

Developing a Sleep Domain Ontology

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Signs, Symptoms and Findings:
Towards an Ontology of Clinical Phenotypes

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Overview

- Sleep Medicine
- Sleep Data
- PhysioMIMI
- Sleep Domain Model

Sleep

- state of unconsciousness
- normal physiological function - ↓ motor and sensory activity
- active process
- mechanism? purpose? - unclear
 - growth, immunity, memory etc
- Stages of sleep:
 - NREM (non-rapid eye movement) - N1, N2, N3
 - REM (rapid eye movement)

Sleep Medicine

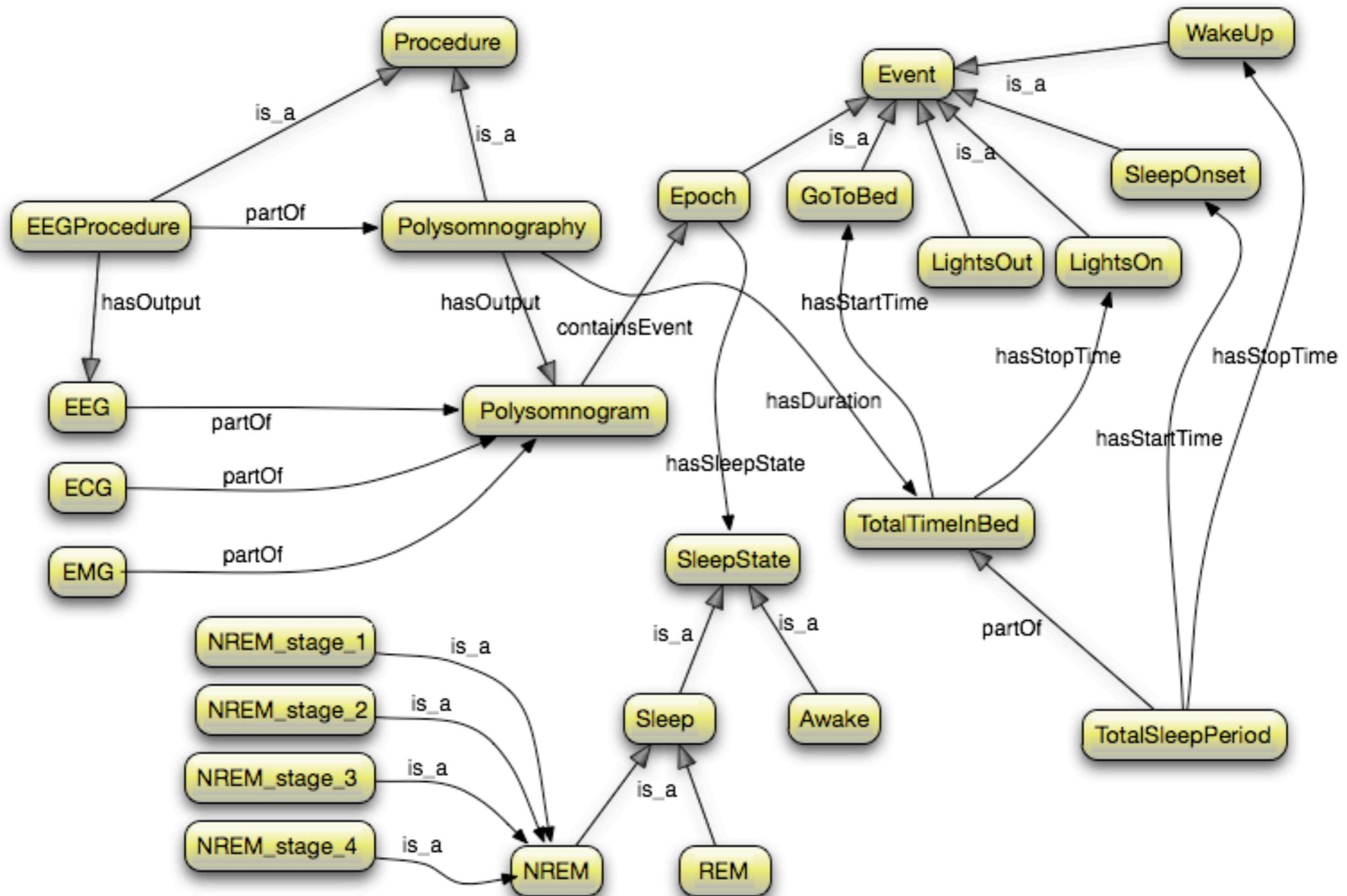
- 50 - 70 million suffer from Sleep Disorders
- sleep deprivation --> fatigue, inability to focus, mood changes, lack of motivation
- consequences of sleep disorders:
 - Errors in judgement - Motor vehicle accidents (20% - IOM study), nuclear accidents at Three Mile Island and Chernobyl, Exxon Valdez oil spill
 - Increased risk of HTN, Heart attack, Stroke, Diabetes, Obesity
- around 90 distinct sleep disorders
- 80 - 90 % of adults with clinically significant Sleep Disordered Breathing undiagnosed

Sleep Data

Polysomnography (PSG)

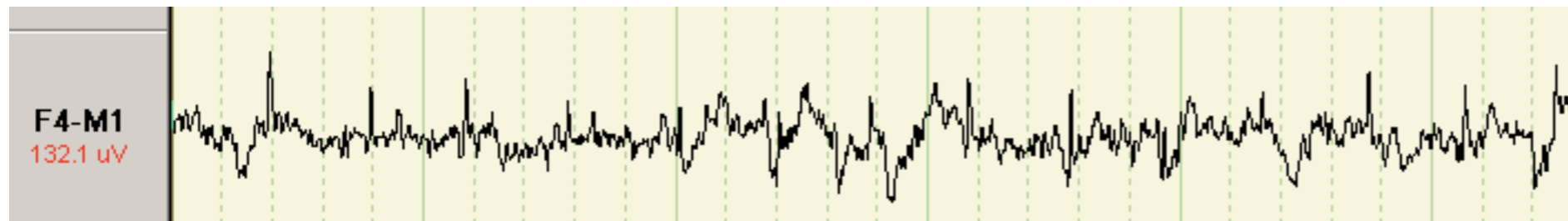
- multi-channel study of sleep or ‘sleep study’
- EEG, EOG, EMG, ECG, Airflow, Oximetry, Breathing effort, Snoring
- EEG electrode placement
- Temporal information

Polysomnography

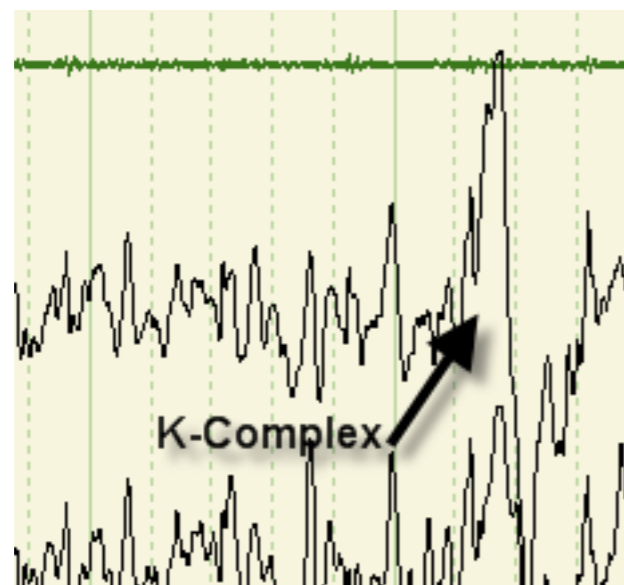
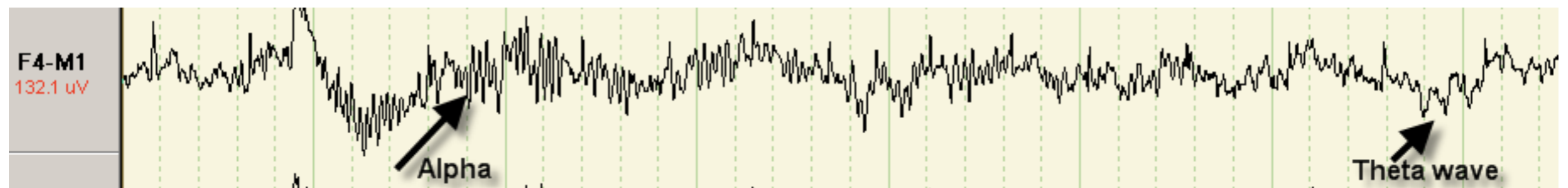


