Capturing Provenance, Evolution and Modification of Clinical Protocols via a Heterogeneous, Semantic Social Network

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A novel approach to describe, organize, manage, trace, use and reuse clinical protocols, based on a heterogeneous semantic social network.

- The proposed approach allows
  - Semantic tagging
  - Semantic enrichment

- Main advantages
  - Tracing protocol provenance, evolution and modifications
  - Protocol meta-description, irrespective of protocol source format
  - Interlinking to related scientific sources (e.g. scientific publications, PHR, etc.) and bodies (e.g. protocol issuing bodies, hospitals, etc.)
BACKGROUND
Formal care plans

• **Clinical guidelines**
  Systematically developed recommendations to address various clinical problems

• **Clinical protocols**
  Detailed algorithms on how to address a particular clinical problem (based on guidelines)

• **Care pathways**
  Care algorithms integrating multidisciplinary tasks for patient care in and outside the hospital (based on guidelines)

• **Other**, e.g. clinical trial protocols, clinical practice guidelines, ...
Examples of formal care plans
State of the art

- Protocol description languages
  - GLIF, EON, Asbru, GUIDE, PROforma, PLAN, ...
- Protocol execution engines and management platforms
  - GLEE, SAGE, DeGeL, NewGuide, SpEM, Tallis, ArezzoTM, HeCaSe2, ...
- Current unmet needs
  - Choose the right protocol
  - Choose the right modification of a protocol (to meet local set-up)
  - Trace protocol use and modification history
  - Trace to protocol provenance, including medical evidence and issuing body
  - Record outcomes of protocol clinical application (e.g. for protocol evaluation)
Our contribution

• Formal protocol meta-description
  – eCP ontology

• Versatile protocol ‘meta-repository’
  – Heterogeneous social network
ECP ONTOLOGY

Conceptual model of care plan meta-description
Conceptual model of care plan meta-description
Conceptual model of care plan **meta**-description
Conceptual model of care plan *meta*-description
Conceptual model of care plan **meta**-description

- **general description**
  - title
  - description

- **classification**
  - genre
  - type
  - related health issue

- **quality & level of recommendation**
  - high
  - moderate
  - low
  - very low
  - strong
  - weak

- **quality of evidence**
  - low
  - very low

- **strength of recommendation**
  - high
  - moderate
  - strong
  - weak

- **issuing body**
  - 1

- **evidence source**
  - 1...N

- **formal care plan**
  - 0...1
  - has
  - is issued by
  - is endorsed by
Conceptual model of care plan meta-description
Conceptual model of care plan **meta**-description

- **title**
- **description**
- **genre**
- **type**
- **related health issue**
- **quality of evidence**: low, very low
- **strength of recommendation**: high, moderate, strong, weak
- **outcomes**
- **issuing body**
- **evidence source**
- **requires**
- **resource**
- **initiated by**
- **is endorsed by**
- **is issued by**
- **observable condition**
- **observable**
- **quality & level of recommendation**
- **quality of evidence**
- **classification**
- **general description**
- **observable condition**
- **observable**
Conceptual model of care plan **meta**-description

**general description**
- title: 1
- description: 0..1

**classification**
- genre
- type
- related health issue: 1..N

**quality of evidence**
- high
- moderate
- low
- very low
- strength of recommendation
  - strong
  - weak
  - is a value of

**formal care plan**
- issuing body: 1
- evidence source: 1..N
  - is issued by
  - is endorsed by
- has: 1..N
- has: 0..1
- has: 1

**outcomes**
- 1..N

**source file**
- identifier
- copyright
- location
- format
- has: 0..N

**observable condition**
- 1..N

**resource**
- requires: 0..N

**observable**
- is part of: 1..N
Conceptual model of care plan *meta*-description
Ontology implementation

- Implemented with OWL2 using Protégé
- Integrated with commonly used standards and controlled vocabularies:
  - ICD-10, SNOMED-CT, QUDT, UO, GRADE and UMLS
Ontology implementation

Available online in: http://purl.bioontology.org/ontology/ECP
E-CLINPRO: CLINICAL PROTOCOL MANAGEMENT SYSTEM
Social networks

Connections and relationships among humans

CarePages
LinkedIn
Facebook

on line digital content, resources, concepts...
Object centered social networks

People interacting on a common social object

on line digital content, resources, concepts...

ResearchGate
Academia
PatientsLikeMe
Heterogeneous social networks

Human and non-human entities are all treated alike, as actors

on line digital content, resources, concepts...

