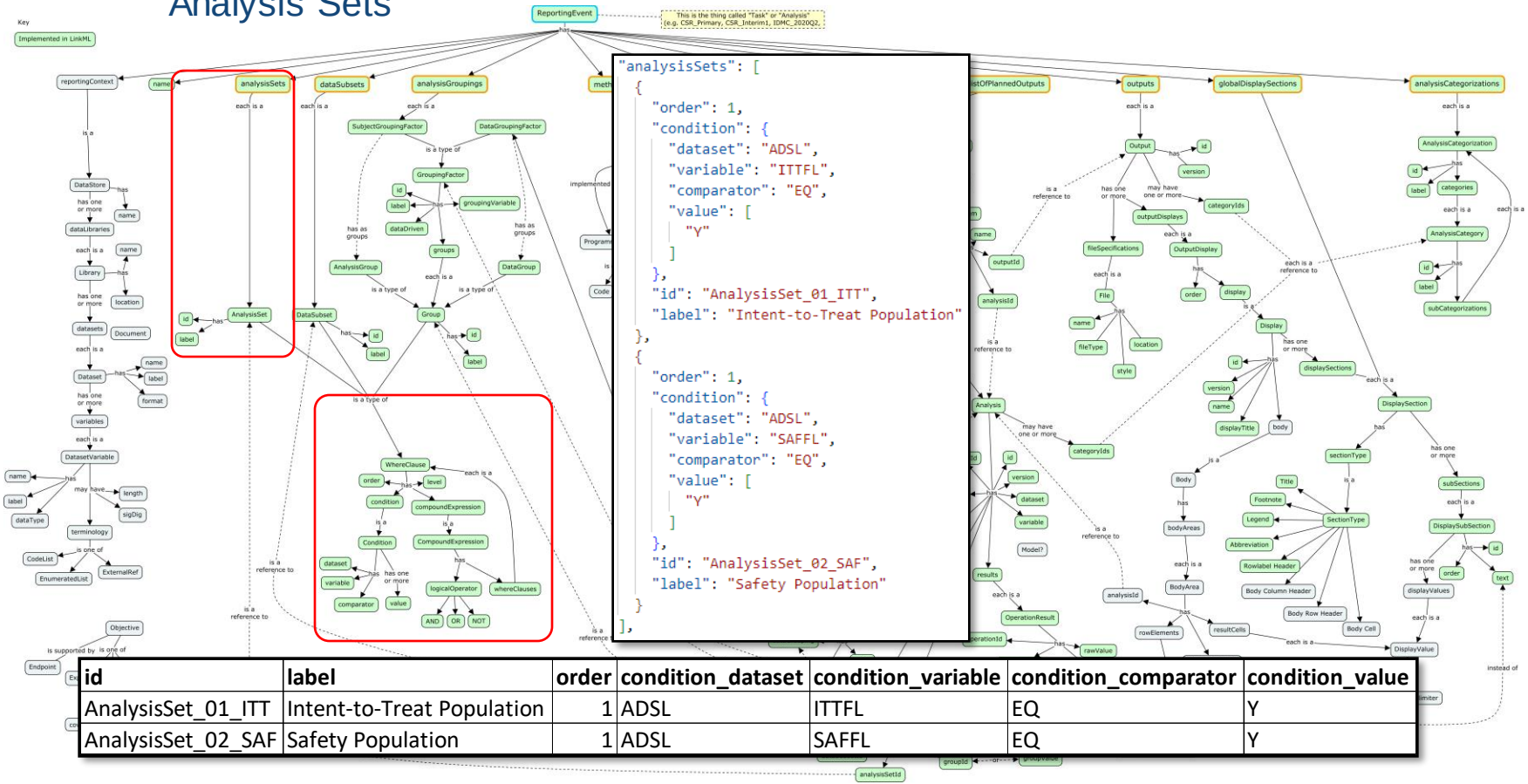

Key
Implemented in LinkML
ReportingEvent
This is the thing called "Task" or "Analysis" (e.g. CSR_Primary, CSR_Interim1, IDMC_2020Q2,
reportingContext
name
analysisSets
dataSubsets
analysisGroupings
methods
analyses
listOfPlannedAnalyses
listOfPlannedOutputs
outputs
globalDisplaySections
analysisCategorizations
DataStore
dataLibraries
Library
datasets
Dataset
variables
DatasetVariable
Document
location
format
label
dataType
length
sigDig
terminology
CodeList
EnumeratedList
ExternalRef
Objective
Endpoint
Exploratory
Primary
Secondary
covariate
AnalysisSet
DataSubset
SubjectGroupingFactor
DataGroupingFactor
GroupingFactor
groupingVariable
dataDriven
AnalysisGroup
DataGroup
Group
WhereClause
Condition
CompoundExpression
logicalOperator
whereClauses
AND
OR
NOT
comparator
value
AnalysisMethod
ProgrammingCode
CodeReference
Context
Operation
resultPattern
referencedOperationRelationships
ReferencedOperationRelationship
operationId
analysisId
referencedOperationRole
OperationRole
NUMERATOR
DENOMINATOR
description
Analysis
methodId
referencedAnalysisOperations
ReferencedAnalysisOperation
referencedOperationId
orderedGroupings
OrderedGroupingFactor
dataGrouping
groupingId
results
OperationResult
rawValue
formattedValue
resultGroups
ResultGroup
groupId
groupValue
dataSubsetId
analysisSetId
NestedList
listItems
OrderedListItem
level
order
sublist
outputId
Output
version
outputDisplays
categoryIds
fileSpecifications
File
fileType
style
OutputDisplay
display
Display
displaySections
DisplaySection
sectionType
SectionType
Title
Footnote
Legend
Abbreviation
Rowlabel Header
Body Column Header
Body Row Header
Body Cell
subSections
DisplaySubSection
displayValues
DisplayValue
delimiter
Body
bodyAreas
BodyArea
rowElements
columnElements
OrderedBodyLine
analysisComponentRef
resultCells
AnalysisCategorization
categories
AnalysisCategory
subCategorizations
ARS Model Representation using CMAP (DRAFT)

ARS Model Representation using Mermaid Markdown (DRAFT)



