Factorizing Determinants of Human Health

Authors: Nicholas Latham · Chris Nodel · Van Quoc Huy Vo

Agenda

- Use case (narrative)
- Competency questions
- Integrated datasets
- Modules (one slide per module)
- Overall knowledge graph & schema
- Retrospective

Use Case — Narrative (1/2)

Life expectancy is the average number of years a person can expect to live. It is shaped by genetics **and** environmental, social, and behavioral factors.

Across Ohio there are disparities by county, ZIP, and neighborhood — giving us a use case for a data-driven knowledge graph that integrates many datasets to estimate life expectancy and surface drivers of disparities.

Use Case — Narrative (2/2)

Objective: Build a scalable knowledge graph that estimates life expectancy across Ohio counties and supports analysis by public health experts, policymakers, and community organizations.

Key inputs: environmental exposures (lead, air/water quality), health behaviors (smoking, diet, exercise, sleep), healthcare access, demographic/population data, and health outcomes (mortality, infant mortality, disease rates).

References: NIEHS (air pollution), BMJ Oncology (air pollution & cancer), National Sleep Foundation (sleep quality).

Competency Questions

- How do lead levels affect life expectancy?
  (Blood Lead Levels ↔ Mortality)
- Is RSV more dangerous to adults than infants?
  (Respiratory dashboard ↔ Mortality ↔ Infant mortality)
- Is secondhand smoke more dangerous than vaping?
  (eCigarette Use ↔ Tobacco Use ↔ Mortality)

Competency Questions

- Does pharmacy access improve mental health outcomes?
  (Pharmacy Access ↔️ Behavioral Health Claims)
- Do diabetes prevention programs decrease diabetes-related hospitalizations?
  (National DPP ↔️ Hospital data)
- Which infectious diseases correlate with higher infant mortality?
  (Summary of Infectious Diseases ↔️ Infant Mortality)

Integrated Datasets — Overview (1/2)

Selected public datasets integrated into the model (examples):

- Behavioral Health Claims Dashboard — demographics, diagnosis types
- Blood Lead Testing (public) — year, age group, µg/dL
- ODH Respiratory Dashboard — flu, COVID-19, RSV, hospitalizations
- Infant Mortality Scorecard — birth outcomes, maternal characteristics

Integrated Datasets — Overview (2/2)

More datasets:

- Mortality — county, year, death counts
- Ohio BRFSS (data & annual report) — conditions, education, percent affected
- Ohio Pharmacy Access — location, open/close dates, pharmacy_type
- National DPP Locator Map — diabetes prevention program locations
- Hospital Registration Information — facility-level services and capacities

Module: Education

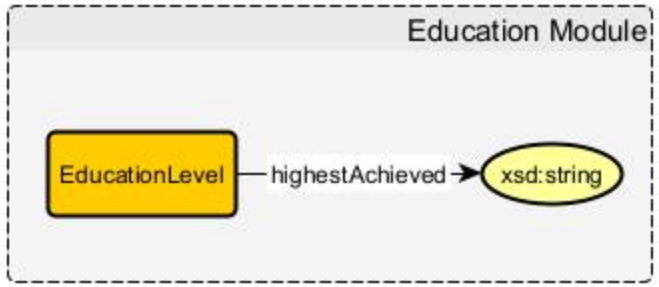
Source pattern: Reporting event
Source data: Behavioral Health Claims, Hospital Registration, BRFSS

Description: Education level influences income, health behaviors, and access to care — downstream effects on health outcomes.

Key axioms (summary):

- `EducationLevel subClassOf Education`
- `EducationLevel subClassOf Education some Income`
- `EducationLevel subClassOf Education some Action`

Module: Education



Module: Environment

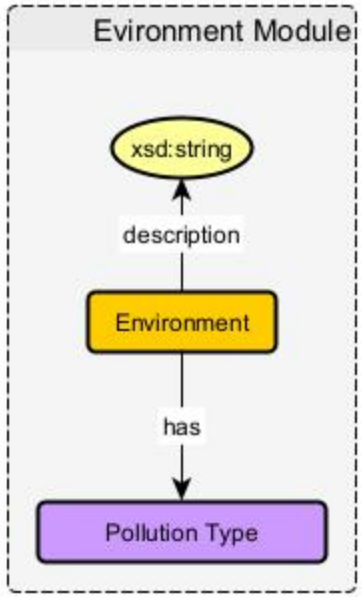
Source pattern: Reporting event
Source data: Blood Lead Testing, environmental datasets

Description: Air/water/pollution influence health (respiratory disease, cancer) and thus life expectancy.

