A Semantic Surveillance Model to Enhance Population Health Decision-making

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Indicators are Critical for Change

“Achieving gains in the nation’s health will require a robust and useful set of indicators…”

“...these data must be integrated, assembled, and communicated to the public, policy makers, and other stakeholders in the health system…”

Institute of Medicine (2010). For the Public’s Health: The Role of Measurement in Action and Accountability. IOM, Washington, DC.
Implications of Current Approach

• Manual Collection
  • Low resolution
  • Cross-sectional

• Manual Calculation
  • Delayed data
  • Laborious and inefficient

• Lacking Explicit Population Health Perspective
  • Not population based
  • Laundry list of numbers
The PopHR Project

- Goal: To develop and evaluate surveillance methods needed for a PopHR
- Funded by CFI and CIHR
- Focused on
  - Automated calculation of population-based indicators
  - Knowledge-based interpretation of indicators
  - Improving Decision making & Policy development
Population Health Record

- Indicators
- Individual Data
- Population Health Indicator Ontology
- Population Health Record
- Neighbourhood Data
- Public Health
- Clinical
- Public
- Built Environment
- Marketing
- Surveys
- Administrative Data
- Clinical Data
- Admissions
- Billing
- Medications
- DSQ
- Population Health Record
- Population Health Indicator Ontology
Conceptual Model for Diabetes
Conceptual Model for Diabetes

- What determinants increase the risk of diabetes? Decrease the risk?
- Which neighborhoods have high risk factors for diabetes but not a high prevalence of diabetes?
- What determinants of diabetes are associated with one another?
- What is the association between depanneur density and diabetes?
- Is green cover associated with walkability? [in general, in Montreal, in which neighborhoods in Montreal]
- Is caloric intake associated with diabetes? [in general, in Montreal, ...]
- What proportion of stroke cases are attributable to diabetes?
- Which age-group has the greatest prevalence of diabetes?
- Which age-group has the highest access to fast food restaurants?
POPHR
Showing the burden of diabetes in Montreal
What is the prevalence of diabetes mellitus in Montreal?
What is the prevalence of diabetes mellitus in Montreal?
between prevalence of diabetes mellitus and prevalence of stroke in Montreal?
## Indicators: Determinants

### Indicators: Built Environment

- Access to dépanneurs
- Access to fast food restaurants
- Access to parks and greenspace
- Neighbourhood walkability index
- Social deprivation index
- Material deprivation index
- Access to food stores
- Food purchasing by category

Source: INSPQ, Nielsen

### Indicators: Health Determinants

- Average Age (yrs)
- Median Age (yrs)
- Male (%)
- Unemployed (%)
- Immigrant (%)
- Median Income ($)
- Average Income ($)
- Income SE
- Low Income Cut Off (%)
- University Education (%)
- French Language (%)
- English Language (%)
- Other Language (%)

Source: 2006 Canadian Census
Why do we need an ontology in PopHR?

• Organizing indicators in a meaningful way
  – Multi-axial classification

• Understanding user queries
  – “Which factors increase the risk of diabetes?”

• Helping users make sense of the results:
  – Using available knowledge to show how different indicators are related (conceptual diagram)
  – Query-dependent data presentation and analytical tools
Ontology Work

• Development of an approach to encoding epidemiological knowledge about indicators
  – Causal relationships
  – Chronic diseases
• Retrieval of concepts and indicators
• Interpretation of indicator values in the context of existing knowledge
The Ontological Structure

**Domain ontologies**
- Disease Ontology (DOID)
  - Taxonomy of diseases
- PopHR - Geography
  - Geographic units
  - Spatial relations
  - Geographic locations (instances)
- Public Health Ontology (PHont)
  - Health issues
  - Health determinants
  - PH interventions
  - Demographics
  - Causal pathways

**Upper ontologies**
- BFO
- SIO

**Application ontology**
- Public Health Indicators (PHIO)
  - Health indicator taxonomy
  - Epidemiological concepts
  - Data specification
  - Statistical methods
  - Temporal units and relations
  - ...
What PopHR knows from its ontology? (Examples)

- Diabetes is a metabolic disease
- High BMI increases the risk of diabetes
- Prevalence of diabetes is an epidemiological indicator
  - it is a proportion of people with diabetes in some population
  - it applies to a particular geographic region
  - it has certain data requirements to be properly calculated (e.g. washout period of 3 years)
  - ...
- To evaluate the difference in incidence of disease between two populations one can use rate ratio
- And more...
Encoding Causal Links

• Nodes = subclasses of:
  – Disease
  – Health Determinant
  – other classes in PHOnt (e.g. Death, Amputation)

• Arrows = probabilistic causal links:
  – has_effect_on
  – has_positive_effect_on
  – has_negative_effect_on

• Additional info attached to the link:
  – supporting evidence
  – strength of association
  – point of stream
  – ??
Encoding Causal Links

- Causality at individual level
- Effects are relative: change in A $\Rightarrow$ change in B
- Effects are not intended for quantitative processing
- Links reflect consensus knowledge
  - functional form not fully known or agreed upon
  - limitations in measurement
  - assumption of independence
Encoding Causal Links: Example
Next Steps

- Enriching the PopHR structure by comparing it with some of the existing standards, methods, and algorithms
- Enabling Rule-based Inferencing
- Advancing the querying method
- Improving the Natural Language Interface (LNI)


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