Analysis Sets




```
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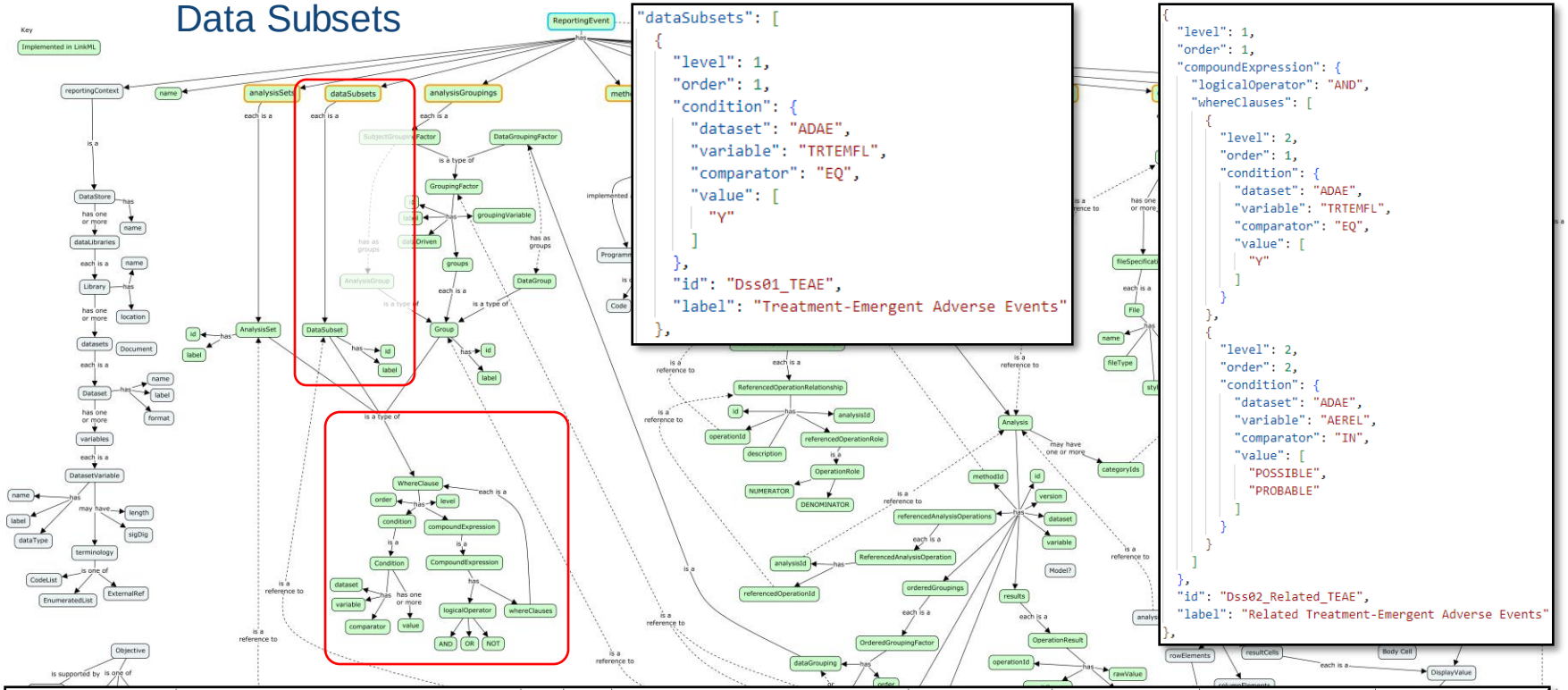
      "value": [
        "Y"
      ]
    },
    "id": "AnalysisSet_01_ITT",
    "label": "Intent-to-Treat Population"
  },
  {
    "order": 1,
    "condition": {
      "dataset": "ADSL",
      "variable": "SAFFL",
      "comparator": "EQ",
      "value": [
        "Y"
      ]
    },
    "id": "AnalysisSet_02_SAF",
    "label": "Safety Population"
  }
],
```

id	label	order	condition_dataset	condition_variable	condition_comparator	condition_value
AnalysisSet_01_ITT	Intent-to-Treat Population	1	ADSL	ITTFL	EQ	Y
AnalysisSet_02_SAF	Safety Population	1	ADSL	SAFFL	EQ	Y

Data Subsets




```
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      "variable": "TRTEMFL",
      "comparator": "EQ",
      "value": [
        "Y"
      ]
    },
    "id": "Dss01_TEAE",
    "label": "Treatment-Emergent Adverse Events"
  },
```

```
{
  "level": 1,
  "order": 1,
  "compoundExpression": {
    "logicalOperator": "AND",
    "whereClauses": [
      {
        "level": 2,
        "order": 1,
        "condition": {
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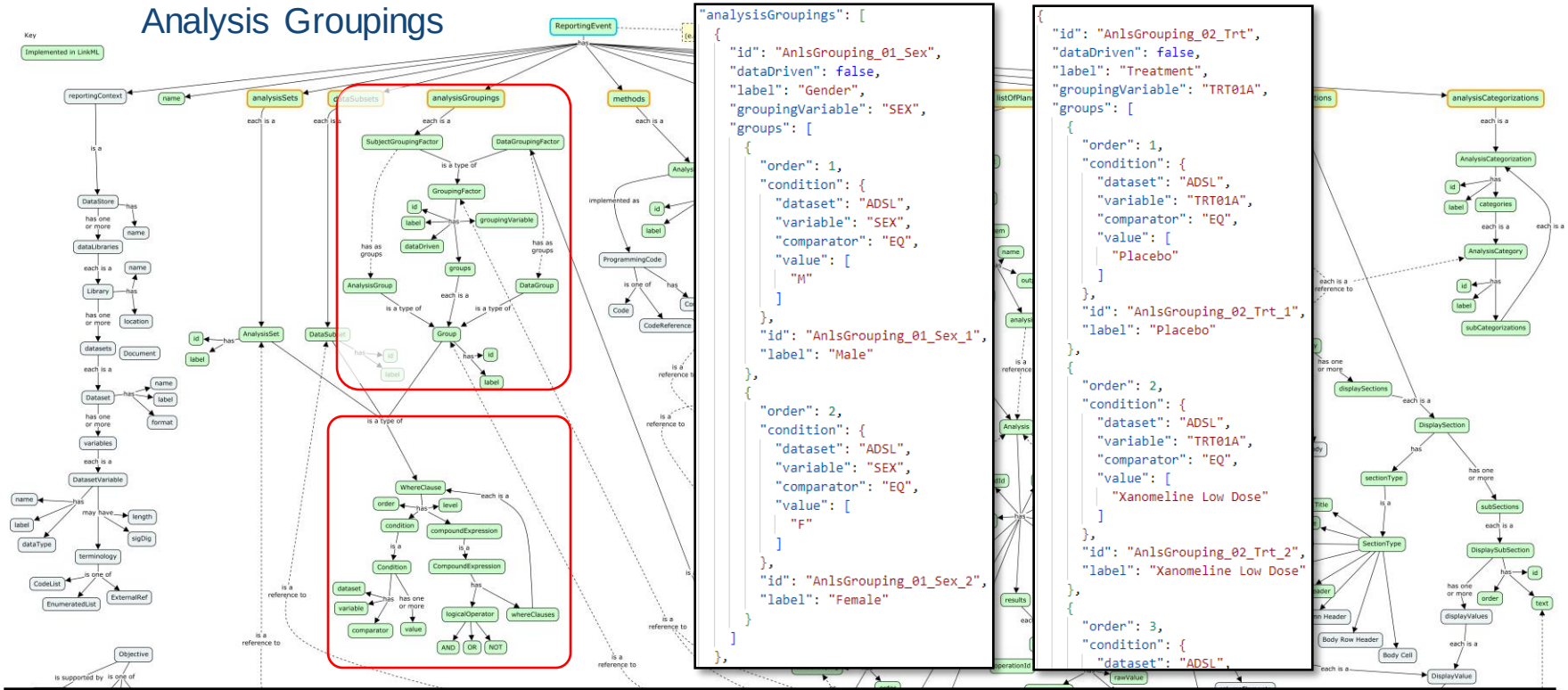
          "variable": "TRTEMFL",
          "comparator": "EQ",
          "value": [
            "Y"
          ]
        }
      },
      {
        "level": 2,
        "order": 2,
        "condition": {
          "dataset": "ADAE",
          "variable": "AEREL",
          "comparator": "IN",
          "value": [
            "POSSIBLE",
            "PROBABLE"
          ]
        }
      }
    ]
  },
  "id": "Dss02_Related_TEAE",
  "label": "Related Treatment-Emergent Adverse Events"
},
```