Key axioms (summary):

- `Environment subClassOf ... some PollutionType`
- `Environment subClassOf ... some HealthOutcome`

Module: Environment



Module: Healthcare Access

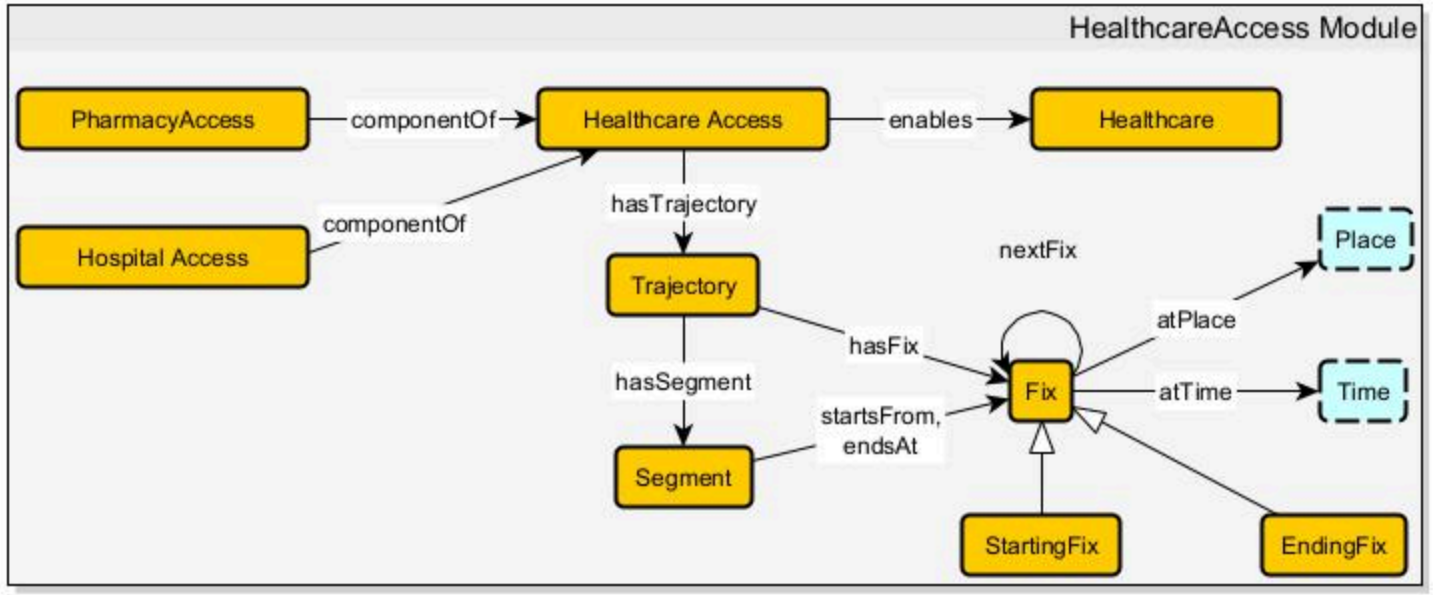
Source pattern: Reporting event
Source data: Best Hospitals, Hospital Registration, Pharmacy Access, National DPP

Description: Access to hospitals, pharmacies, and programs affects treatment, medication adherence, and outcomes.