Electroencephalogram (EEG)

Awake

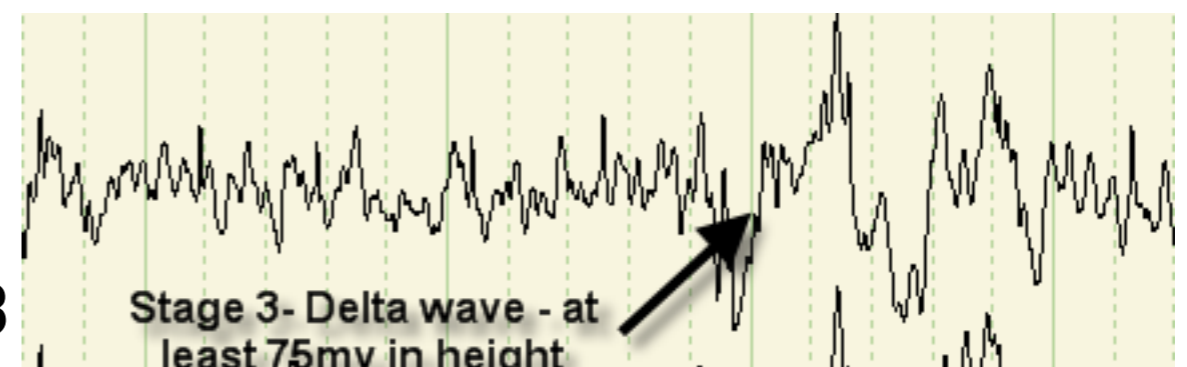


Sleep onset



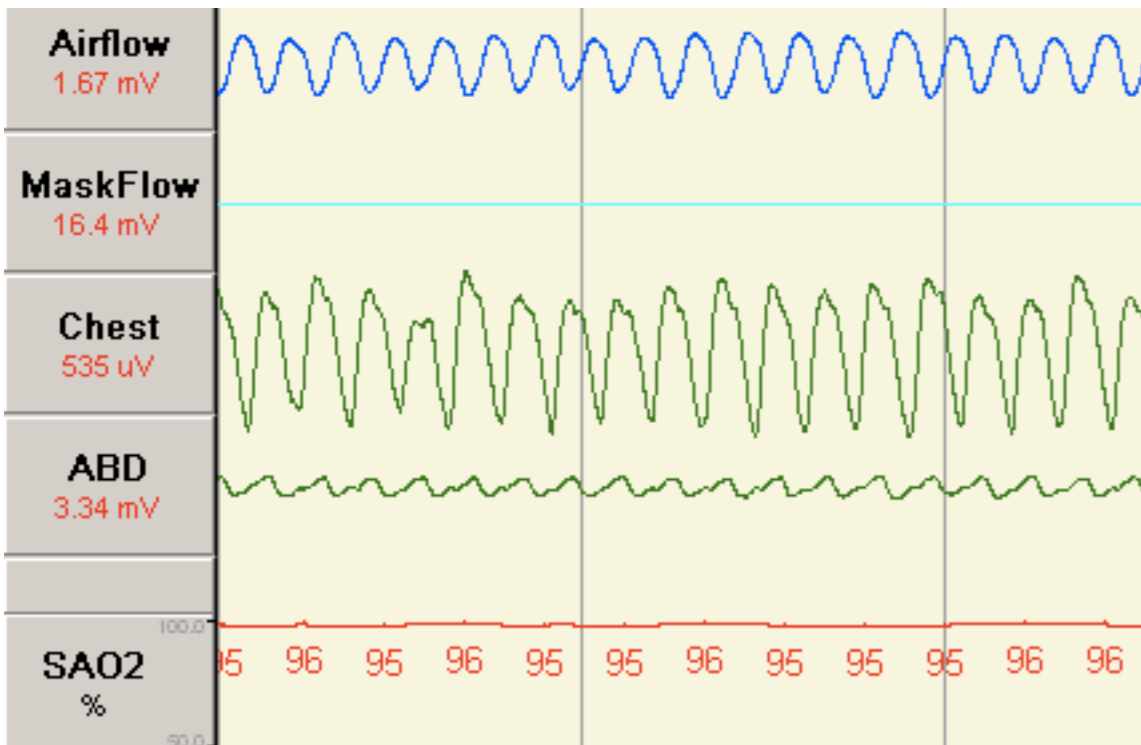
Stage 2

Stage 3

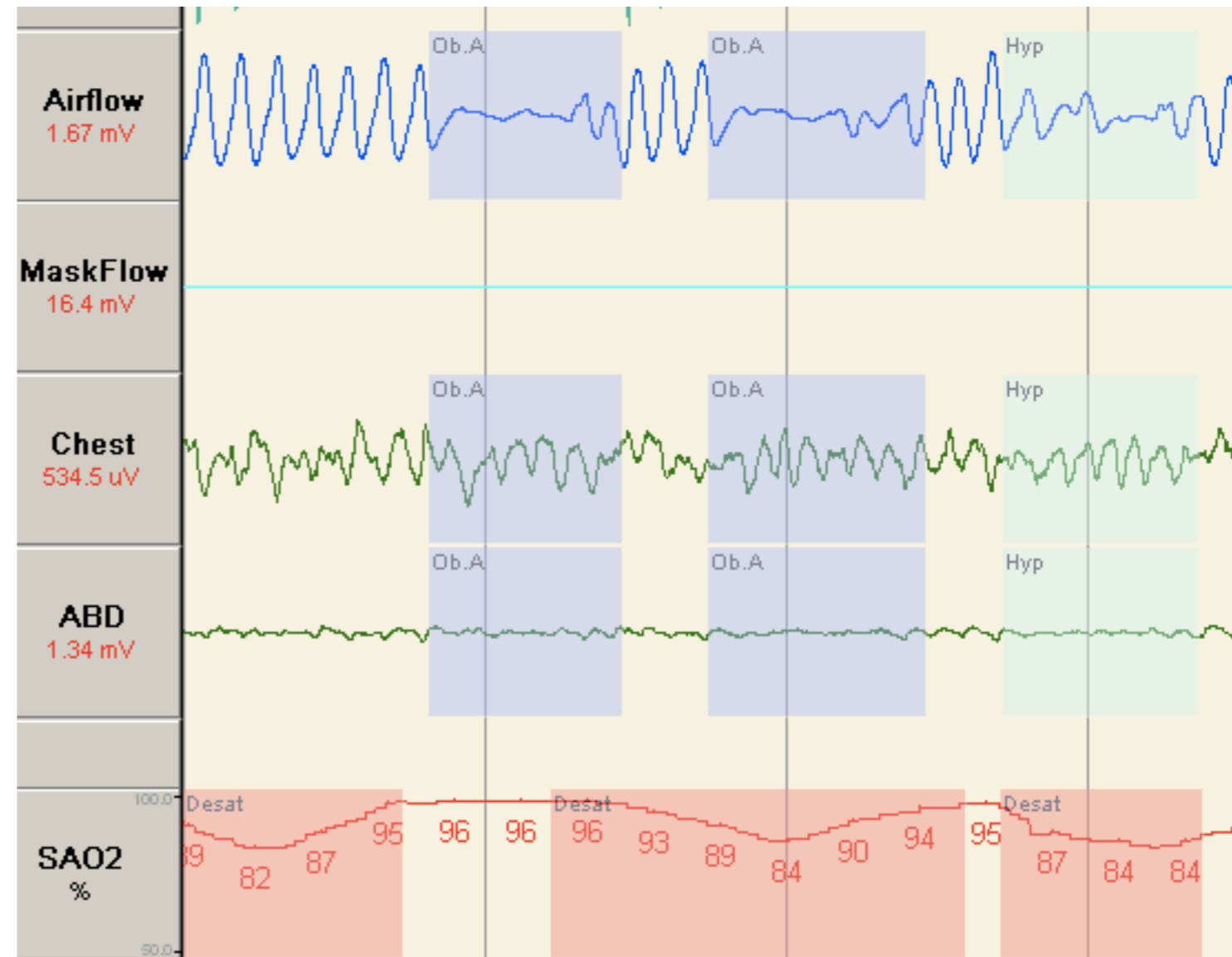


Apnea & Hypopnea

Normal



Apnea/Hypopnea with Desaturation



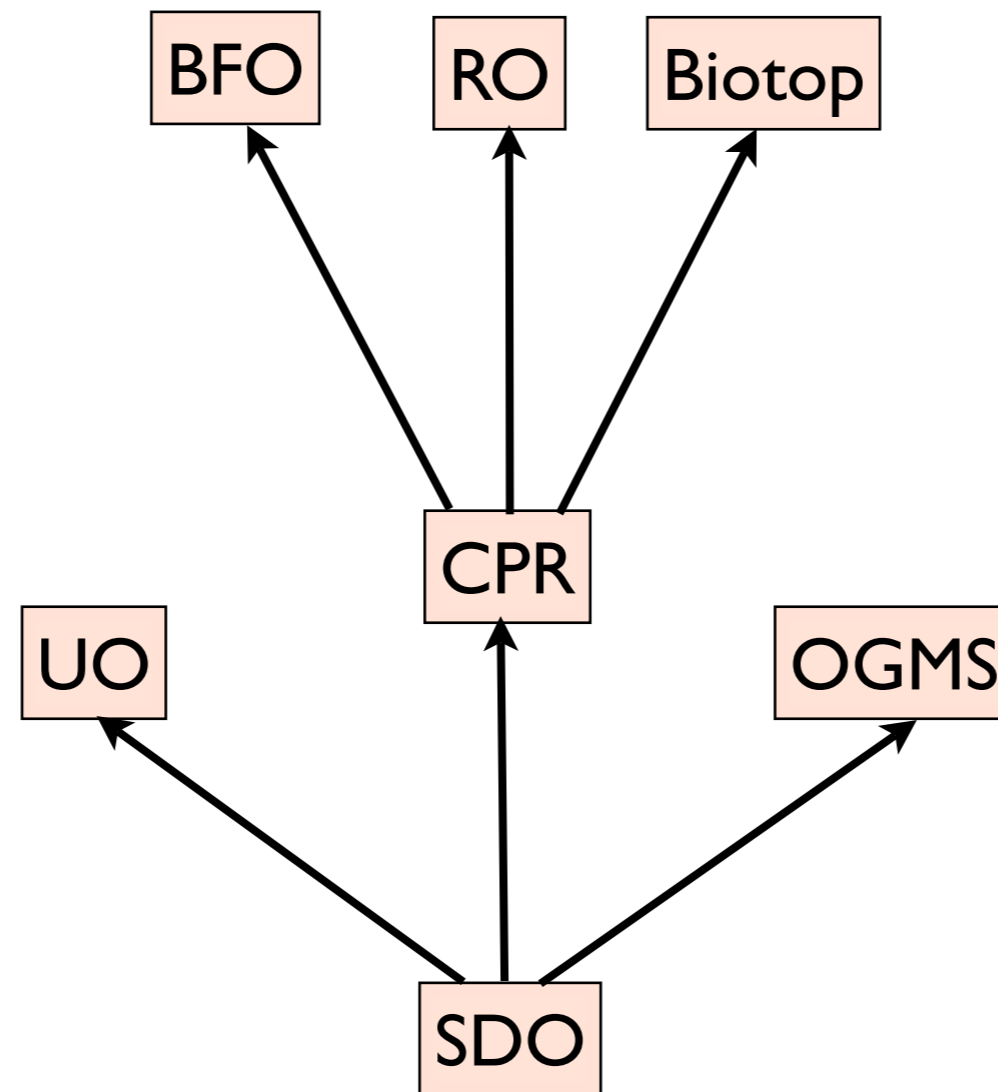
Sleep Data

```
<ScoredEvent>  
  <EventConcept>CentralApneaSleepEvent</EventConcept>  
  <Start>18460.385</Start>  
  <Duration>11.183</Duration>  
  <Interval>23.698</Interval>  
</ScoredEvent>
```

```
<ScoredEvent>  
  <EventConcept>Oximetry Desaturation Event</EventConcept>  
  <Start>5787.100</Start>  
  <Duration>8.800</Duration>  
  <SpO2Nadir>92.8</SpO2Nadir>  
  <Desaturation>3.5</Desaturation>  
  <SpO2Baseline>96.3</SpO2Baseline>  
</ScoredEvent>
```

Sleep Domain Model

Sleep Domain Model



Challenges #1

- ☰ Continuant
 - ▼ ☰ DependentContinuant
 - ▼ ● GenericallyDependentContinuant
 - ▶ ● http://purl.obolibrary.org/obo/OGMS_0000013
 - ▶ ● http://purl.obolibrary.org/obo/OGMS_0000074
 - ▼ ☰ SpecificallyDependentContinuant
 - ▼ ● Quality
 - ▼ ● http://purl.obolibrary.org/obo/OGMS_0000039
 - ▼ ● http://purl.obolibrary.org/obo/OGMS_0000040
 - ▼ ● RealizableEntity
 - ▼ ● Disposition
 - ▶ ● http://purl.obolibrary.org/obo/OGMS_0000030
 - ▶ ● http://purl.obolibrary.org/obo/OGMS_0000031
 - ▶ ● http://purl.obolibrary.org/obo/OGMS_0000032
 - Function
 - Role
 - ▼ ☰ IndependentContinuant
 - ▼ ☰ MaterialEntity
 - http://purl.obolibrary.org/obo/OGMS_0000077
 - http://purl.obolibrary.org/obo/OGMS_0000078
 - http://purl.obolibrary.org/obo/OGMS_0000079