id	label	level	order	compoundExpression_logicalOperator	condition_dataset	condition_variable	condition_comparator	condition_value
Dss01_TEAE	Treatment-Emergent Adverse Events	1	1		ADAE	TRTEMFL	EQ	Y
Dss02_Related_TEAE	Related Treatment-Emergent Adverse Events	1	1	AND				
Dss02_Related_TEAE	Related Treatment-Emergent Adverse Events	2	1		ADAE	TRTEMFL	EQ	Y
Dss02_Related_TEAE	Related Treatment-Emergent Adverse Events	2	2		ADAE	AEREL	IN	POSSIBLE | PROBABLE

Analysis Groupings

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"analysisGroupings": [
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    "groupingVariable": "SEX",
    "groups": [
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        "order": 1,
        "condition": {
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          "variable": "SEX",
          "comparator": "EQ",
          "value": [
            "M"
          ]
        },
        "id": "AnlsGrouping_01_Sex_1",
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      },
      {
        "order": 2,
        "condition": {
          "dataset": "ADSL",
          "variable": "SEX",
          "comparator": "EQ",
          "value": [
            "F"
          ]
        },
        "id": "AnlsGrouping_01_Sex_2",
        "label": "Female"
      }
    ]
  },
```

```
{
  "id": "AnlsGrouping_02_Trt",
  "dataDriven": false,
  "label": "Treatment",
  "groupingVariable": "TRT01A",
  "groups": [
    {
      "order": 1,
      "condition": {
        "dataset": "ADSL",
        "variable": "TRT01A",
        "comparator": "EQ",
        "value": [
          "Placebo"
        ]
      },
      "id": "AnlsGrouping_02_Trt_1",
      "label": "Placebo"
    },
    {
      "order": 2,
      "condition": {
        "dataset": "ADSL",
        "variable": "TRT01A",
        "comparator": "EQ",
        "value": [
          "Xanomeline Low Dose"
        ]
      },
      "id": "AnlsGrouping_02_Trt_2",
      "label": "Xanomeline Low Dose"
    },
    {
      "order": 3,
      "condition": {
        "dataset": "ADSL",
```

id	label	groupingVariable	dataDriven	group_id	group_label	group_order	group_condition_dataset	group_condition_variable	group_condition_comparator	group_condition_value
AnlsGrouping_01_Sex	Gender	SEX	FALSE	AnlsGrouping_01_Sex_1	Male	1	ADSL	SEX	EQ	M
AnlsGrouping_01_Sex	Gender	SEX	FALSE	AnlsGrouping_01_Sex_2	Female	2	ADSL	SEX	EQ	F
AnlsGrouping_02_Trt	Treatment	TRT01A	FALSE	AnlsGrouping_02_Trt_1	Placebo	1	ADSL	TRT01A	EQ	Placebo
AnlsGrouping_02_Trt	Treatment	TRT01A	FALSE	AnlsGrouping_02_Trt_2	Xanomeline Low Dose	2	ADSL	TRT01A	EQ	Xanomeline Low Dose
AnlsGrouping_02_Trt	Treatment	TRT01A	FALSE	AnlsGrouping_02_Trt_3	Xanomeline High Dose	3	ADSL	TRT01A	EQ	Xanomeline High Dose

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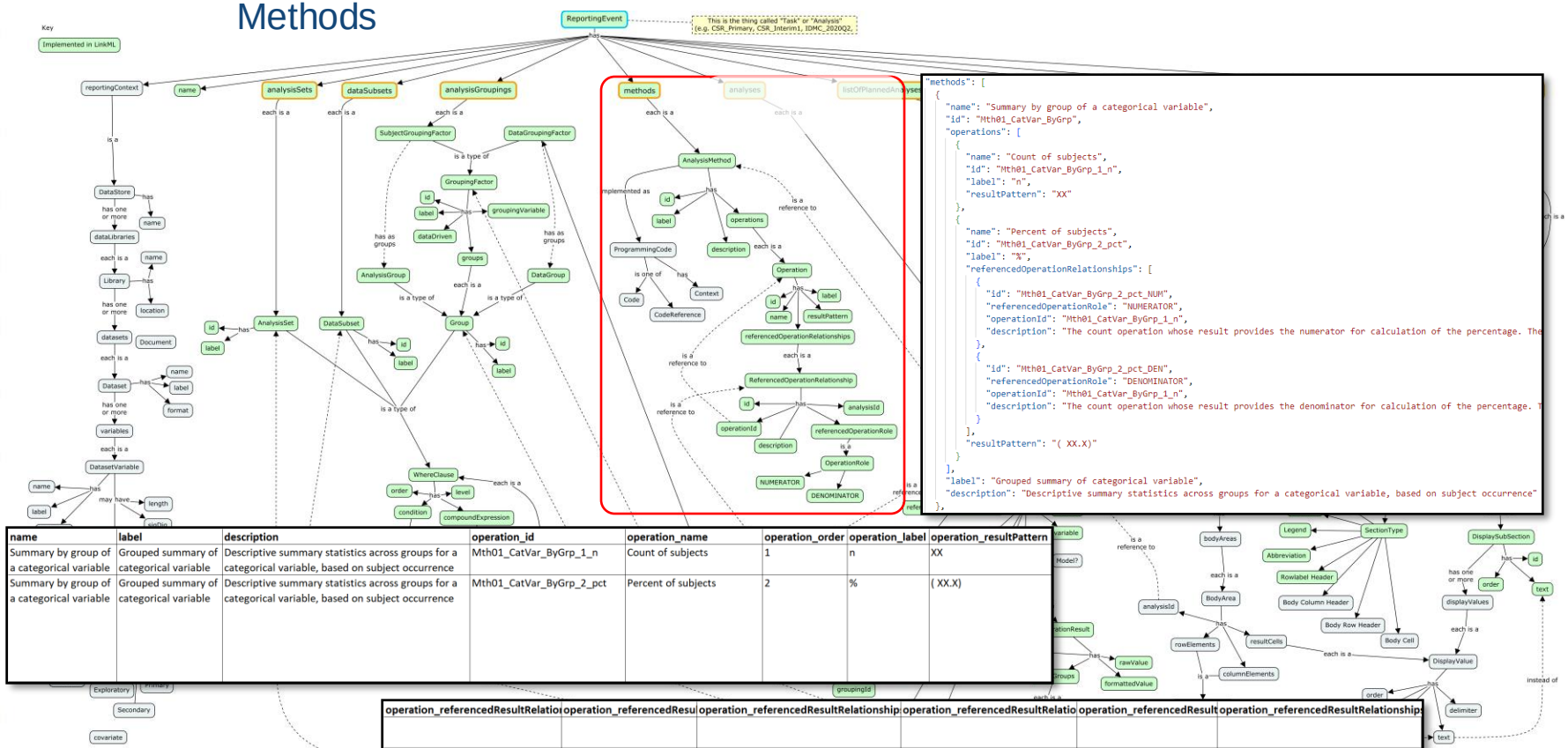
Methods