Key axioms (summary):

- `HospitalAccess subClassOf HealthcareAccess`
- `PharmacyAccess subClassOf HealthcareAccess`
- `EndingFix subClassOf HealthcareAccess Module some HealthOutcome`

Module: Healthcare Access



Module: HealthOutcomes

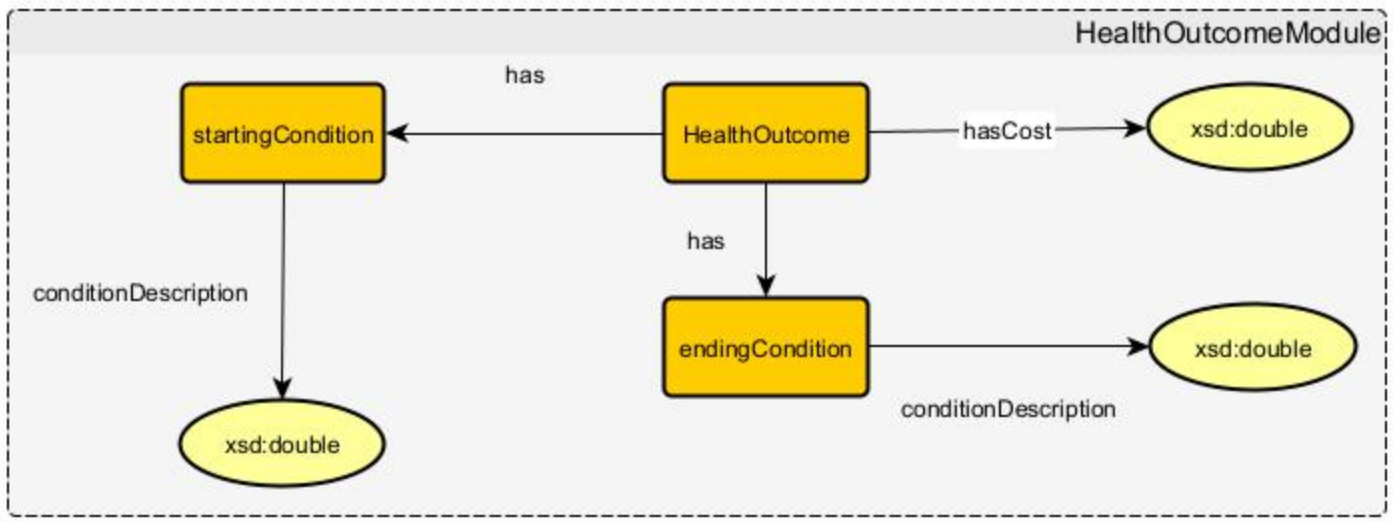
Source pattern: Recurring event
Source data: Mortality, Cancer stats, Behavioral Claims, Infectious disease summaries

Description: Health events (disease, hospitalization, death) are the primary outcomes we model and link to exposures and behaviors.

Key axioms (summary):

- `HealthOutcome subClassOf LifeEvent`
- `HealthOutcome subClassOf LifeEvent some Cost`
- `HealthOutcome subClassOf LifeEvent some startingCondition`

Module: HealthOutcomes



Module: KeyBehaviors

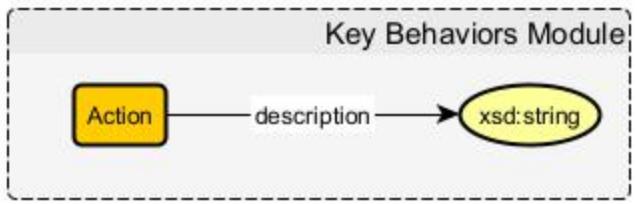
Source pattern: Reporting event

Source data: BRFSS, Tobacco/eCigarette datasets, Behavioral Claims

Description: Behaviors such as smoking, vaping, diet, exercise, and sleep are tracked and linked to health outcomes.

Key axioms (summary):

- `Action subClassOf KeyBehaviors some description`
- `Action subClassOf KeyBehaviors some HealthOutcome`