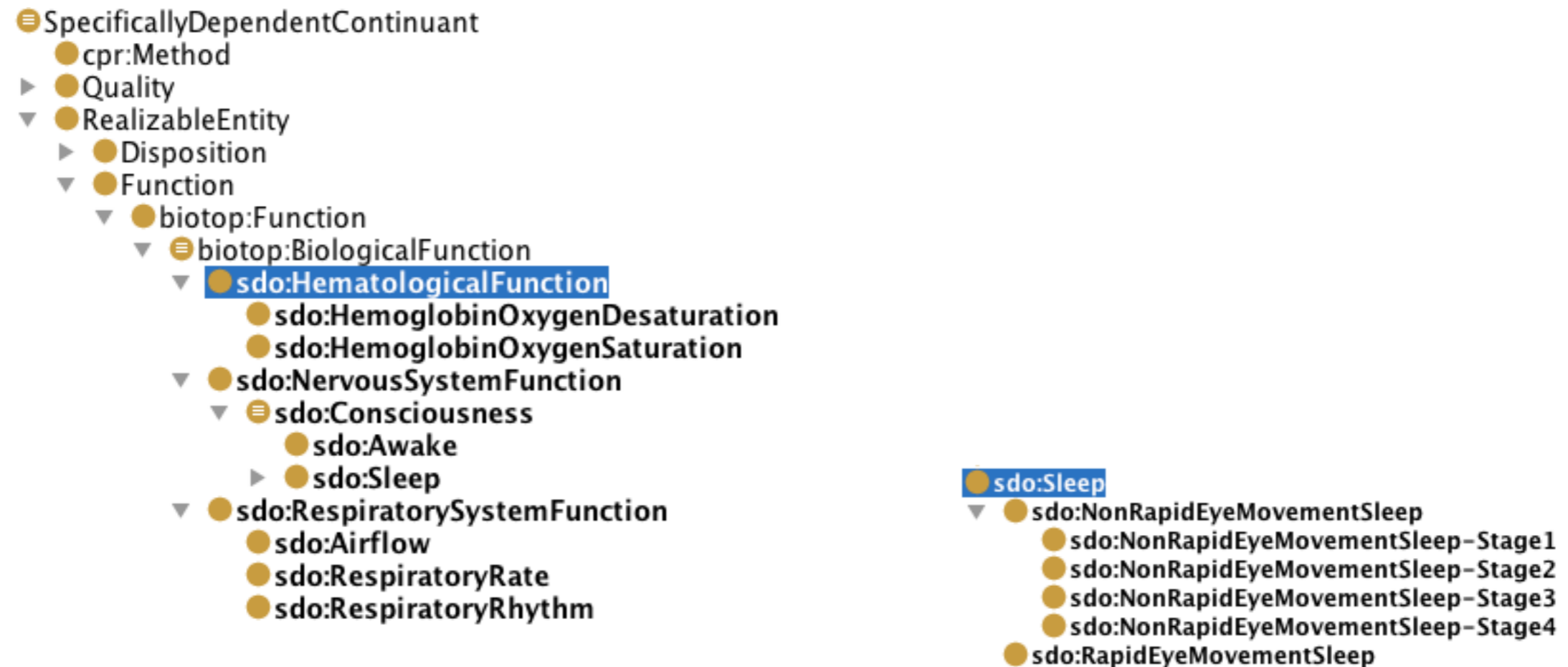
Opaque IDs

Challenges: Opaque IDs

- Continuant
 - DependentContinuant
 - GenericallyDependentContinuant
 - http://purl.obolibrary.org/obo/OGMS_000013
 - http://purl.obolibrary.org/obo/OGMS_000074
 - SpecificallyDependentContinuant
 - Quality
 - http://purl.obolibrary.org/obo/OGMS_000039
 - http://purl.obolibrary.org/obo/OGMS_000040
 - RealizableEntity
 - Disposition
 - http://purl.obolibrary.org/obo/OGMS_000030
 - http://purl.obolibrary.org/obo/OGMS_000031
 - http://purl.obolibrary.org/obo/OGMS_000032
 - Function
 - Role
 - IndependentContinuant
 - MaterialEntity
 - http://purl.obolibrary.org/obo/OGMS_000077
 - http://purl.obolibrary.org/obo/OGMS_000078
 - http://purl.obolibrary.org/obo/OGMS_000079

- Continuant
 - DependentContinuant
 - GenericallyDependentContinuant
 - ogms:NormalValue**
 - ogms:Representation**
 - SpecificallyDependentContinuant
 - Quality
 - ogms:Configuration**
 - RealizableEntity
 - Disposition
 - ogms:Disease**
 - ogms:Homeostasis**
 - ogms:PredispositionToDisease**
 - Function
 - Role
 - IndependentContinuant
 - MaterialEntity
 - http://purl.obolibrary.org/obo/OGMS_000077
 - http://purl.obolibrary.org/obo/OGMS_000079
 - ogms:PathologicalAnatomicalStructure**

SDO: Biological Functions



SDO: Quality

- ☰ SpecificallyDependentContinuant
 - cpr:Method
 - ▼ ● Quality
 - ▶ ● ogms:Configuration
 - ▼ ● **biotop:Quality**
 - ▼ ● sdo:BiologicalSex
 - sdo:GeneticSex
 - ▼ ● sdo:PhenotypicSex
 - sdo:Female
 - sdo:Hermaphrodite
 - sdo:Male
 - ▶ ● sdo:Pseudohermaphrodite
 - sdo:PhysicalLength
 - sdo:PhysicalWeight
 - biotop:AgeQuality
 - ☰ biotop:Canonicity
 - biotop:DevelopmentalQuality
 - biotop:PhysicalForce
 - biotop:PhysicalMass
 - biotop:PhysicalState
 - biotop:PhysicalVolume

SDO: Disorders

- ☰ IndependentContinuant
 - ▶ ● biotop:ImmaterialNonphysicalEntity
 - ▶ ● biotop:ImmaterialPhysicalEntity
 - ▶ ☰ biotop:MaterialEntity
 - ▼ ☰ MaterialEntity
 - http://purl.obolibrary.org/obo/OGMS_0000077
 - http://purl.obolibrary.org/obo/OGMS_0000079
 - ogms:PathologicalAnatomicalStructure
 - ▼ ● FiatObjectPart
 - ▼ ● ogms:Disorder
 - ▼ ● sdo:SleepRelatedDisorder
 - ▼ ● sdo:SleepBreathingDisorder
 - ▼ ☰ sdo:SleepApnea
 - sdo:CentralSleepApnea
 - sdo:MixedSleepApnea
 - sdo:ObstructiveSleepApnea
 - ogms:EpigeneticDisorder
 - ▶ ● ogms:GeneticDisorder
 - ogms:InfectiousDisorder
 - ogms:SecondaryInfection

Modeling Principle

- **Core clinical concepts (Kernel concepts):**
Disorder/Disease, Pathological process, Bodily Feature, ...
- **Recordable concepts (Situations):**
Diagnosis, Clinical Findings (Signs & Symptoms, Lab results), ...

SDO: Findings

- ☰ DependentContinuant
 - cpr:dependent-organismal-continuant
 - ▼ ● GenericallyDependentContinuant
 - ogms:NormalValue
 - ▼ ● **ogms:Representation**
 - ▼ ● ogms:ClinicalFinding
 - ▶ ● **sdo:GeneralClinicalFinding**
 - ▶ ● **sdo:NervousSystemFinding**
 - ▶ ● **sdo:RespiratoryFinding**
 - ogms:ClinicalHistory
 - ogms:ClinicalPicture
 - ogms:Diagnosis
 - ogms:ImageFinding
 - ▼ ● ogms:LaboratoryFinding
 - ▶ ● **sdo:HematologicalFinding**
 - ogms:PreclinicalFinding

- ▼ ● **sdo:GeneralClinicalFinding**
 - ▶ ● **sdo:AgeFinding**
 - ▶ ● **sdo:BodyMassIndexFinding**
 - ▶ ● ☰ **sdo:GenderFinding**
 - ▶ ● **sdo:HeightFinding**
 - ▶ ● **sdo:WeightFinding**
- ▼ ● **sdo:NervousSystemFinding**
 - ▼ ● **sdo:SleepFinding**
 - ▶ ● **sdo:PercentOfTimeInSleepStage**
 - ▼ ● **sdo:SleepDurationFinding**
 - **sdo:TimeInNonREMSleep**
 - **sdo:TimeInREMSleep**
 - **sdo:TotalSleepTime**
- ▼ ● **sdo:HematologicalFinding**
 - ▼ ● **sdo:HemoglobinOxygenDesaturationFinding**
 - ☰ **sdo:HemoglobinOxygenDesaturation_3_percent_or_more**
 - ☰ **sdo:HemoglobinOxygenDesaturation_5_percent_or_more**
 - ▼ ● **sdo:HemoglobinOxygenSaturationFinding**
 - **sdo:BaselineHemoglobinOxygenSaturation**
 - **sdo:MaximumHemoglobinOxygenSaturation**
 - ▶ ● **sdo:MeanHemoglobinOxygenSaturation**
 - ▶ ● **sdo:MinimumHemoglobinOxygenSaturation**

