BUILDING AN ONTOLOGY OF PUBLIC HEALTH INTERVENTIONS AND TOOLS FOR EVIDENCE-BASED PUBLIC HEALTH

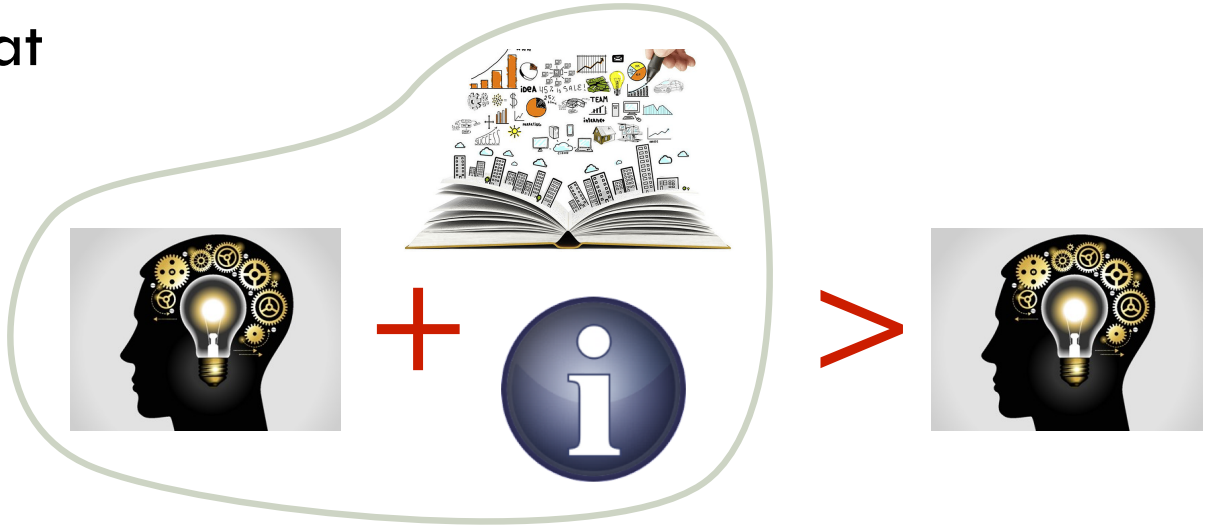
David BUCKERIDGE :: May 23, 2018

Introduction

Tools for evidence-based public health (EBPH)

Evidence-based Public Health

- PH decisions made using better knowledge and information are better
  - i.e. lead to better outcomes
- Better knowledge and information:
  - relevant to task at hand
  - in a usable format
  - sufficient amount
  - high quality



PopHR: Population Health Record

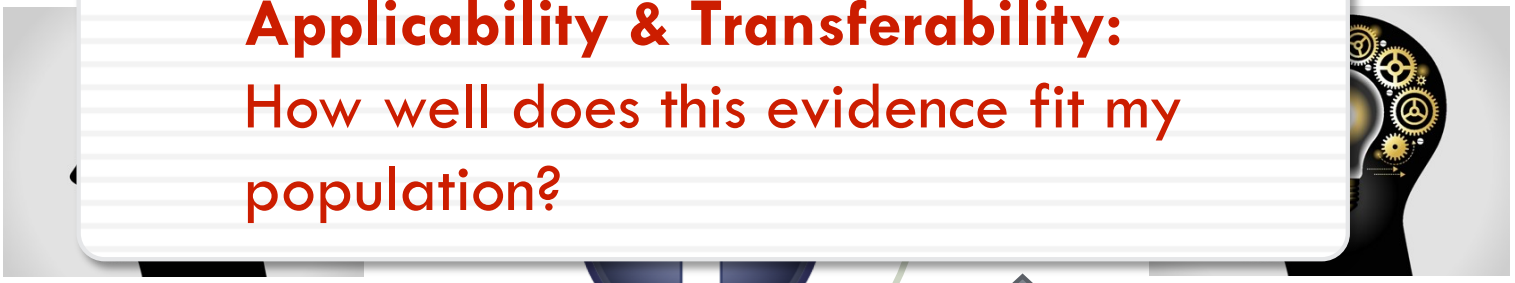
- Web-based software platform for intelligent analysis and visualization of population health information
- Integrates heterogeneous data from multiple sources to calculate up-to-date indicators:
  - health determinants
  - diseases and conditions
  - health system performance
- Indicators are contextualized by public health knowledge
- Addresses common limitations of existing web portals
  - out-of-date indicators
  - low geographical resolution
  - poor support for simultaneous analysis of multiple indicators

PopHR as an EBPH tool

Knowledge in epi & PH:
Public Health Ontology

Intervention evidence:
HealthEvidence© ⇨ OPHI ⇨ Interventions KB

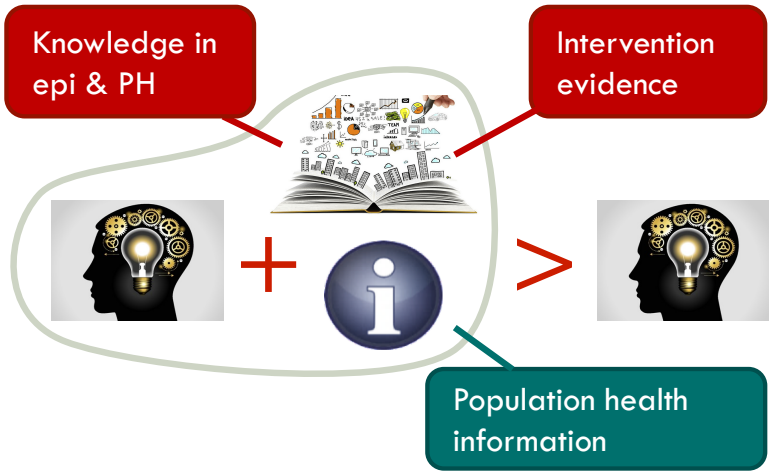
Applicability & Transferability:
How well does this evidence fit my population?