```
"methods": [
  {
    "name": "Summary by group of a categorical variable",
    "id": "Mth01_CatVar_ByGrp",
    "operations": [
      {
        "name": "Count of subjects",
        "id": "Mth01_CatVar_ByGrp_1_n",
        "label": "n",
        "resultPattern": "XX"
      },
      {
        "name": "Percent of subjects",
        "id": "Mth01_CatVar_ByGrp_2_pct",
        "label": "%",
        "referencedOperationRelationships": [
          {
            "id": "Mth01_CatVar_ByGrp_2_pct_NUM",
            "referencedOperationRole": "NUMERATOR",
            "operationId": "Mth01_CatVar_ByGrp_1_n",
            "description": "The count operation whose result provides the numerator for calculation of the percentage. The
          },
          {
            "id": "Mth01_CatVar_ByGrp_2_pct_DEN",
            "referencedOperationRole": "DENOMINATOR",
            "operationId": "Mth01_CatVar_ByGrp_1_n",
            "description": "The count operation whose result provides the denominator for calculation of the percentage. T
          }
        ],
        "resultPattern": "( XX.X)"
      }
    ],
    "label": "Grouped summary of categorical variable",
    "description": "Descriptive summary statistics across groups for a categorical variable, based on subject occurrence"
  },
```


name	label	description	operation_id	operation_name	operation_order	operation_label	operation_resultPattern
Summary by group of a categorical variable	Grouped summary of categorical variable	Descriptive summary statistics across groups for a categorical variable, based on subject occurrence	Mth01_CatVar_ByGrp_1_n	Count of subjects	1	n	XX
Summary by group of a categorical variable	Grouped summary of categorical variable	Descriptive summary statistics across groups for a categorical variable, based on subject occurrence	Mth01_CatVar_ByGrp_2_pct	Percent of subjects	2	%	(XX.X)

operation_referencedResultRelatio	operation_referencedResu	operation_referencedResultRelationship	operation_referencedResultRelatio	operation_referencedResult	operation_referencedResultRelationship
Mth01_CatVar_ByGrp_2_pct_NUM	Mth01_CatVar_ByGrp_1_n	The count operation whose result provides the numerator for calculation of the percentage. The referenced analysis should be the analysis that contains this percent operation.	Mth01_CatVar_ByGrp_2_pct_DEN	Mth01_CatVar_ByGrp_1_n	The count operation whose result provides the denominator for calculation of the percentage. The referenced analysis should have the same analysis set and subject grouping(s) as the analysis containing this percent operation.

Analyses

id	versi	name	categoryIds	analysisSetId	groupingId1	groupingId2	groupingId3	dataSubsetId	data	variable	method_id
An03.02_AgeGrp_ByTrt	1	Summary of Subjects by Treatment and Age Group		AnalysisSet_02_SAF	AnlsGrouping_02_Trt	AnlsGrouping_03_AgeGp			ADSL	USUBJID	Mth01_CatVar_ByGrp
An08.02_ChgBl_ByTrt	1	Summary of Change from Baseline by Treatment, Parameter and Visit		AnalysisSet_02_SAF	AnlsGrouping_02_Trt	AnlsGrouping_08_Param	AnlsGrouping_09_Visit	Dss10_VS_NonBl_AnRec	ADVS	CHG	Mth02_ContVar_ByGrp

referencedAnalysisOperations_r	referencedAnalysisOp	referencedAnalysisOperations_	referencedAnaly
Mth01_CatVar_ByGrp_2_pct_NUM	An03.02_AgeGrp_ByTrt	Mth01_CatVar_ByGrp_2_pct_DEN	An01.05_SAF_ByTrt