Sleep Duration

- sdo:NervousSystemFinding
 - ▼ ● sdo:SleepFinding
 - ▶ ● sdo:PercentOfTimeInSleepStage
 - ▼ ● sdo:SleepDurationFinding
 - sdo:TimeInNonREMSleep
 - sdo:TimeInREMSleep
 - sdo:TotalSleepTime
 - sdo:RespiratoryFinding
- ogms:ClinicalHistory
- ogms:ClinicalPicture
- ogms:Diagnosis
- ogms:ImageFinding

Superclasses +
● sdo:SleepFinding
● sdo:hasUnits some unit:UO_0000031_minute
● sdo:hasDataValue some xsd:integer
● sdo:hasDataValue some xsd:integer[>= "0"^^xsd:integer]
● sdo:hasDataValue some xsd:integer[<= "600"^^xsd:integer]
Inferred anonymous superclasses
● sdo:hasConsciousnessStage some sdo:Sleep

Hb O₂ Saturation

- ogms:Diagnosis
- ogms:ImageFinding
- ogms:LaboratoryFinding
- ▼ ● sdo:HematologicalFinding
 - ▶ ● sdo:HemoglobinOxygenDesaturationFinding
 - ▶ ● sdo:HemoglobinOxygenSaturationFinding
- ogms:PreclinicalFinding
- specificallyDependentContinuant
- independentContinuant
- Region

Superclasses +
● sdo:HematologicalFinding
● cpr:representationOf some sdo:HemoglobinOxygenSaturation
● cpr:representationOf only sdo:HemoglobinOxygenSaturation
● sdo:hasHemoglobinOxygenSaturationValue some xsd:integer
● sdo:hasHemoglobinOxygenSaturationValue some xsd:integer[>= "0"^^xsd:integer]
● sdo:hasHemoglobinOxygenSaturationValue some xsd:integer[<= "100"^^xsd:integer]

Hb O₂ De-saturation

- ogms:Diagnostic
- ogms:ImageFinding
- ogms:LaboratoryFinding
- ▼ sdo:HematologicalFinding
 - ▶ sdo:HemoglobinOxygenDesaturationFinding
 - ▼ sdo:HemoglobinOxygenSaturationFinding
 - sdo:BaselineHemoglobinOxygenSaturation
 - sdo:MaximumHemoglobinOxygenSaturation
 - ▶ sdo:MeanHemoglobinOxygenSaturation
 - ▶ sdo:MinimumHemoglobinOxygenSaturation
- ogms:PreclinicalFinding

Superclasses +
● sdo:HematologicalFinding
● cpr:representationOf some sdo:HemoglobinOxygenDesaturation
● cpr:representationOf only sdo:HemoglobinOxygenDesaturation
● sdo:hasHemoglobinOxygenDesaturationValue some xsd:integer
● sdo:hasHemoglobinOxygenDesaturationValue some xsd:integer[>= "0"^^xsd:integer]
● sdo:hasHemoglobinOxygenDesaturationValue some xsd:integer[<= "100"^^xsd:integer]

Hb O₂ De-saturation

ogms:Diagnostic
ogms:ImageFinding
ogms:LaboratoryFinding
▼ sdo:HematologicalFinding
▶ sdo:HemoglobinOxygenDesaturationFinding
▼ sdo:HemoglobinOxygenSaturationFinding
 sdo:BaselineHemoglobinOxygenSaturation
 sdo:MaximumHemoglobinOxygenSaturation
 ▶ sdo:MeanHemoglobinOxygenSaturation
 ▶ sdo:MinimumHemoglobinOxygenSaturation
ogms:PreclinicalFinding

Superclasses +

- sdo:HematologicalFinding
- cpr:representationOf some sdo:HemoglobinOxygenDesaturation
- cpr:representationOf only sdo:HemoglobinOxygenDesaturation
- sdo:hasHemoglobinOxygenDesaturationValue some xsd:integer
- sdo:hasHemoglobinOxygenDesaturationValue some xsd:integer[>= "0"^^xsd:integer]
- sdo:hasHemoglobinOxygenDesaturationValue some xsd:integer[<= "100"^^xsd:integer]

Hb O₂ desaturation = Percentage of Hemoglobin in blood that is NOT bound to Oxygen

Hb O₂ De-saturation

The image shows a class hierarchy diagram. On the left, a tree view shows the following classes: `ogms:Diagnostic`, `ogms:ImageFinding`, `ogms:LaboratoryFinding`, `sdo:HematologicalFinding` (expanded), `sdo:HemoglobinOxygenDesaturationFinding` (highlighted), `sdo:HemoglobinOxygenSaturationFinding` (expanded), `sdo:BaselineHemoglobinOxygenSaturation`, `sdo:MaximumHemoglobinOxygenSaturation`, `sdo:MeanHemoglobinOxygenSaturation`, and `sdo:MinimumHemoglobinOxygenSaturation`. On the right, a 'Superclasses' panel lists the following superclasses for `sdo:HemoglobinOxygenDesaturationFinding`: `sdo:HematologicalFinding`, `cpr:representationOf some sdo:HemoglobinOxygenDesaturation`, `cpr:representationOf only sdo:HemoglobinOxygenDesaturation`, `sdo:hasHemoglobinOxygenDesaturationValue some xsd:integer`, `sdo:hasHemoglobinOxygenDesaturationValue some xsd:integer[>= "0"^^xsd:integer]`, and `sdo:hasHemoglobinOxygenDesaturationValue some xsd:integer[<= "100"^^xsd:integer]`.

Hb O₂ desaturation = Percentage of Hemoglobin in blood that is NOT bound to Oxygen

Challenge #2

Hb O₂ De-saturation

- ogms:Diagnostic
- ogms:ImageFinding
- ogms:LaboratoryFinding
- ▼ sdo:HematologicalFinding
 - ▶ sdo:HemoglobinOxygenDesaturationFinding
 - ▼ sdo:HemoglobinOxygenSaturationFinding
 - sdo:BaselineHemoglobinOxygenSaturation
 - sdo:MaximumHemoglobinOxygenSaturation
 - ▶ sdo:MeanHemoglobinOxygenSaturation
 - ▶ sdo:MinimumHemoglobinOxygenSaturation
- ogms:PreclinicalFinding

Superclasses +	
●	sdo:HematologicalFinding
●	cpr:representationOf some sdo:HemoglobinOxygenDesaturation
●	cpr:representationOf only sdo:HemoglobinOxygenDesaturation
●	sdo:hasHemoglobinOxygenDesaturationValue some xsd:integer
●	sdo:hasHemoglobinOxygenDesaturationValue some xsd:integer[>= "0"^^xsd:integer]
●	sdo:hasHemoglobinOxygenDesaturationValue some xsd:integer[<= "100"^^xsd:integer]

Annotations: sdo:HemoglobinOxygenDesaturationFinding

Annotations +

comment

"Calculation: (SDO:BaselineHemoglobinOxygenSaturation - SDO:HemoglobinOxygenSaturationFinding)"

comment

"Definition: Percentage of hemoglobin in blood that is NOT bound to oxygen."