Population health information:
Ontology-based Health Indicators

Public Health Ontology (PHOnt)

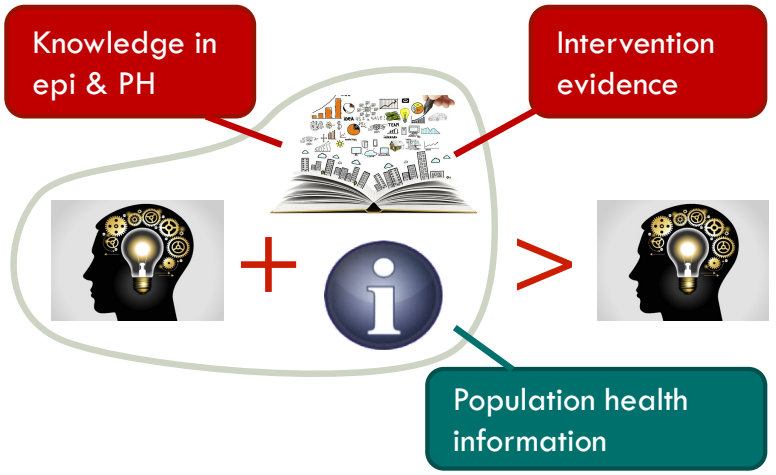
- Based on the Australian Classification of PH Activity *Jorm, Gruszin, and Churches (2009)*
- Definitions of concepts in following categories:
  - determinants of health and risk factors
  - health issues (diseases, functioning, well-being)
  - populations and their characteristics
  - PH resources and settings
- Formal encoding of causal epi knowledge



Ontology-based health indicators

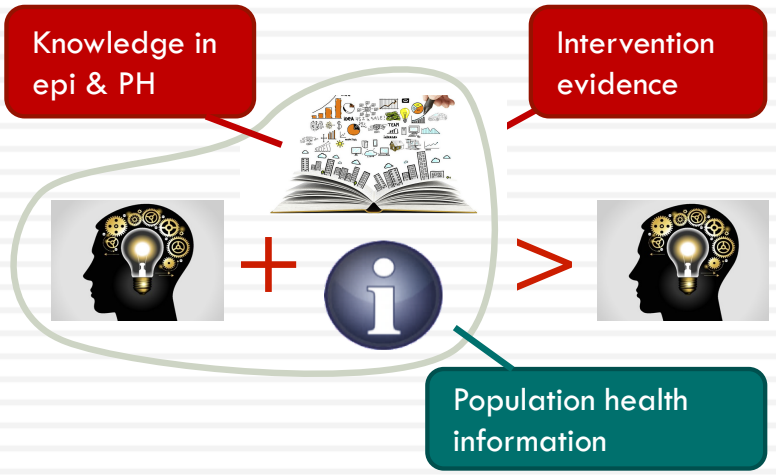
- Systematized using multiaxial taxonomy in Health Indicators Ontology
- Defined properties that have implications for analysis and visualization (e.g. measurement units)
- Linked to health conditions and determinants of health via PHOnt

Facilitated analysis of health information



Ontology of PH Interventions (OPHI)

Intervention evidence



Barriers to using evidence about PH interventions in practice

- Poorly organized evidence
  - ongoing efforts (HealthEvidence.org, CDC DB, BEEM project) have limitations
  - need a conceptual framework and a universal vocabulary to consistently describe interventions and evidence about their effectiveness

current focus:

- Varying quality of research and reporting (difficult to assess)
- Remaining knowledge gaps
- Lack of tools providing access to the evidence within health information systems

Advantages of ontology

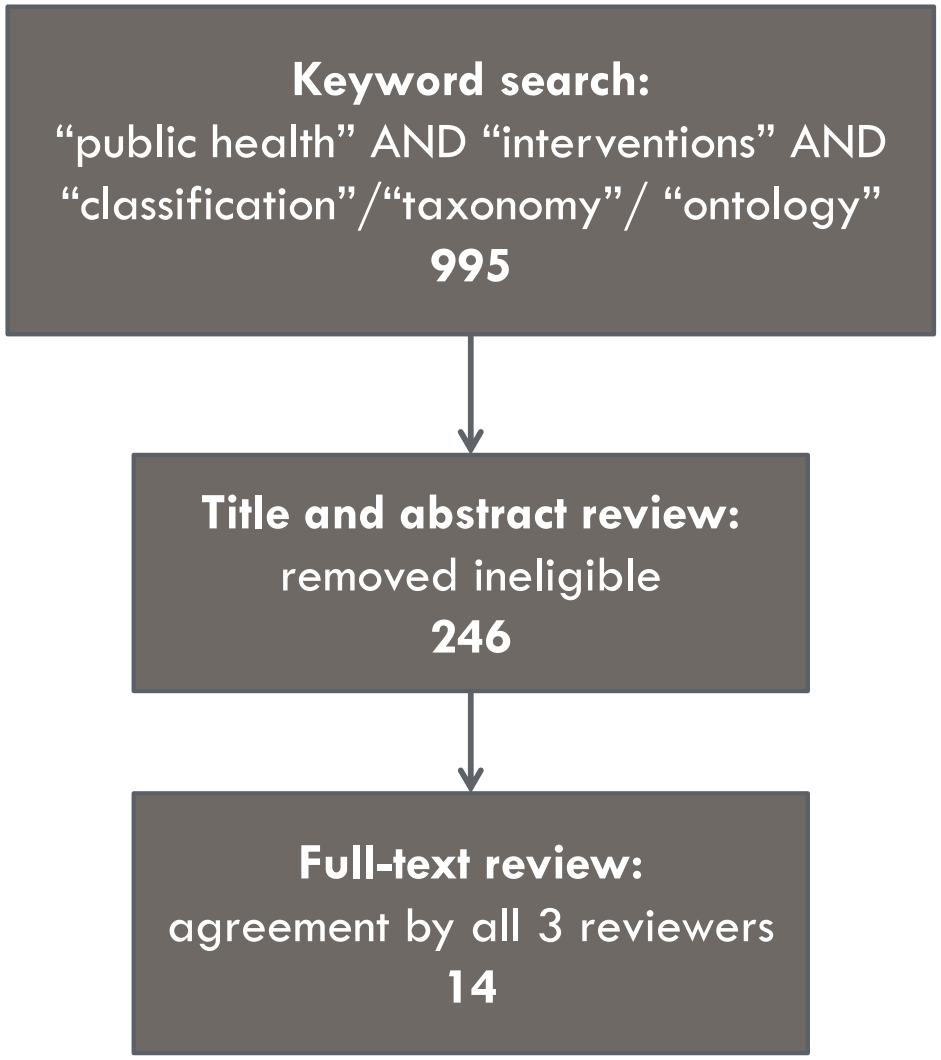
- Supports multi-axial classifications
  - interventions can be described by many properties
- Relationships among entities have clear semantic (unlike keywords and tags)
  - e.g. interventions to *prevent COPD* vs. interventions for improving outcomes in *people with COPD*
- Machine-readable
  - automatic tools can be developed
- Relationships encoded as logical axioms to allow automated reasoning
  - e.g. use knowledge about risk factors to search for upstream interventions

Is there an existing ontology?