Module: Life & LifeEvent

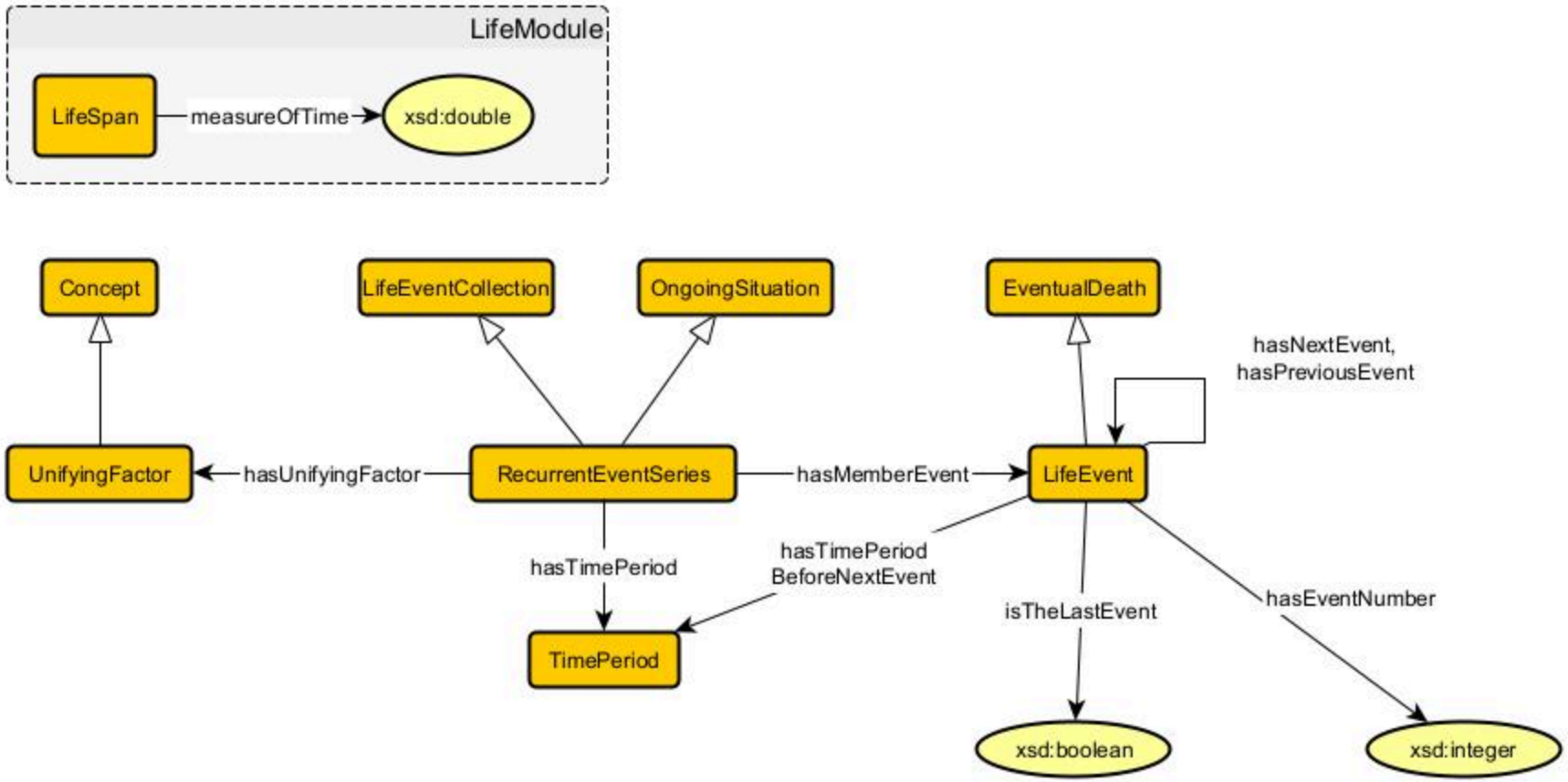
Source pattern: Reporting / Recurring events
Source data: Mortality, Infant Mortality Scorecard, Hospital Data

Description: LifeEvents (birth, hospitalization, death) form the temporal backbone; Life module represents lifespan measures.