Hb O₂ De-saturation

- **sdo:HemoglobinOxygenDesaturationFinding**
 - sdo:HemoglobinOxygenDesaturation_3_percent_or_more
 - sdo:HemoglobinOxygenDesaturation_5_percent_or_more

Description: sdo:HemoglobinOxygenDesaturation_3_percent_or_more

Equivalent classes +

- **sdo:HemoglobinOxygenDesaturationFinding**
and sdo:hasHemoglobinOxygenDesaturationValue some xsd:integer[>= "3"^^xsd:integer]

Description: sdo:HemoglobinOxygenDesaturation_5_percent_or_more

Equivalent classes +

- **sdo:HemoglobinOxygenDesaturationFinding**
and sdo:hasHemoglobinOxygenDesaturationValue some xsd:integer[>= "5"^^xsd:integer]

Hb O₂ De-saturation

- **sdo:HemoglobinOxygenDesaturationFinding**
 - sdo:HemoglobinOxygenDesaturation_3_percent_or_more
 - sdo:HemoglobinOxygenDesaturation_5_percent_or_more

Description: sdo:HemoglobinOxygenDesaturation_3_percent_or_more

Equivalent classes +

- **sdo:HemoglobinOxygenDesaturationFinding**
and sdo:hasHemoglobinOxygenDesaturationValue some xsd:integer[> = "3"^^xsd:integer]

Description: sdo:HemoglobinOxygenDesaturation_5_percent_or_more

Equivalent classes +

- **sdo:HemoglobinOxygenDesaturationFinding**
and sdo:hasHemoglobinOxygenDesaturationValue some xsd:integer[> = "5"^^xsd:integer]

Members +

- ◆ sdo:HbO2Desat_3
- ◆ sdo:HbO2Desat_4
- ◆ sdo:HbO2Desat_5
- ◆ sdo:HbO2Desat_6

Classification

- sdo:HemoglobinOxygenDesaturationFinding
 - ☰ sdo:HemoglobinOxygenDesaturation_3_percent_or_more
 - ☰ sdo:HemoglobinOxygenDesaturation_5_percent_or_more

- sdo:HemoglobinOxygenDesaturationFinding
 - ▼ ☰ sdo:HemoglobinOxygenDesaturation_3_percent_or_more
 - ☰ sdo:HemoglobinOxygenDesaturation_5_percent_or_more

Classification

- sdo:HemoglobinOxygenDesaturationFinding
 - ☰ sdo:HemoglobinOxygenDesaturation_3_percent_or_more
 - ☰ sdo:HemoglobinOxygenDesaturation_5_percent_or_more

- sdo:HemoglobinOxygenDesaturationFinding
 - ▼ ☰ sdo:HemoglobinOxygenDesaturation_3_percent_or_more
 - ☰ sdo:HemoglobinOxygenDesaturation_5_percent_or_more

- sdo:HemoglobinOxygenDesaturationFinding
 - ▼ ☰ sdo:HemoglobinOxygenDesaturation_3_percent_or_more
 - ☰ sdo:HemoglobinOxygenDesaturation_5_percent_or_more
 - sdo:HemoglobinOxygenSaturationFinding
 - s:PreclinicalFinding
 - DependentContinuant
 - Continuant
 - hinton:SpatialRegion

Members +

- ◆ sdo:HbO2Desat_3
- ◆ sdo:HbO2Desat_4
- ◆ sdo:HbO2Desat_5
- ◆ sdo:HbO2Desat_6

Classification

- sdo:HemoglobinOxygenDesaturationFinding
 - ☰ sdo:HemoglobinOxygenDesaturation_3_percent_or_more
 - ☰ sdo:HemoglobinOxygenDesaturation_5_percent_or_more

- sdo:HemoglobinOxygenDesaturationFinding
 - ▼ ☰ sdo:HemoglobinOxygenDesaturation_3_percent_or_more
 - ☰ sdo:HemoglobinOxygenDesaturation_5_percent_or_more

- sdo:HemoglobinOxygenDesaturationFinding
 - ▼ ☰ sdo:HemoglobinOxygenDesaturation_3_percent_or_more
 - ☰ sdo:HemoglobinOxygenDesaturation_5_percent_or_more
 - sdo:HemoglobinOxygenSaturationFinding
 - s:PreclinicalFinding
 - DependentContinuant
 - Continuant
 - stion: SpatialRegion

Members +

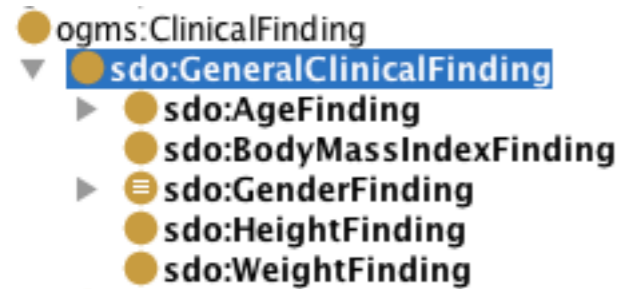
- ◆ sdo:HbO2Desat_3
- ◆ sdo:HbO2Desat_4
- ◆ sdo:HbO2Desat_5
- ◆ sdo:HbO2Desat_6

- sdo:HemoglobinOxygenDesaturationFinding
 - ▼ ☰ sdo:HemoglobinOxygenDesaturation_3_percent_or_more
 - ☰ sdo:HemoglobinOxygenDesaturation_5_percent_or_more
 - sdo:HemoglobinOxygenSaturationFinding
 - s:PreclinicalFinding
 - DependentContinuant

Members +

- ◆ sdo:HbO2Desat_5
- ◆ sdo:HbO2Desat_6

General Clinical Findings



Description: sdo:AgeFinding

Superclasses +

- sdo:GeneralClinicalFinding
- sdo:hasUnits **some** unit:UO_0000036_year
- cpr:representationOf **some** biotop:AgeQuality
- sdo:hasDuration **some** xsd:integer
- sdo:hasDuration **some** xsd:integer[>= "0"^^xsd:integer]
- sdo:hasDuration **some** xsd:integer[<= "120"^^xsd:integer]

Description: sdo:GenderFinding

- sdo:FemaleGender
- or sdo:MaleGender

Superclasses +

- sdo:GeneralClinicalFinding
- cpr:representationOf **some** sdo:PhenotypicSex

Description: sdo:HeightFinding

Superclasses +


- sdo:GeneralClinicalFinding
- sdo:hasUnits **some** unit:UO_0000015_centimeter
- cpr:representationOf **some** sdo:PhysicalLength
- sdo:hasLengthValue **some** xsd:float
- sdo:hasLengthValue **some** xsd:float[>= 0]
- sdo:hasLengthValue **some** xsd:float[<= 250]


Description: sdo:WeightFinding

Superclasses +

- sdo:GeneralClinicalFinding
- sdo:hasUnits **some** unit:UO_0000009_kilogram
- cpr:representationOf **some** sdo:PhysicalWeight
- sdo:hasWeightValue **some** xsd:float
- sdo:hasWeightValue **some** xsd:float[>= 0]
- sdo:hasWeightValue **some** xsd:float[<= 200]

Body Mass Index (BMI)

Description: sdo:BodyMassIndexFinding
Superclasses 
● sdo:GeneralClinicalFinding
● sdo:hasUnits some unit:UO_0000086_kilogram_per_square_meter
● sdo:hasDataValue some xsd:float
● sdo:hasDataValue some xsd:float[>= 0]
● sdo:hasDataValue some xsd:float[<= 100]

Annotations: sdo:BodyMassIndexFinding
Annotations 
comment "Calculation: Metric BMI Formula (Weight in Kilograms / (Height in Meters) x (Height in Meters))"
comment "altLabel: BMI"
label "Body Mass Index"