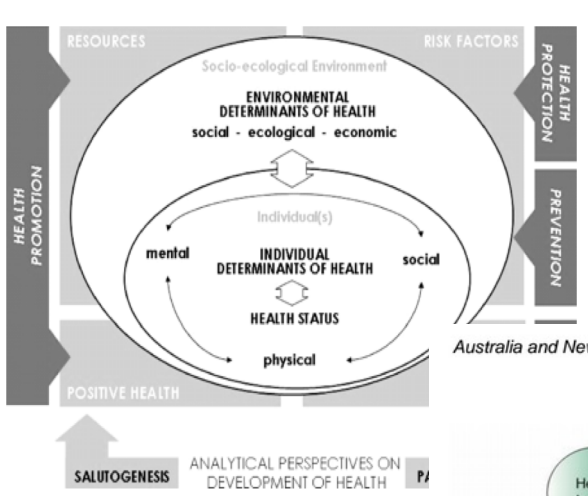
- Extensive classifications exist for clinical, but not for public health interventions
- ICHI: an attempt to extend clinical interventions taxonomy to public health
  - in practice, not many attributes of clinical interventions are relevant to PH, and the other way around
- Australian classification of public health
  - broad scope extending beyond interventions
  - includes comprehensive lists of methods, settings and resources relevant to interventions
  - lacks important properties to fully describe interventions

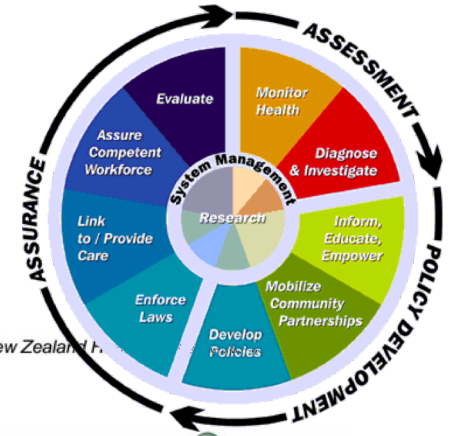
Search for existing frameworks

- 3 independent reviewers
- Literature search:
  - PubMed
  - Scopus
  - Google Scholar
  - Cochrane Library
- Gray literature search (misc. documents):
  - PHAC
  - INSPQ
  - WHO: PHE
  - NPHP

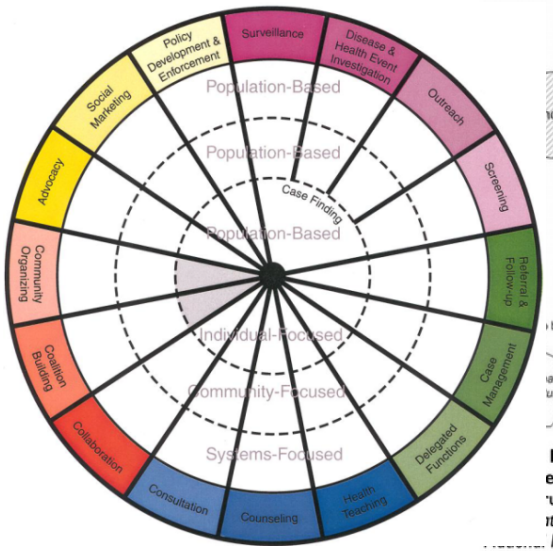


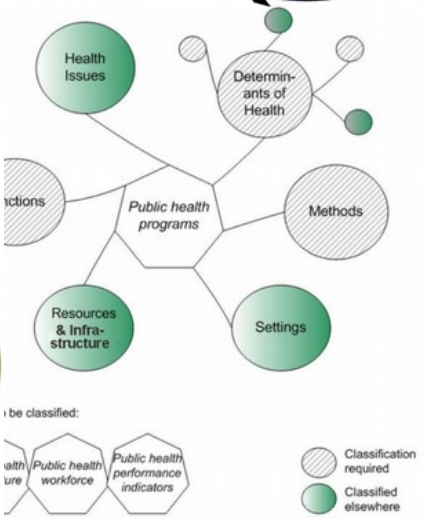
Synthesis and term alignment





Australia and New Zealand H...





el of public health classification. Source: Adapted
uszin S, Jorm L, Churches T, Straton J: *Public Health*
tions Project Phase One: Final Report: Report to the
Public Health Partnership Group. Melbourne: National
Public Health Partnership; 2005.

- high-frequency concepts
- synonyms
- classification dimensions
- properties of interventions

OPHI conceptual framework

Core concepts

Intervention

- Refers to an organized activity that intends to improve population health
- Not limited to activities performed by PH agencies
- Instances are specific programs deployed within specific populations and geo-spatial context

Evidence

- Refers to a study establishing an effect of an intervention on a specific health outcome
- Unless there is evidence of effect, knowledge about possible interventions is of little relevance to practitioners