Key axioms (summary):

- `LifeSpan subClassOf Life some measureOfTime`
- `EventualDeath subClassOf LifeEvent max 1 LifeSpan`

Module: Life & LifeEvent



Module: Location & Population

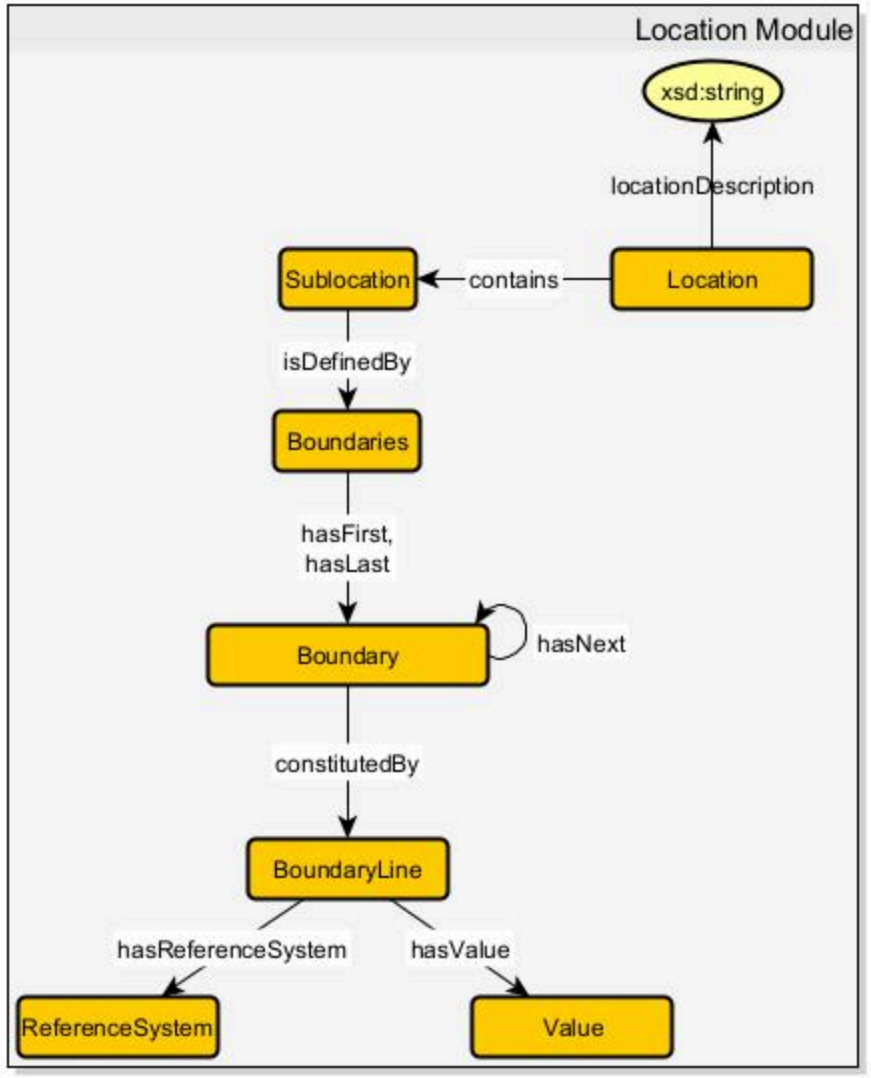
Source pattern: Reporting event / Quantity
Source data: Population Data for Rates, Hospital Registration, BRFSS

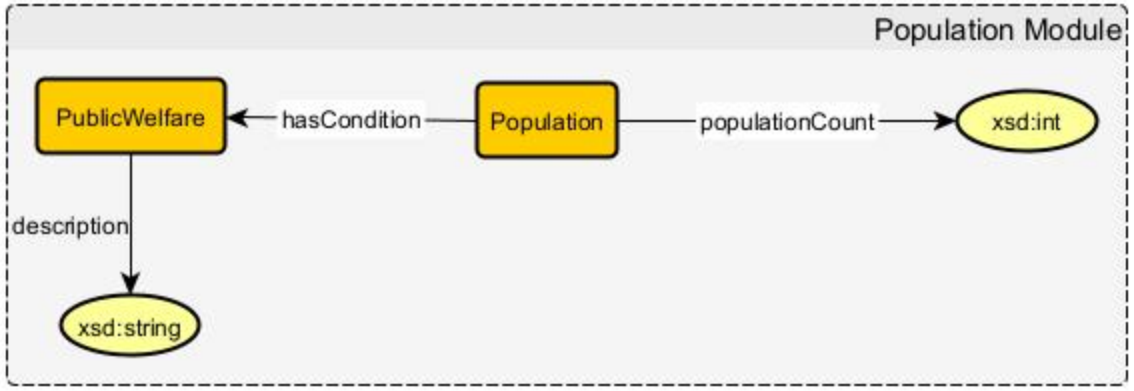
Description: Geography (county / ZIP / tract) determines environmental exposures, access to care, and aggregated population measures (rates).