```
"analyses": [
  { ···
  },
```


```
{
  "name": "Summary of Change from Baseline by Treatment, Parameter and Visit",
  "id": "An08.02_ChgBl_ByTrt",
  "methodId": "Mth02_ContVar_ByGrp",
  "version": 1,
  "analysisSetId": "AnalysisSet_02_SAF",
  "orderedGroupings": [
    {
      "order": 1,
      "groupingId": "AnlsGrouping_02_Trt"
    },
    {
      "order": 2,
      "groupingId": "AnlsGrouping_08_Param"
    },
    {
      "order": 3,
      "groupingId": "AnlsGrouping_09_Visit"
    }
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```


```
  "results": [ ···
  ]
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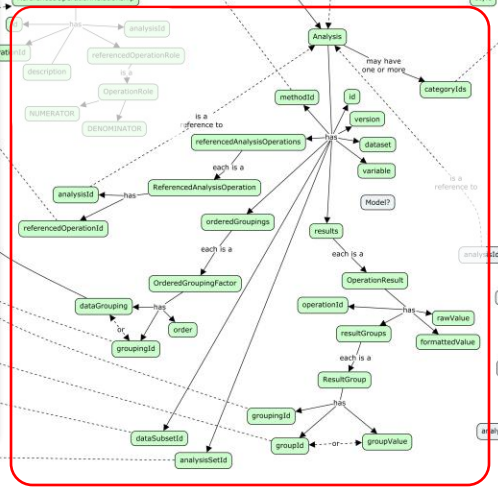

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Analysis Results

id	operation_id	resultGroup1_groupingId	resultGroup1_groupId	resultGroup2_groupingId	resultGroup2_groupId	resultGroup3_groupingId	resultGroup3_groupId	rawValu	formattedVal
An08.02_ChgBl_ByTrt	Mth02_ContVar_ByGrp_1_n	AnlsGrouping_02_Trt	AnlsGrouping_02_Trt_1	AnlsGrouping_08_Param	AnlsGrouping_08_Param_1	AnlsGrouping_09_Visit	AnlsGrouping_09_Visit_02	249	249
An08.02_ChgBl_ByTrt	Mth02_ContVar_ByGrp_2_Mean	AnlsGrouping_02_Trt	AnlsGrouping_02_Trt_1	AnlsGrouping_08_Param	AnlsGrouping_08_Param_1	AnlsGrouping_09_Visit	AnlsGrouping_09_Visit_02	-3.3012	- 3.3
An08.02_ChgBl_ByTrt	Mth02_ContVar_ByGrp_3_SD	AnlsGrouping_02_Trt	AnlsGrouping_02_Trt_1	AnlsGrouping_08_Param	AnlsGrouping_08_Param_1	AnlsGrouping_09_Visit	AnlsGrouping_09_Visit_02	14.60121	(14.60)
An08.02_ChgBl_ByTrt	Mth02_ContVar_ByGrp_4_Media			Grouping_08_Param	AnlsGrouping_08_Param_1	AnlsGrouping_09_Visit	AnlsGrouping_09_Visit_02	-2	- 2.0
An08.02_ChgBl_ByTrt	Mth02_ContVar_ByGrp_5_Q1			Grouping_08_Param	AnlsGrouping_08_Param_1	AnlsGrouping_09_Visit	AnlsGrouping_09_Visit_02	-12	-12.0
An08.02_ChgBl_ByTrt	Mth02_ContVar_ByGrp_6_Q3			Grouping_08_Param	AnlsGrouping_08_Param_1	AnlsGrouping_09_Visit	AnlsGrouping_09_Visit_02	4	4.0
An08.02_ChgBl_ByTrt	Mth02_ContVar_ByGrp_7_Min			Grouping_08_Param	AnlsGrouping_08_Param_1	AnlsGrouping_09_Visit	AnlsGrouping_09_Visit_02	-38	-38
An08.02_ChgBl_ByTrt	Mth02_ContVar_ByGrp_8_Max			Grouping_08_Param	AnlsGrouping_08_Param_1	AnlsGrouping_09_Visit	AnlsGrouping_09_Visit_02	40	40
An08.02_ChgBl_ByTrt	Mth02_ContVar_ByGrp_1_n			Grouping_08_Param	AnlsGrouping_08_Param_1	AnlsGrouping_09_Visit	AnlsGrouping_09_Visit_03	243	243
An08.02_ChgBl_ByTrt	Mth02_ContVar_ByGrp_2_Mean			Grouping_08_Param	AnlsGrouping_08_Param_1	AnlsGrouping_09_Visit	AnlsGrouping_09_Visit_03	-3.02469	- 3.0
An08.02_ChgBl_ByTrt	Mth02_ContVar_ByGrp_3_SD			Grouping_08_Param	AnlsGrouping_08_Param_1	AnlsGrouping_09_Visit	AnlsGrouping_09_Visit_03	15.66829	(15.67)
An08.02_ChgBl_ByTrt	Mth02_ContVar_ByGrp_4_Media			Grouping_08_Param	AnlsGrouping_08_Param_1	AnlsGrouping_09_Visit	AnlsGrouping_09_Visit_03	-2	- 2.0
An08.02_ChgBl_ByTrt	Mth02_ContVar_ByGrp_5_Q1			Grouping_08_Param	AnlsGrouping_08_Param_1	AnlsGrouping_09_Visit	AnlsGrouping_09_Visit_03	-12	-12.0
An08.02_ChgBl_ByTrt	Mth02_ContVar_ByGrp_6_Q3			Grouping_08_Param	AnlsGrouping_08_Param_1	AnlsGrouping_09_Visit	AnlsGrouping_09_Visit_03	6	6.0
An08.02_ChgBl_ByTrt	Mth02_ContVar_ByGrp_7_Min			Grouping_08_Param	AnlsGrouping_08_Param_1	AnlsGrouping_09_Visit	AnlsGrouping_09_Visit_03	-48	-48
An08.02_ChgBl_ByTrt	Mth02_ContVar_ByGrp_8_Max			Grouping_08_Param	AnlsGrouping_08_Param_1	AnlsGrouping_09_Visit	AnlsGrouping_09_Visit_03	50	50


```
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      {
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        "groupId": "AnlsGrouping_08_Param_1"
      },
      {
        "groupingId": "AnlsGrouping_09_Visit",
        "groupId": "AnlsGrouping_09_Visit_02"
      }
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  },
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    "resultGroups": [
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        "groupId": "AnlsGrouping_02_Trt_1"
      },
      {
        "groupingId": "AnlsGrouping_08_Param",
        "groupId": "AnlsGrouping_08_Param_1"
      },
      {
        "groupingId": "AnlsGrouping_09_Visit",
        "groupId": "AnlsGrouping_09_Visit_02"
      }
    ],
    "rawValue": "-3.301204819",
    "formattedValue": "- 3.3"
  },
  {
    "operationId": "Mth02_ContVar_ByGrp_3_SD",
    "resultGroups": [
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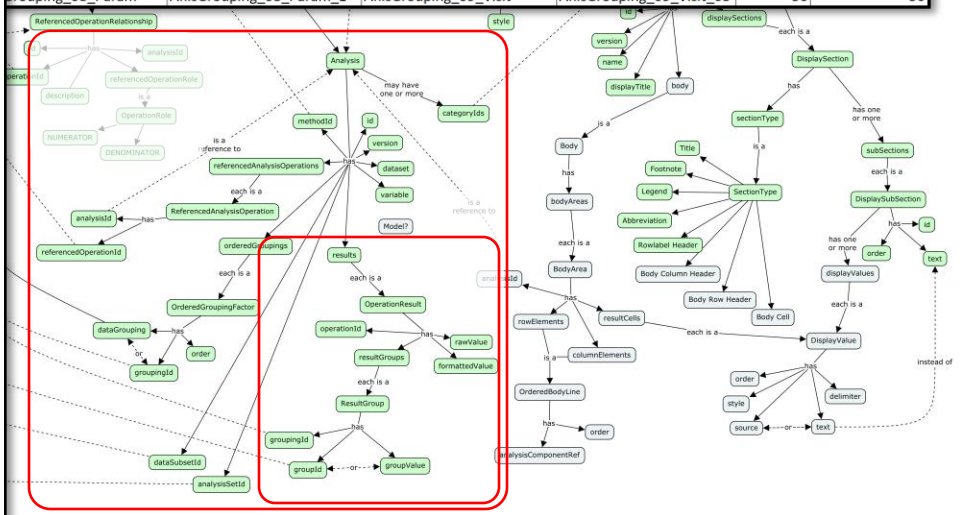

Concepts, Not Layout

Analysis ID:	An03.2_AgeGrp_ByTrt						
Display Value:	formattedValue						
			AnlsGrouping_02_Trt	Treatment	Placebo	Xanomeline Low Dose	Xanomeline High Dose
		AnlsGrouping_03_AgeGp	Mth01_CatVar_ByGrp				
		Age Group	Operation				
		< 65 years	n		14	8	11
		< 65 years	%		(16.3)	(9.5)	(13.1)
		≥ 65 years	n		72	76	73
		≥ 65 years	%		(83.7)	(90.5)	(86.9)