PhysioMIMI

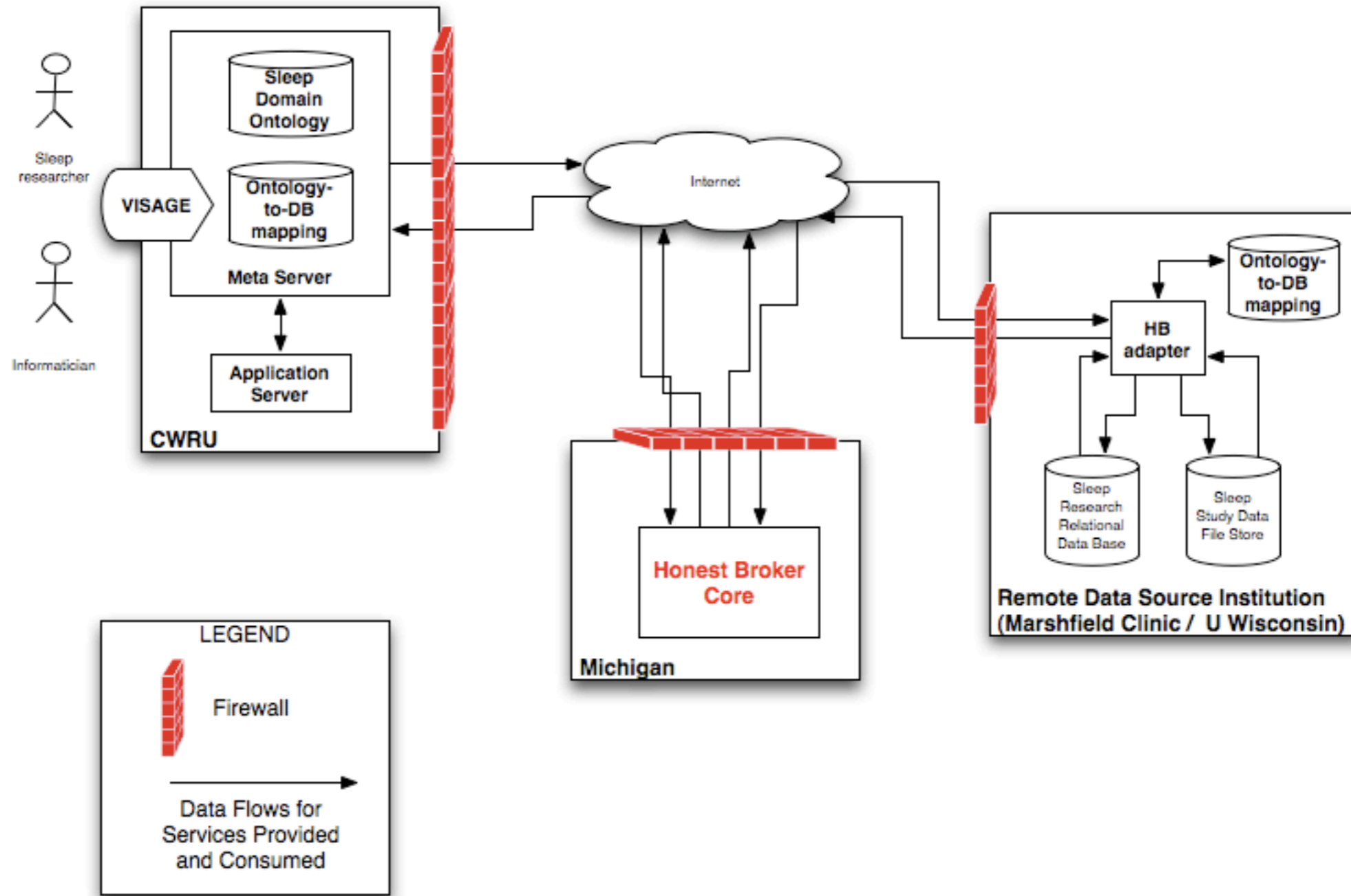
PhysioMIMI project

- Federated data integration environment
- Facilitate collaborative clinical and translational research
- Four CTSA institutions:
 - CWRU/UH, Univ. of Michigan, Marshfield Clinic and Univ. of Wisconsin)
- Sleep Domain

PhysioMIMI Components

- VISAGE - user interface
- Sleep Domain Ontology - data model
- Application Tools - signal analysis
- Honest Broker - communication, security, etc

Architecture



VISAGE

- VISual AGgregator and Explorer
- Query Interface:
 - Query Builder
 - Query Manager
 - Query Explorer
- Database Mapper
- Data model Browser

VISAGE: Query Builder

The screenshot shows the PhysioMIMI Query Builder interface in a Mozilla Firefox browser window. The browser address bar shows the URL <http://mimi.case.edu/queries/builder>. The page title is "PhysioMIMI - Query Builder".

The interface includes a navigation menu with links for "QUERY", "INFORMATICIAN", "ONTOLOGY", "ADMINISTRATION", "STATISTICS", and "HONEST BROKER". The main content area is titled "Query Builder" and features an "Ontological Dictionary" on the left with a "Tree Hierarchy of Ontological Terms" search box. A list of terms is visible, including "Abnormal Airflow", "Airflow", "Airflow Change Event", "Airflow Change Finding", "Airflow Event", "Airflow Finding", "Airflow Increased", "Airflow Normal", "Airflow Pattern", "Airflow Reduced", "Airflow Reduced 30 Percent", "Airflow Reduced 50 Percent", and "Airflow Reduced 75".

The central query builder area is highlighted with a green border and contains the following elements:

- Group: Ungroup Selected | Flip | NAME: DATABASE:
- Gender: Female Male (1379 records)
- Current Chronological Age: (3077 records)
- Age Range Slider: A horizontal slider with markers at 18 and 100.
- Total Studies Found: 1379 records
- DESCRIPTION: A large empty text area.
- Create Query: A button at the bottom of the query builder area.

The footer of the page reads: "PHYSIOMIMI | RELEASE 0.0.0 | LAST UPDATED 14 MAY 2009".

VISAGE: Query Explorer

PHYSIOMIMI | NLS13@CASE.EDU | CASE WESTERN RESERVE UNIVERSITY | SETTINGS | LOGOUT

QUERY | INFORMATICIAN | ONTOLOGY | ADMINISTRATION | STATISTICS | HONEST BROKER

Query Explorer | query manager

Select Attribute: Add

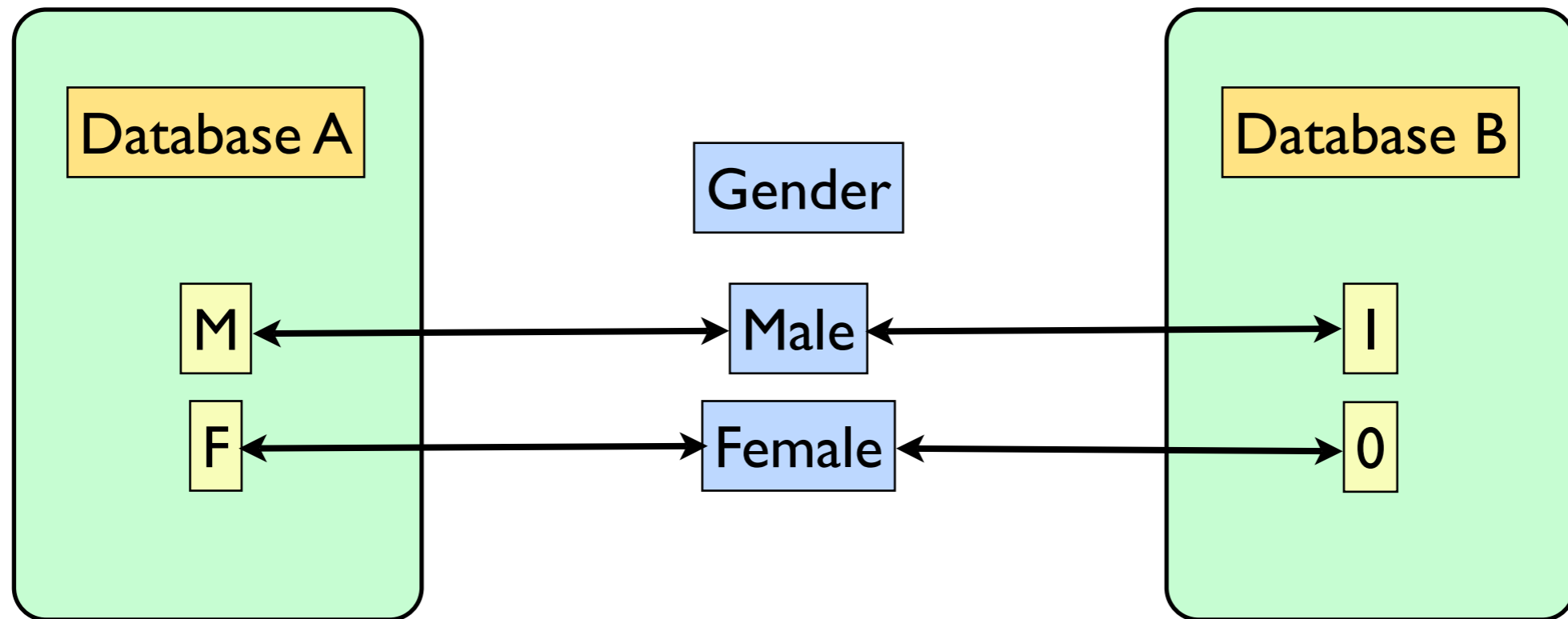
Available Controls: \bar{x} σ α

Actions: Show Options, Explore!