Key axioms (summary):

- `Population subClassOf Population Module some Location`
- `Location subClassOf Location Module some HealthcareAccess`

Module: Location & Population





Module: Person & RacialAttribute

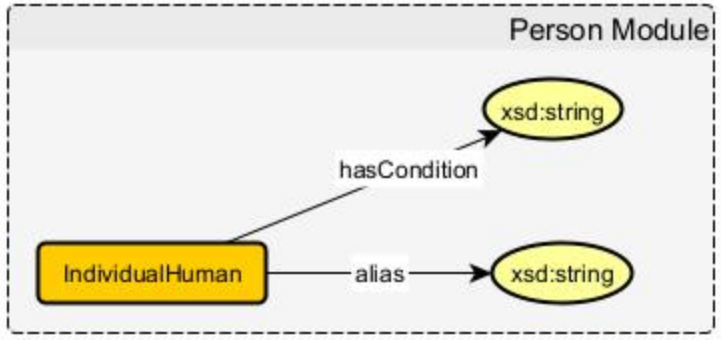
Source pattern: Agent / Reporting event
Source data: Behavioral Claims, BRFSS, Population Data

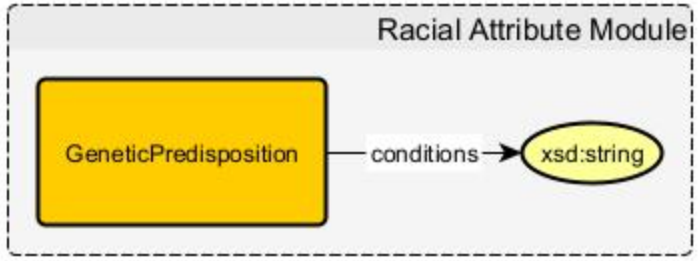
Description: Individual-level entities (IndividualHuman) with demographics, education, income, behaviors, and health outcomes.

Representative axioms:

- `IndividualHuman subClassOf Person max 1 LifeSpan`
- `IndividualHuman subClassOf Person some RacialAttribute`
- `GeneticPredisposition subClassOf RacialAttribute some HealthOutcome`

Module: Person & RacialAttribute





Module: Wealth

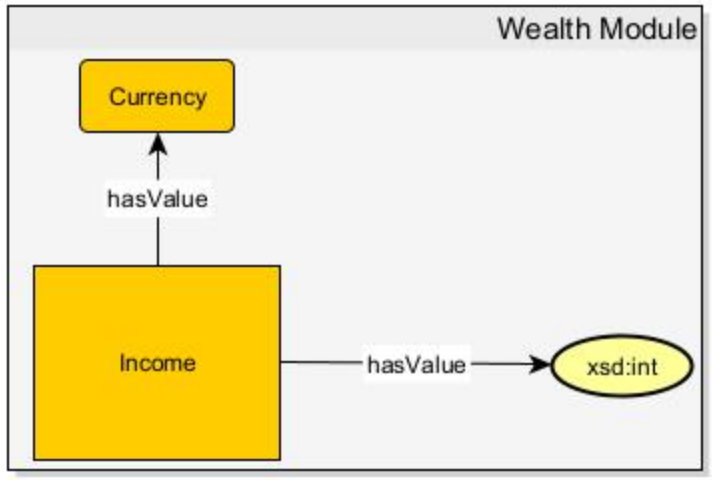
Source pattern: Reporting event
Source data: Behavioral Claims, Hospital Registration, BRFSS

Description: Income/wealth link to healthcare access and education, modifying risk and resilience.