Analysis ID:	An03.2_AgeGrp_ByTrt									
Display Value:	formattedValue									
			AnlsGrouping_02_Trt	Treatment	Placebo	Placebo	Xanomeline Low Dose	Xanomeline Low Dose	Xanomeline High Dose	Xanomeline High Dose
			Mth01_CatVar_ByGrp	Operation	n	%	n	%	n	%
		AnlsGrouping_03_AgeGp								
		Age Group								
		< 65 years			14	(16.3)	8	(9.5)	11	(13.1)
		≥ 65 years			72	(83.7)	76	(90.5)	73	(86.9)

Analysis ID:	An03.2_AgeGrp_ByTrt				
Display Value:	formattedValue				
			Mth01_CatVar_ByGrp	Operation	n	%
		AnlsGrouping_02_Trt	AnlsGrouping_03_AgeGp			
		Treatment	Age Group			
		Placebo	< 65 years		14	(16.3)
		Placebo	≥ 65 years		72	(83.7)
		Xanomeline Low Dose	< 65 years		8	(9.5)
		Xanomeline Low Dose	≥ 65 years		76	(90.5)
		Xanomeline High Dose	< 65 years		11	(13.1)
		Xanomeline High Dose	≥ 65 years		73	(86.9)

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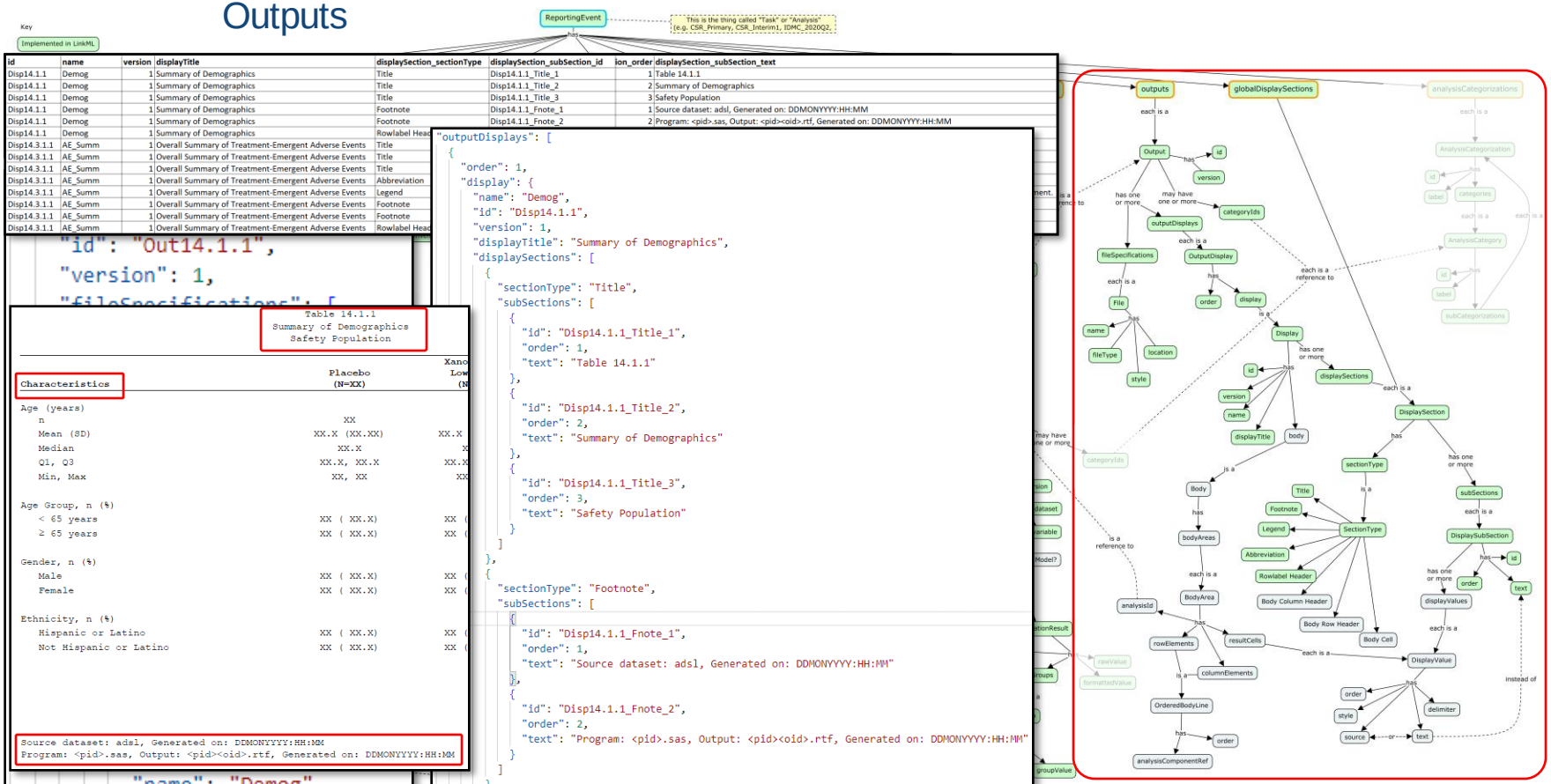
Outputs