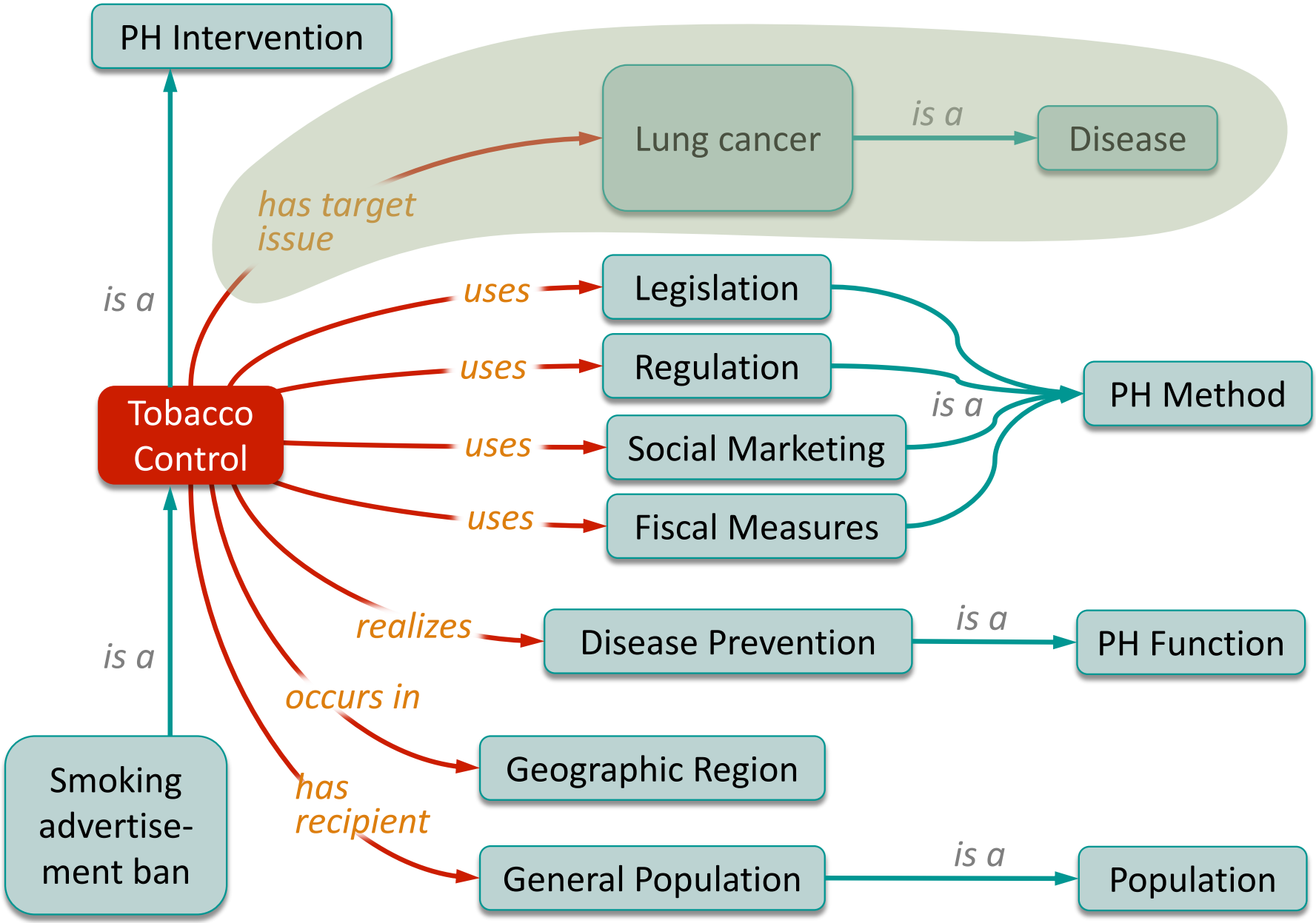
Properties of interventions

Property (preferred term)	Range	Cardinality	Definition / description	Synonyms (in other frameworks)
intent	PH Function(?)	1	High-level purpose category (e.g. promote-prevent-protect)	purpose, strategy
distal target	Health Issue	1+	Existing health issue being addressed by an intervention, an ultimate goal of an intervention (as opposed to specific immediate outcomes of an intervention).	problem, issue, health priority
recipient	Population	1	The population, to which an intervention applies	target, target population
actor	Organization	1+	Entity (organization) that makes an intervention possible in some capacity (Who does it and in what role?)	
setting	PH Setting	1(?)	Institutional and social environments, partnerships, and locations in which public health activity occurs	context
resources	PH Resource	1+	The means available for the operation of health systems, including human resources, facilities, equipment and supplies, financial funds and knowledge	resources & infrastructure, means
time frame			Start, end, duration	
geography			Geo location	
evidence	Evidence	0+	Evidence of effectiveness for particular target issue(s)	

Properties of evidence

Property (preferred term)	Range	Cardinality	Definition / description
intervention	Intervention	1	Which intervention has been evaluated
effect	Health Issue, Health Determinant	1	What was demonstrated to change as a result of the intervention? (measureable outcome)
effect size	{strong, moderate, weak}	1	The magnitude/significance of observed changes
effect direction	{positive, negative}	1	Although we may assume that an intervention would have an intended effect on the outcome, it is better to specify explicitly how an intervention affected the outcome
type	EvidenceType	1	What's the type/quality of evidence? (e.g. individual peer reviewed study vs. systematic review)

- Using Ontology of Clinical Research (OCRe) to represent study design & other properties
- Additional attributes of evidence are being considered based on the input from knowledge translation experts

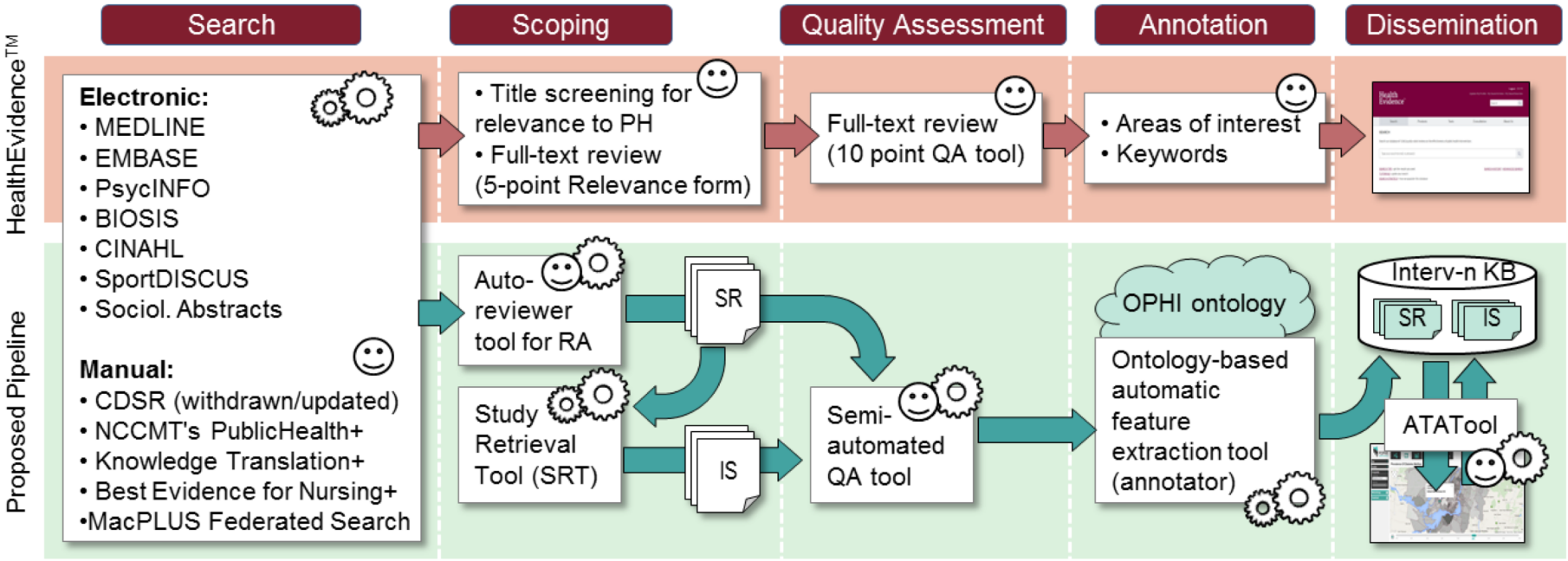

PH Intervention
Lung cancer
is a
Disease
has target issue
is a
uses
Legislation
uses
Regulation
Tobacco Control
uses
Social Marketing
uses
Fiscal Measures
is a
PH Method
realizes
Disease Prevention
is a
PH Function
is a
occurs in
Geographic Region
Smoking advertise-ment ban
has recipient
General Population
is a
Population

Repository of health evidence

- Instances of evidence from literature encoded in terms of OPHI
  - Essential to include original studies and not just systematic reviews
  - Each study can produce multiple instances of evidence – for each measured outcome

Phase I: Manually encoded small set of studies (smoking cessation)