Axioms (summary):

- `Currency subClassOf Income some Value`
- `Income subClassOf WealthModule some HealthcareAccess`
- `Income subClassOf WealthModule some EducationLevel`

Module: Wealth

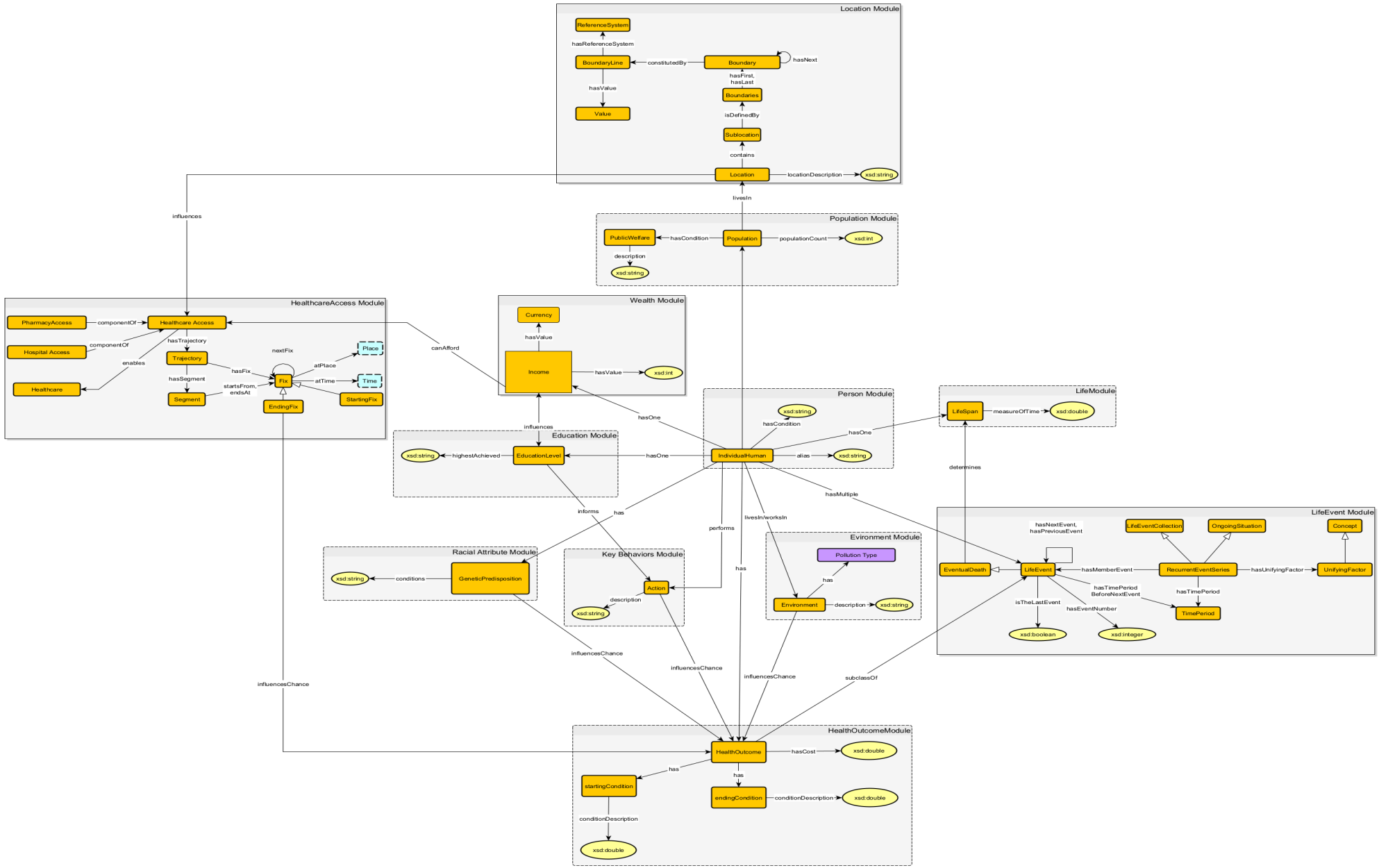


The Overall Knowledge Graph

Namespaces: (prefixes to be defined in the repo/OWL)

High-level connections

- `Person` — linked to → `Location`, `EducationLevel`, `Income`, `HealthBehavior`, `HealthOutcome`
- `Population` — aggregates → `Person` and provides rates used to normalize outcomes
- `Environment` — influences → `HealthOutcome` (direct exposure links)
- `HealthcareAccess` — mediates → `HealthOutcome` (access, capacity)