List of Planned Analyses/Outputs

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      "name": "Summary of Demographics",
      "level": 1,
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      },
      "outputId": "Out14.1.1"
    },
    {
      "name": "Overall Summary of Treatment-Emergent Adverse Events",
      "level": 1,
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      "sublist": {
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      },
      "outputId": "Out14.3.1.1"
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    {
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      "level": 1,
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      "sublist": {
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            "level": 2,
            "order": 1,
            "analysisId": "An07.09_Soc_ByTrt"
          },
          {
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            "level": 2,
            "order": 2,
            "analysisId": "An07.10_SocPt_ByTrt"
          }
        ]
      },
      "outputId": "Out14.3.2.1"
    },
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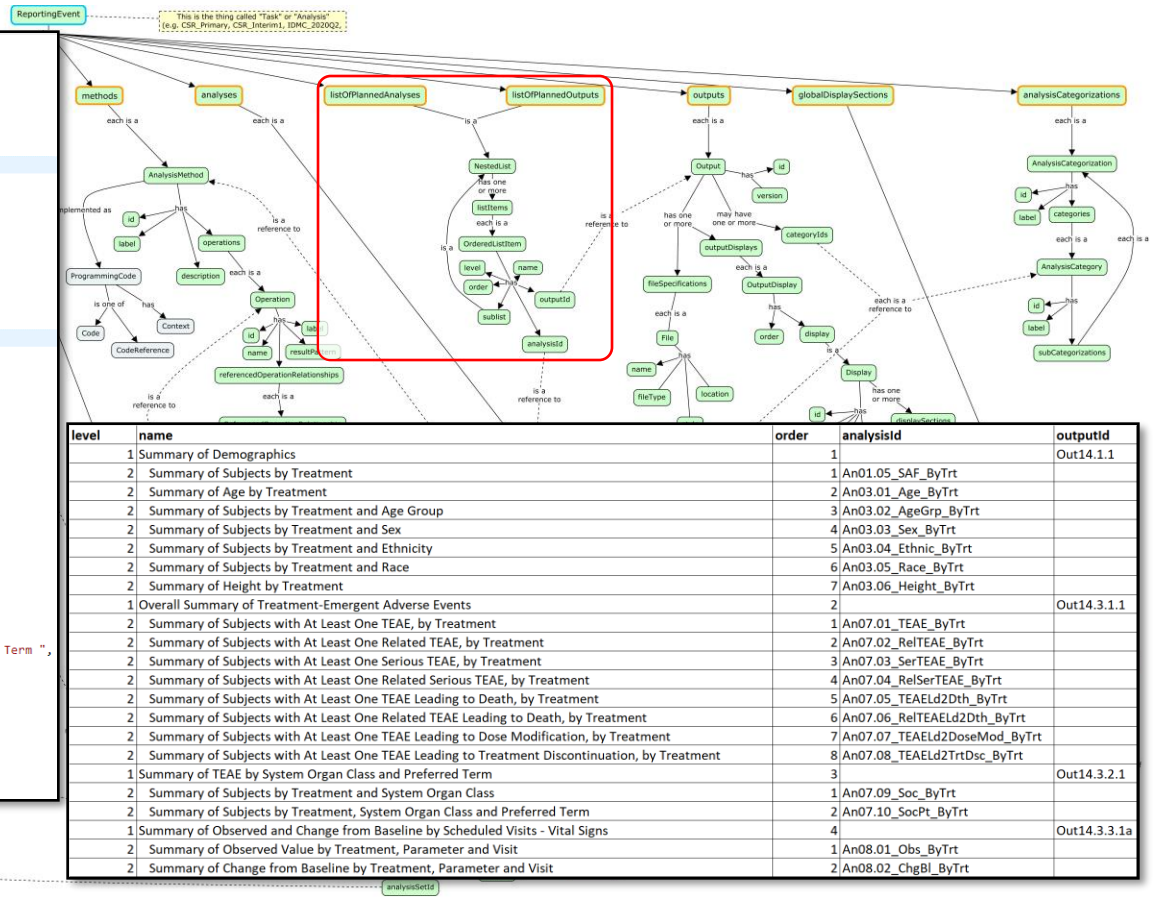


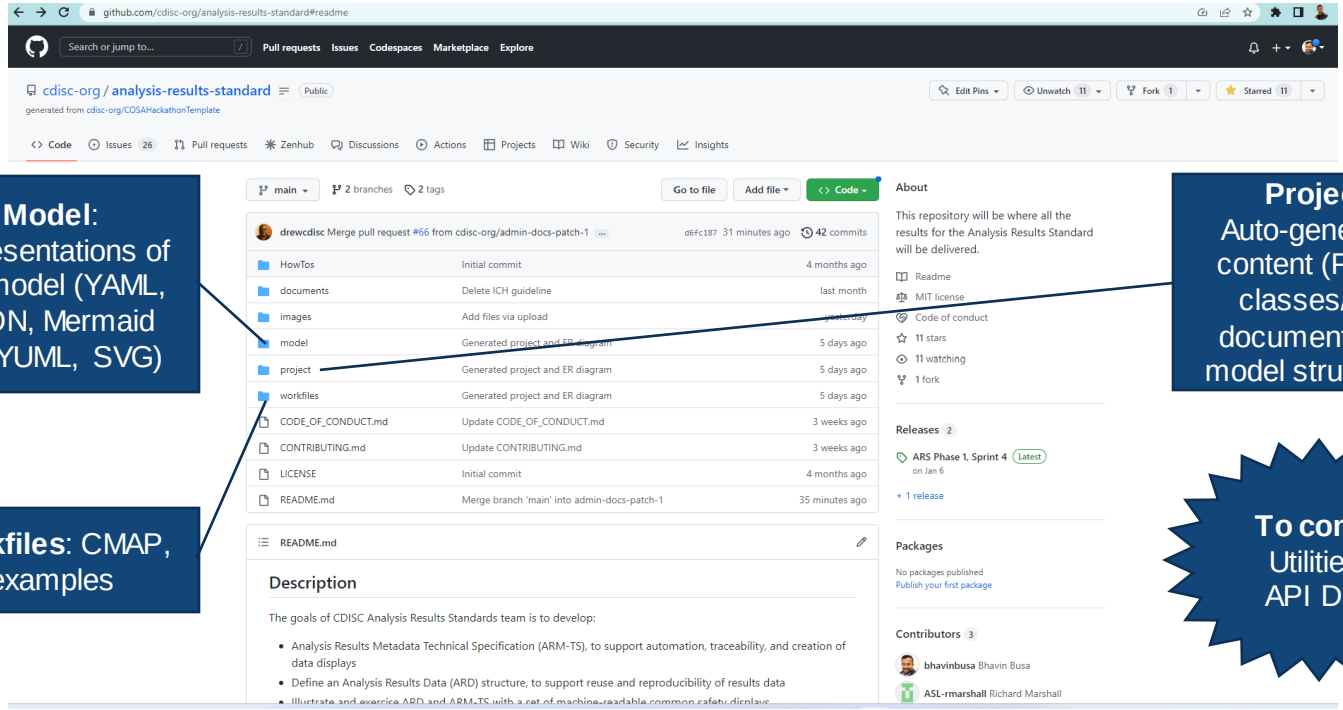
level	name	order	analysisId	outputId
1	Summary of Demographics	1		Out14.1.1
2	Summary of Subjects by Treatment	1	An01.05_SAF_ByTrt	
2	Summary of Age by Treatment	2	An03.01_Age_ByTrt	
2	Summary of Subjects by Treatment and Age Group	3	An03.02_AgeGrp_ByTrt	
2	Summary of Subjects by Treatment and Sex	4	An03.03_Sex_ByTrt	
2	Summary of Subjects by Treatment and Ethnicity	5	An03.04_Ethnic_ByTrt	
2	Summary of Subjects by Treatment and Race	6	An03.05_Race_ByTrt	
2	Summary of Height by Treatment	7	An03.06_Height_ByTrt	
1	Overall Summary of Treatment-Emergent Adverse Events	2		Out14.3.1.1
2	Summary of Subjects with At Least One TEAE, by Treatment	1	An07.01_TEAE_ByTrt	
2	Summary of Subjects with At Least One Related TEAE, by Treatment	2	An07.02_RelTEAE_ByTrt	
2	Summary of Subjects with At Least One Serious TEAE, by Treatment	3	An07.03_SerTEAE_ByTrt	
2	Summary of Subjects with At Least One Related Serious TEAE, by Treatment	4	An07.04_RelSerTEAE_ByTrt	
2	Summary of Subjects with At Least One TEAE Leading to Death, by Treatment	5	An07.05_TEAELd2Dth_ByTrt	
2	Summary of Subjects with At Least One Related TEAE Leading to Death, by Treatment	6	An07.06_RelTEAELd2Dth_ByTrt	
2	Summary of Subjects with At Least One TEAE Leading to Dose Modification, by Treatment	7	An07.07_TEAELd2DoseMod_ByTrt	
2	Summary of Subjects with At Least One TEAE Leading to Treatment Discontinuation, by Treatment	8	An07.08_TEAELd2TrtDsc_ByTrt	
1	Summary of TEAE by System Organ Class and Preferred Term	3		Out14.3.2.1
2	Summary of Subjects by Treatment and System Organ Class	1	An07.09_Soc_ByTrt	
2	Summary of Subjects by Treatment, System Organ Class and Preferred Term	2	An07.10_SocPt_ByTrt	
1	Summary of Observed and Change from Baseline by Scheduled Visits - Vital Signs	4		Out14.3.3.1a
2	Summary of Observed Value by Treatment, Parameter and Visit	1	An08.01_Obs_ByTrt	
2	Summary of Change from Baseline by Treatment, Parameter and Visit	2	An08.02_ChgBl_ByTrt	