Phase II: Use NLP to populate PH Interventions Knowledgebase



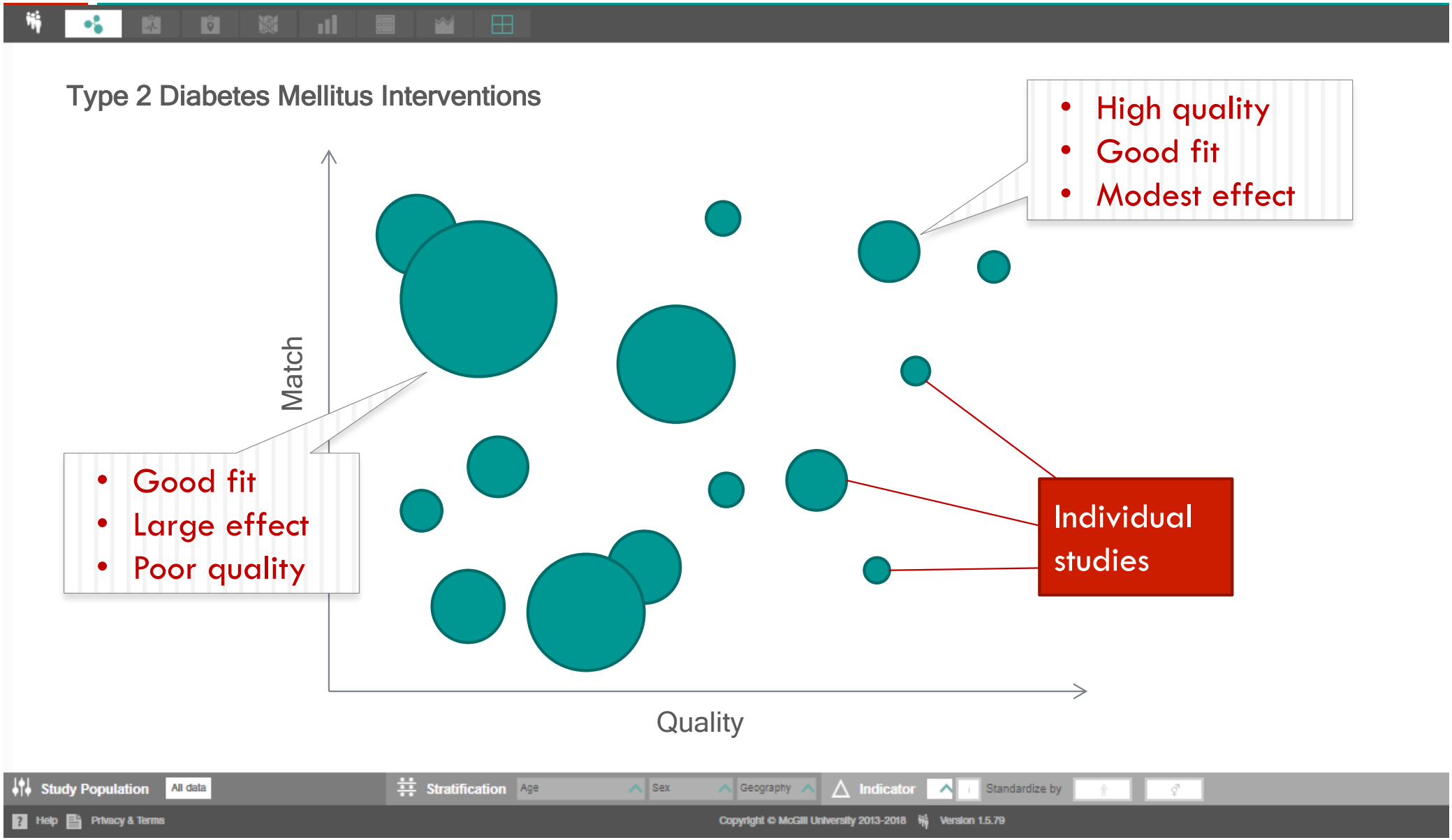
Transferability assessment

Transferability assessment

For an intervention with proven effectiveness, can I expect similar results in my target region?

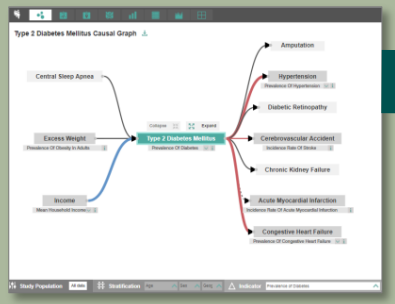
- Assess the similarity between study population/setting & target population/setting
  - Define phenotype (characteristics to be considered
  - Choose similarity metrics (conceptual/semantic similarity, Euclidian distance,…)
  - Possibly pool results across different characteristic
- The better the match between study population/setting and the target, the higher transferability

Visualization



Putting it all together in PopHR

Causal knowledge



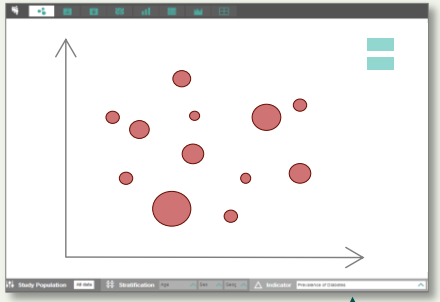
Extend/narrow search for conditions & RFs

HealthEvidence©

Reviews

+ annotations
+ original studies

Interventions tab

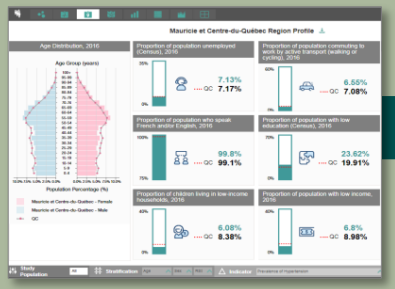


3D ranking:

- match
- effect size
- quality

Intervention KB

Region profile



Population characteristics

Matching Algorithms

- euclidian distance
- semantic similarity

Relevant studies

Reviews+

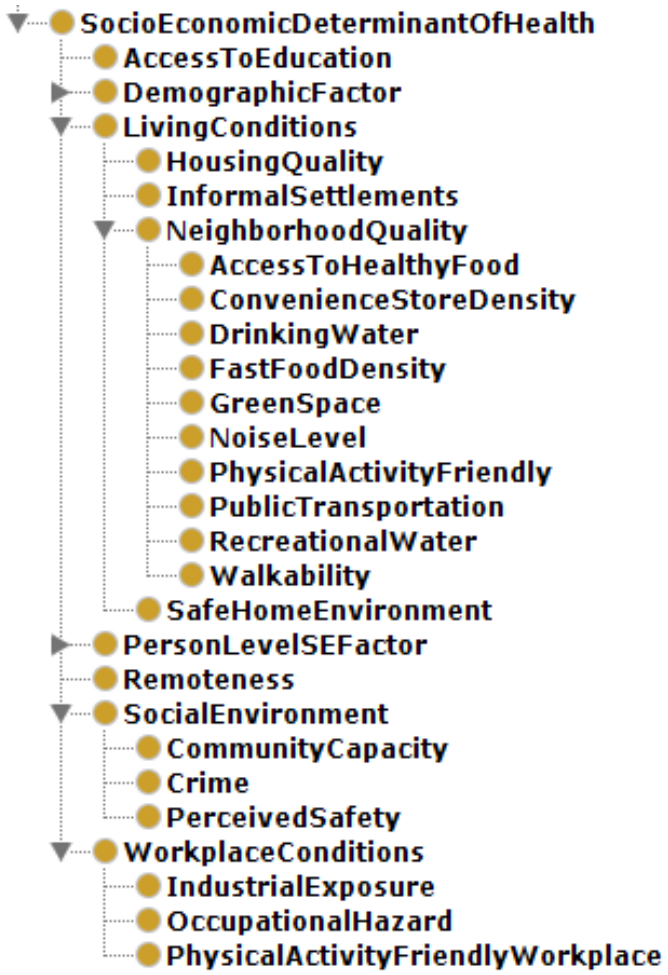
Original Studies

PopHR 1.5

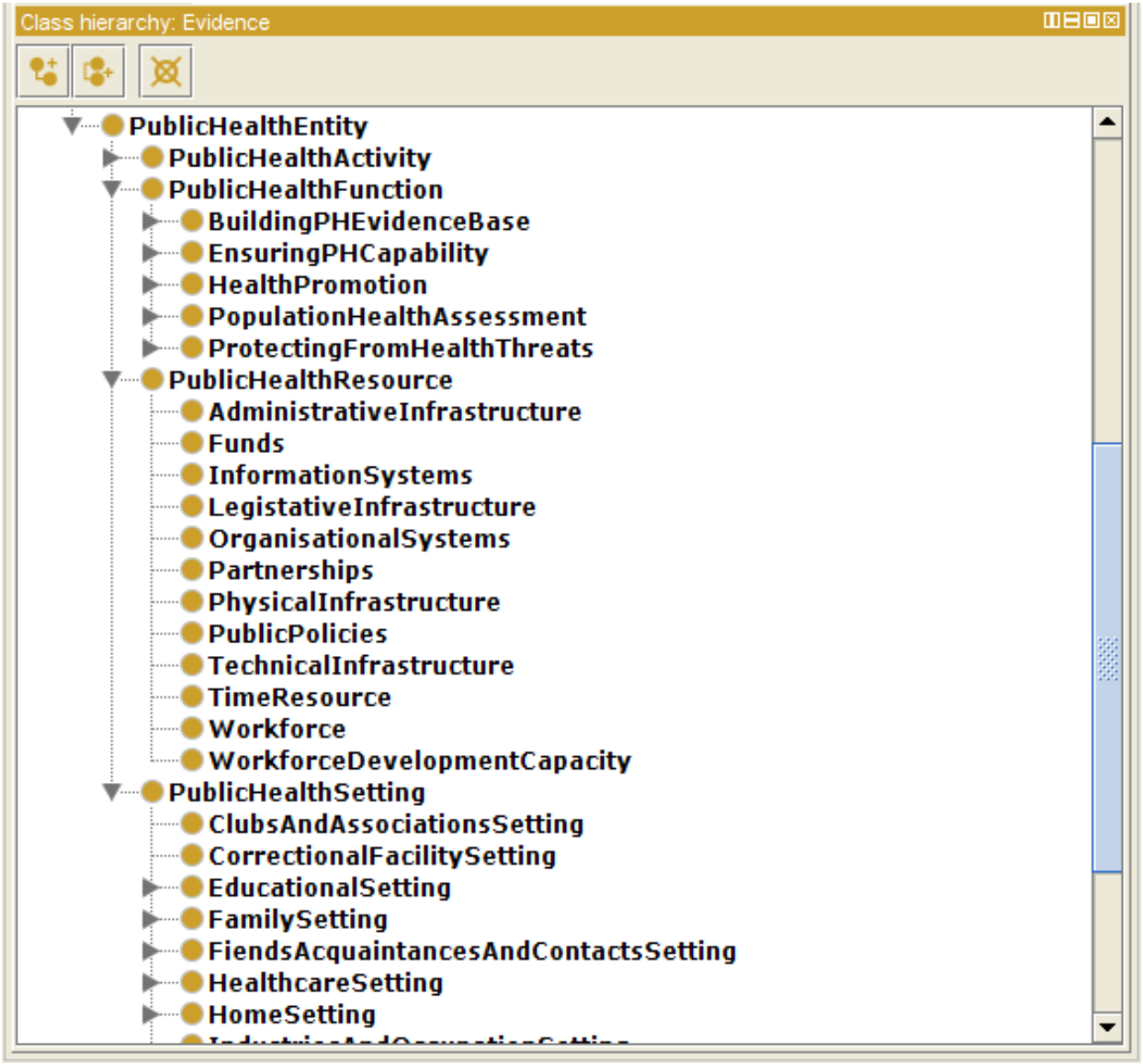
PopHR 2.0

Extras

PHOnt taxonomy examples: Determinants of Health

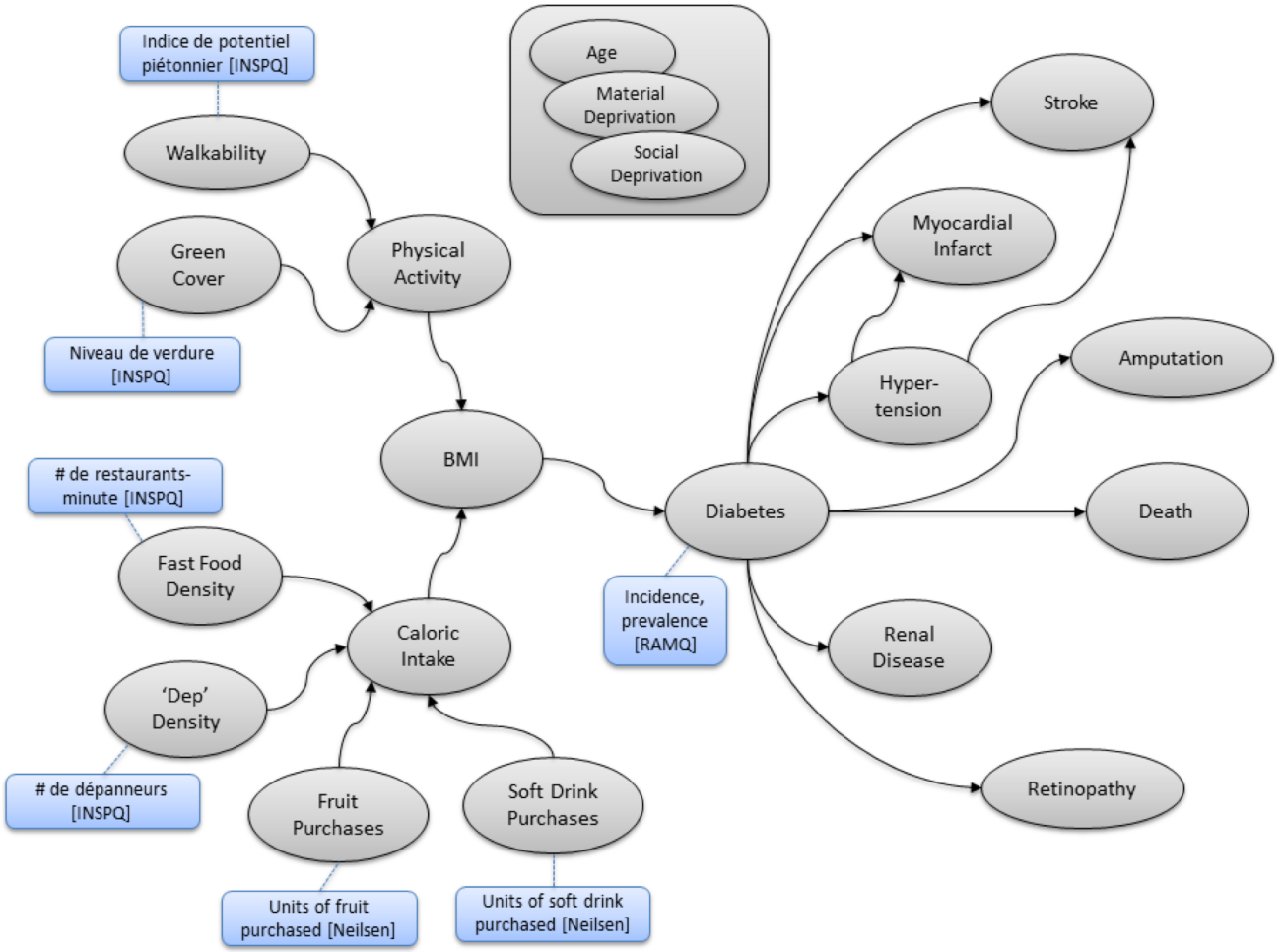


PHOnt taxonomy examples:
PH functions, settings, and resources



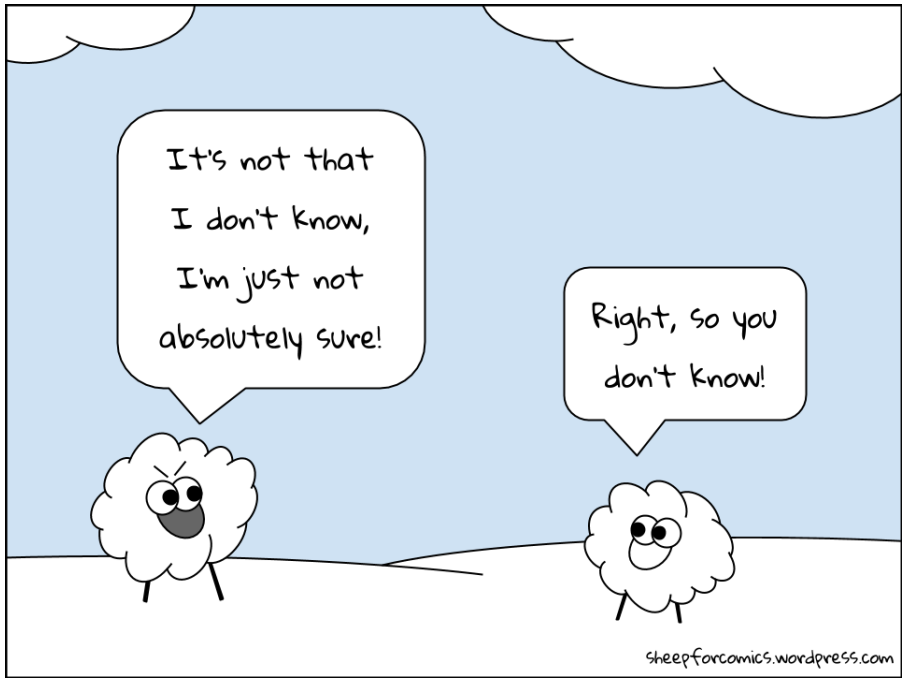
Encoding causal links: diabetes example

- Consensus knowledge exists regarding risk factors and downstream conditions
- Links established at the population level



Causal knowledge: encoding challenges

- Non-deterministic causation
- Causal links established from the analysis of populations don't always hold for all individuals
- Ontology languages, like OWL, don't deal well with uncertainty



Need to express uncertainty vs. **Rigid formal logic**

From causal diagram to ontology

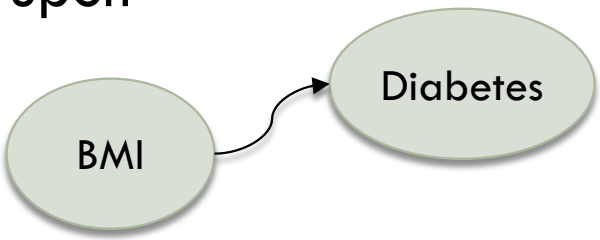
- Nodes:
  - Diseases and conditions
  - Health determinants
  - Health-related events and procedures (e.g. Amputation)

Encoded as classes

- Arrows = probabilistic causal links:
  - *has_effect_on* (positive/negative)
  - generally transitive
  - allow versatile DL queries

Encoded as properties

- Implications of *consensus knowledge*
  - functional form not fully known or agreed upon
  - limitations in measurement
  - assumption of independence