Location Module
ReferenceSystem
hasReferenceSystem
BoundaryLine
constitutedBy
Boundary
hasNext
hasFirst, hasLast
Boundaries
hasValue
Value
isDefinedBy
Sublocation
contains
Location
locationDescription
xsd:string
livesIn
influences
Population Module
PublicWelfare
hasCondition
Population
populationCount
xsd:int
description
xsd:string
HealthcareAccess Module
PharmacyAccess
componentOf
Healthcare Access
Hospital Access
componentOf
hasTrajectory
Trajectory
nextFix
Place
enables
hasFix
atPlace
Healthcare
hasSegment
Fix
atTime
Time
startsFrom, endsAt
Segment
EndingFix
StartingFix
canAfford
Wealth Module
Currency
hasValue
Income
hasValue
xsd:int
influences
hasOne
Person Module
xsd:string
hasCondition
hasOne
LifeModule
LifeSpan
measureOfTime
xsd:double
Education Module
xsd:string
highestAchieved
EducationLevel
hasOne
IndividualHuman
alias
xsd:string
determines
hasMultiple
informs
has
livesIn/worksIn
performs
has
LifeEvent Module
hasNextEvent, hasPreviousEvent
LifeEventCollection
OngoingSituation
Concept
EventualDeath
LifeEvent
hasMemberEvent
RecurrentEventSeries
hasUnifyingFactor
UnifyingFactor
hasTimePeriod BeforeNextEvent
hasTimePeriod
isTheLastEvent
hasEventNumber
TimePeriod
xsd:boolean
xsd:integer
Racial Attribute Module
xsd:string
conditions
GeneticPredisposition
Key Behaviors Module
Action
description
xsd:string
Evironment Module
Pollution Type
has
Environment
description
xsd:string
influencesChance
influencesChance
influencesChance
influencesChance
subclassOf
HealthOutcomeModule
HealthOutcome
hasCost
xsd:double
has
has
startingCondition
endingCondition
conditionDescription
xsd:double
conditionDescription
xsd:double

Representative Axioms (summary)

- `EducationLevel subClassOf Education some Income.`
- `Environment subClassOf Environment Module some HealthOutcome`
- `HealthOutcome subClassOf LifeEvent`
- `Action subClassOf KeyBehaviors some HealthOutcome`
- `EventualDeath subClassOf LifeEvent max 1 LifeSpan`
- `IndividualHuman subClassOf Person some RacialAttribute`
- `Income subClassOf WealthModule some HealthcareAccess`

Retrospective — Comments

Nicholas Latham

- Contributions: Drafted Use Case sections, Key Notions, Module and Overall Schema Diagrams, and Axioms; extracted dataset metadata tag lists.
- What went well: Once we got going, the development process seemed mostly straightforward.
- What could be improved: Some of the datasets we chose have restricted access, so we had to glean whatever we could from public reports, and many of the others were still difficult to download.

Retrospective — Comments

Chris Nodel

- Contributions: contributed to Use Case, Key Notions, Axioms, Schema Diagrams, Modules; generally in charge of double checking and oversight
- What went well: The workflow was generally rather smooth and communication was well coordinated.
- What could be improved: The data aquisition proved the most difficult part of the process due to inaccessability.

Retrospective — Comments

Van Quoc Huy Vo

- Contributions: integrated datasets list, Module descriptions, Schema Diagrams and Axioms; coordinated the overall narrative.
- What went well: Strong integration of public datasets and clear competency questions.
- What could be improved: Streamline data acquisition early; standardize property naming and units across datasets.

Retrospective — Comments

Course Rating (group summary):

- Useful: ✅
- Fun: somewhat (interesting but rigorous)
- Overall: Recommended for practical exposure to knowledge graphs and public-health data integration.

Next Steps & Deliverables

- Convert this Marp Markdown to PDF for submission.
- Produce `documentation.md` (full template) from these slides.
- Implement OWL/TTL exports from the schema and create example SPARQL competency queries.

Thank you — Questions?