Implementations

```
        > Mth02_ContVar_ByGrp_7_Min: Minimum (Min)
        > Mth02_ContVar_ByGrp_8_Max: Maximum (Max)
1.3. Summary of Subjects by Treatment and Age Group
  Analysis: An03.02_AgeGrp_ByTrt
    Population: Safety Population [ADSL.SAFFL EQ 'Y']
    Groupings:
      1. Treatment:
         1. Placebo [ADSL.TRT01A EQ 'Placebo']
         2. Xanomeline Low Dose [ADSL.TRT01A EQ 'Xanomeline Low Dose']
         3. Xanomeline High Dose [ADSL.TRT01A EQ 'Xanomeline High Dose']
      2. Age Group:
         1. < 65 years [ADSL.AGEGR1 EQ '<65']
         2. ≥ 65 years [ADSL.AGEGR1 IN ('65-80', '>80')]
    Analysis Variable: ADSL.USUBJID
    Method: Summary by group of a categorical variable
      Operations:
        > Mth01_CatVar_ByGrp_1_n: Count of subjects (n)
        > Mth01_CatVar_ByGrp_2_pct: Percent of subjects (%)
          - Numerator: result of operation Mth01_CatVar_ByGrp_1_n for this analysis
          - Denominator: result of operation Mth01_CatVar_ByGrp_1_n for analysis An01.05_SAF_ByTrt
1.4. Summary of Subjects by Treatment and Sex
  Analysis: An03.03_Sex_ByTrt
    Population: Safety Population [ADSL.SAFFL EQ 'Y']
    Groupings:
      1. Treatment:
         1. Placebo [ADSL.TRT01A EQ 'Placebo']
         2. Xanomeline Low Dose [ADSL.TRT01A EQ 'Xanomeline Low Dose']
         3. Xanomeline High Dose [ADSL.TRT01A EQ 'Xanomeline High Dose']
      2. Gender:
         1. Male [ADSL.SEX EQ 'M']
         2. Female [ADSL.SEX EQ 'F']
```

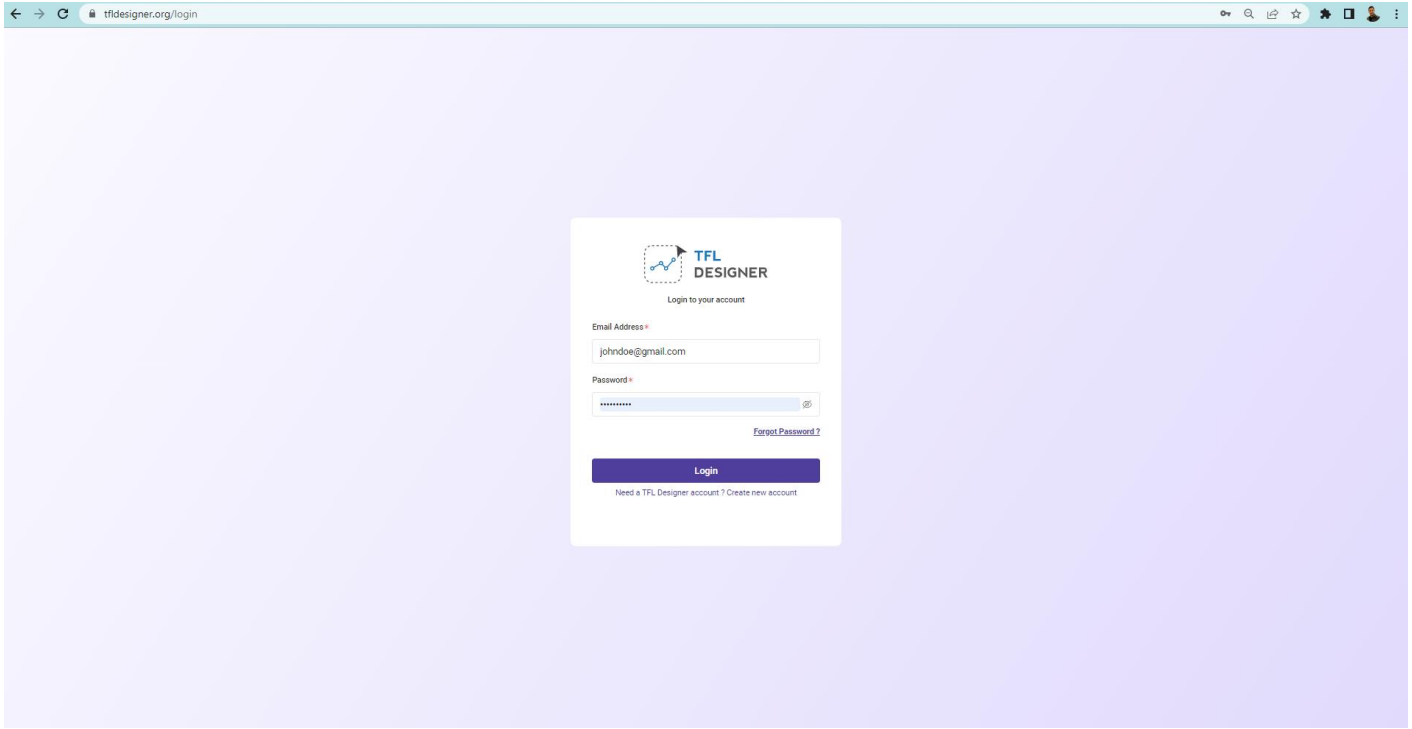
Analysis Results Standard Repo on GitHub

- https://github.com/cdisc-org/analysis-results-standard



ARS model will drive automation and open-source tool development

Reference Implementation Example: TFL Designer



ARS Roadmap

MVP for v1.0 (Summer 2023)

- Logical Model of to support ARM TS/ARD
- Four common safety examples based on team developed tables
  - Demographics
  - Adverse Events
  - Vital signs

Future Development

- Expanded use cases
- APIs for extraction of examples from the CDISC Library
- Conformance rules
- Terminology

Contact Details

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Richard Marshall
Principal Data Modeler
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CDISC ARS GitHub Repo:
https://github.com/cdisc-org/analysis-results-standard