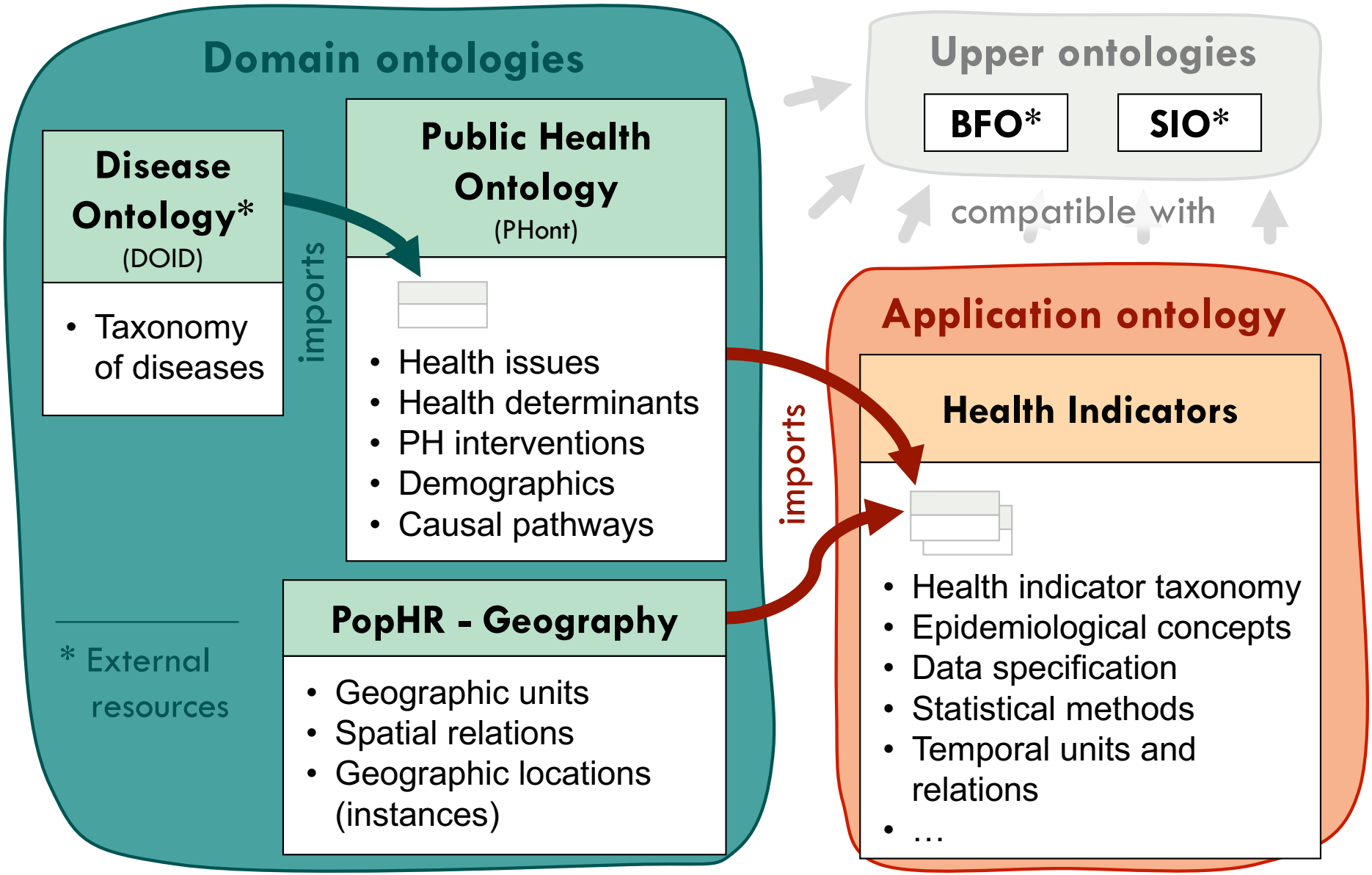


PHOnt Future work

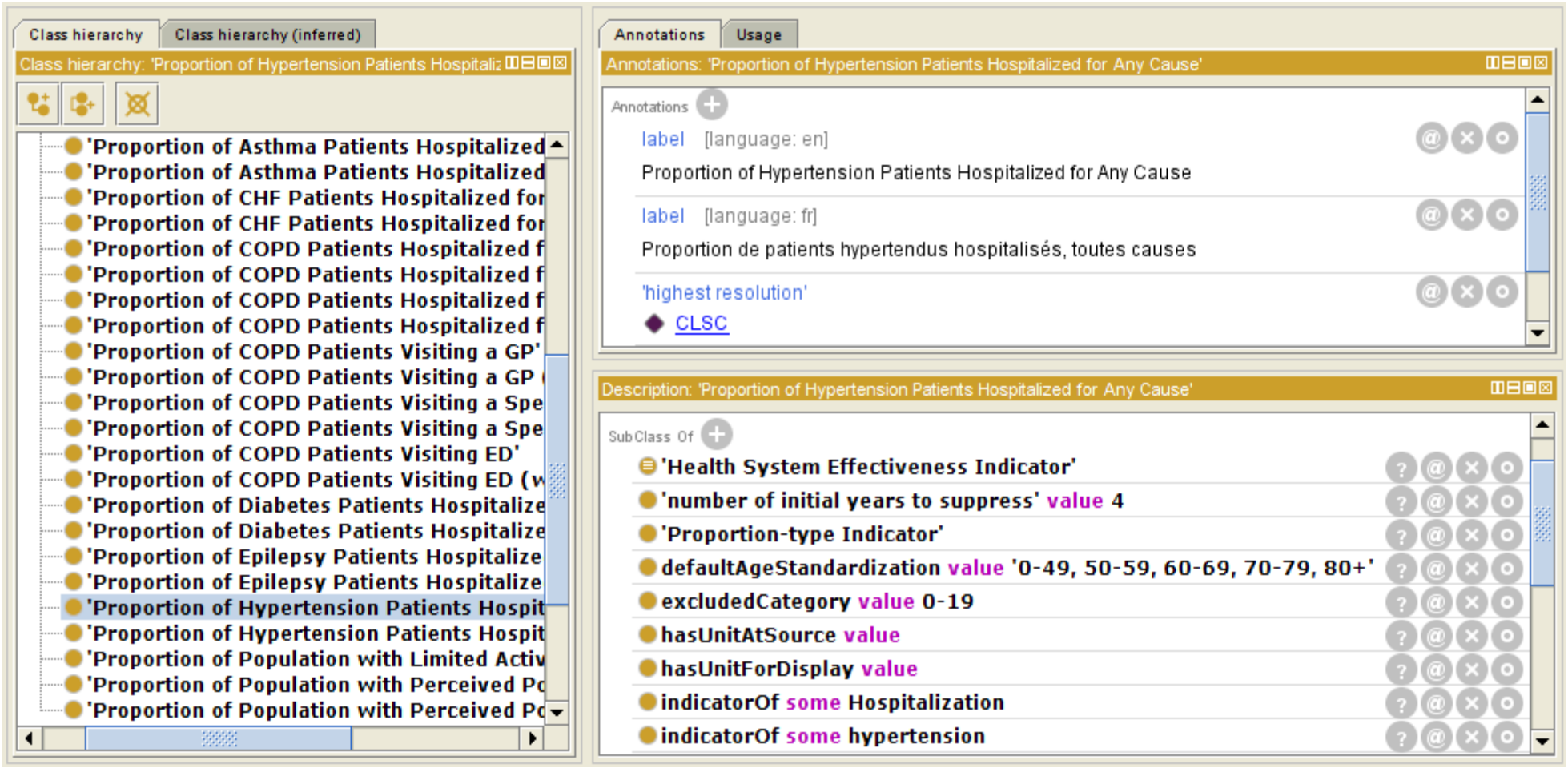
- Causal knowledge in PHOnt is incomplete
  - current scope: PHAC Chronic Disease framework
  - built in collaboration with experts from INSPQ and DSP
  - manual knowledge extraction process is not scalable

Use statistical NLP for automatic extraction of causal findings from published literature

Current PopHR Ontology Suite



Indicator encoding example



Indicators at the PopHR front-end