Query	Body mass index	Obstructive sleep apnea syndrome																
Male Adults from SHHS2(Q1)	<table border="1"> <tr><td>count</td><td>1364</td></tr> <tr><td>missing</td><td>15</td></tr> <tr><td>minimum</td><td>14.9004</td></tr> <tr><td>maximum</td><td>48.5977</td></tr> <tr><td>mean</td><td>29.2</td></tr> <tr><td>standard deviation</td><td>4.6</td></tr> </table>	count	1364	missing	15	minimum	14.9004	maximum	48.5977	mean	29.2	standard deviation	4.6	<table border="1"> <tr><td>false [0]</td><td>675</td></tr> <tr><td>true [1]</td><td>704</td></tr> </table>	false [0]	675	true [1]	704
count	1364																	
missing	15																	
minimum	14.9004																	
maximum	48.5977																	
mean	29.2																	
standard deviation	4.6																	
false [0]	675																	
true [1]	704																	
Female Adults from UH(Q2)	<table border="1"> <tr><td>count</td><td>1679</td></tr> <tr><td>missing</td><td>69</td></tr> <tr><td>minimum</td><td>11.2096461437822</td></tr> <tr><td>maximum</td><td>86.1906733411118</td></tr> <tr><td>mean</td><td>38.4</td></tr> <tr><td>standard deviation</td><td>10.4</td></tr> </table>	count	1679	missing	69	minimum	11.2096461437822	maximum	86.1906733411118	mean	38.4	standard deviation	10.4	<table border="1"> <tr><td>false [0]</td><td>1030</td></tr> <tr><td>true [1]</td><td>718</td></tr> </table>	false [0]	1030	true [1]	718
count	1679																	
missing	69																	
minimum	11.2096461437822																	
maximum	86.1906733411118																	
mean	38.4																	
standard deviation	10.4																	
false [0]	1030																	
true [1]	718																	
Summary	<p>Body mass index</p>	<p>Obstructive sleep apnea syndrome</p> <p>Drag Controls Here</p>																
	<table border="1"> <tr><th>Query</th><th>Count</th></tr> <tr><td>Q1</td><td>27</td></tr> <tr><td>Q2</td><td>35</td></tr> </table>	Query	Count	Q1	27	Q2	35											
Query	Count																	
Q1	27																	
Q2	35																	

VISAGE: Database Mapper

- Distributed databases
- Different terms/values - *same meaning*



VISAGE: Database Mapper

Database Columns Mapped: 6 out of 24 fully mapped. [25.00%]

Columns Left to Map Suggested Terms | or Map to Multiple Concepts

BENZOD2 ["BENZOD2", "int(11)", "YES", "", nil] ignore
 MAOI1 ["MAOI1", "int(11)", "YES", "", nil] ignore
 TCA1 ["TCA1", "int(11)", "YES", "", nil] ignore
 ai_all ["ai_all", "float", "YES", "", nil] ignore
 ai_nrem ["ai_nrem", "float", "YES", "", nil] ignore
 ai_rem ["ai_rem", "float", "YES", "", nil] ignore
 ess_s2 ["ess_s2", "int(11)", "YES", "", nil] ignore
 minnremp ["minnremp", "float", "YES", "", nil] ignore
 minremp ["minremp", "float", "YES", "", nil] ignore
 psgtype ["psgtype", "int(11)", "YES", "", nil] ignore
 sh318b ["sh318b", "int(11)", "YES", "", nil] ignore
 sh318c ["sh318c", "int(11)", "YES", "", nil] ignore
 slpprdp ["slpprdp", "float", "YES", "", nil] ignore
 tmremp ["tmremp", "float", "YES", "", nil] ignore
 tmstg1p ["tmstg1p", "float", "YES", "", nil] ignore
 tmstg2p ["tmstg2p", "float", "YES", "", nil] ignore
 tmstg34p ["tmstg34p", "float", "YES", "", nil] ignore

Mapped Columns and Values

FULLY MAPPED	COLUMN NAME CONCEPT	COLUMN STATISTICS	CHART
✗	AGE_s2 Continuous UNITS used: <input type="text"/> <input type="button" value="Save"/> or cancel	count 3077 minimum 44 maximum 98 mean 67.3 standard deviation 10.1	
✓	BMI_s2 → [CONCEPT] BODY MASS INDEX Concept is continuous Units used: kg/m^2	count 3041 minimum 13.984375 maximum 59.928657531738 mean 29.3 standard deviation 5.5	
✓	GENDER → [CONCEPT] GENDER Concept is categorical M: Male F: Female	F 1699 M 1379	

VISAGE: Data model Browser

QUERY | INFORMATICIAN | ONTOLOGY | ADMINISTRATION | STATISTICS | HONEST BROKER

Concepts

UNIQUE NAME	SHORT NAME	DESCRIPTION
#HemoglobinOxygenDesaturationEvent	Hemoglobin Oxygen Desaturation Event	
#HemoglobinOxygenDesaturationEvent_3_percent	Hemoglobin Oxygen Desaturation Event 3 Percent	Definition: A recording of a hemoglobin oxygen desaturation equal to or greater than 3%
#HemoglobinOxygenDesaturationEvent_5_percent	Hemoglobin Oxygen Desaturation Event 5 Percent	Definition: A recording of a hemoglobin oxygen desaturation equal to or greater than 3%
#HemoglobinOxygenDesaturationFinding	Hemoglobin Oxygen Desaturation Finding	Calculation: (SDO:BaselineHemoglobinOxygenSaturation - SDO:HemoglobinOxygenSaturationFinding)

QUERY | INFORMATICIAN | ONTOLOGY | ADMINISTRATION | STATISTICS | HONEST BROKER

Concept [#HemoglobinOxygenDesaturationFinding](#) | [view all concepts](#)

Name	#HemoglobinOxygenDesaturationFinding
Terms	
Parents	#HematologicalFinding
Children	
Interprets	
Interpreted By	
Part Of	
Has Parts	
Finding Site	
Finding Site Reverse	

Hemoglobin Oxygen Desaturation Finding hasHemoglobinOxygenDesaturationValue Integer
 Hemoglobin Oxygen Desaturation Finding representationOf Hemoglobin Oxygen Saturation

Application Tools

- Toolset for Sleep Research
 - Normalize PSG data from different applications
 - De-identify records
 - Visualization Tools
- File download - signal data, images, genomic data, etc.

PhysioMIMI strengths

- Distributed Database Mapping
 - Map to existing databases
 - Sites free to store data in ways that are meaningful to them
 - ➔ No enforcement of a central model
 - Harmonization by mapping
- Visual Query and Data Analysis
- Application 'neutral' domain model and mapping

Acknowledgements

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- Susan Redline, MD
- GQ Zhang, PhD

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- Songmao Zhang, PhD