Clinical protocol provenance, evolution and modification

• Provenance
  – Issuing bodies
  – Clinical practice guidelines
  – Scientific evidence sources

• Evolution
  – Update of a previous version, e.g. due to new evidence

• Modification
  – Infrastructure limitations, e.g. lack of a diagnostic equipment
  – Clinical restrictions, e.g. due to concurrent clinical protocols
  – Patient choices and objections, e.g. due to religion
  – Insurance policy constraints, e.g. to firstly perform a lower cost procedure
  – Adaptation to local settings, e.g. different language
  – Restrictions due to comorbidities
Example of clinical protocols’ relationships in the semantic social network

Health units

- University General Hospital of Alexandroupolis
- Hospital of Komotini "Sismanogleio"

Issuing bodies

- NICE
- KDIGO

Care plans

- Acute kidney injury (Protocol)
- Acute kidney injury (Guideline)
- Acute coronary syndrome (Pathway)
- Blood pressure in CKD (Guideline)
- Acute kidney injury (Protocol) - Greek

Issuing bodies

- NICE
- KDIGO
Semantic tagging and interlinking

• Profile of clinical protocol based on the eCP ontology¹

• Entry point: observables and observable condition described via the CARRE ontology²

• Issuing bodies and healthcare units are described following the SWRC ontology³

• Semantic tagging of medical terms with external resources via ICD-10 and SNOMED

• Medical evidence description based on the Bibliographic Ontology (via PubMed identifier and DOI)


Semantic tagging and interlinking

eCP
- General Information
- Technical Information
- Clinical Care Plan
- Evolution
- Exit Points

SWRC
- Issuing body
- Health Unit

CARRE
- Entry Point

ICD10, SNOMED-CT
- observables
- conditions
- resources

Bibliographic Ontology
(PubMed ID & DOI)
E-CLINPRO: IMPLEMENTATION
e-ClinPro implementation

• Backend
  – Server: NodeJS
  – API: LoopBack framework
  – Database: MongoDB

• Frontend
  – Visual Interface: AngularJS
  – Graph visualizations: Vis.JS

• Integration with
  – NCBO BioPortal API
  – PubMed API

• Available online in:
E-ClinPro: Login
E-ClinPro: Dashboard
E-ClinPro: Visualizations
E-ClinPro: Care plans list

- Helicobacter pylori
  - Diagnostic guideline
    - Helicobacter pylori
    - Dyspepsia
  - Entry points
    - Dyspepsia diagnosed AND (Melena diagnosed OR Hematemesis diagnosed OR Weight loss diagnosed OR Dysphagia diagnosed OR Anemia diagnosed)
  - Helicobacter pylori (Variation)
    - Diagnostic guideline (deviation)
      - Helicobacter pylori
      - Dyspepsia
      - Entry points

- Acute coronary syndrome
  - Management pathway
    - Acute coronary syndrome
    - Stable angina
    - Myocardial infarction
    - Chest pain
    - Hyperglycaemia, unspecified
  - Entry points
    - Chest pain yes AND (Assessment of chest pain yes AND Assessment of chest pain stable OR Assessment of chest pain unstable)
  - KDOQI Clinical Practice Guidelines for Chronic Kidney Disease: Evaluation, Classification, and Stratification 2002
  - Diagnostic guideline
    - Chronic kidney disease stage 1
    - Chronic kidney disease stage 2
Acute kidney injury

Description
The kidneys clean the blood by removing waste products. Many different conditions can lead to the ki... More

Genre: Guideline
Type: Management
Related Health Issues:
- Acute nontraumatic kidney injury

Entry points:
( ( Serum creatine kinase measurement ≥ 300% of baseline OR Serum creatine kinase measurement ≥ 0.4 mg/dL) AND ( Urine ≥ 0.3 mL/kg/hr OR Urine ≥ 100 mL/24h) ) OR acute kidney injury diagnosis ≥ severe

Exit points:

Issuing Body: NICE
Evidence sources:
E-ClinPro: Edit care plan

Issuing body:
NICE

Select article to add as evidence:
Search in pubmed...

1. Improving early detection of chronic kidney disease.
   PMID: 25816501
   Authors: Larmour KE, Maxwell AP, Courtney AE. ©2015

2. Long-term prognosis after acute kidney injury (AKI): what is the role of baseline kidney function and recovery?
   A systematic review.
   PMID: 25564144
   Authors: Sawhney S, Mitchell M, Marks A, Ruck N, Black C. ©2015
E-ClinPro: Initial condition builder

User friendly output:

( ( Serum creatine kinase measurement \(>\) 300\% of baseline OR Serum creatine kinase measurement \(>\) 0.4 mg/dL) AND ( Urine \(<\) 0.3 mL/kg/hr OR Urine \(<\) 100 mL/24h) ) OR acute kidney injury diagnosis \(=\) severe)
CONCLUSION
Our contribution

• Formal protocol meta-description
  – eCP ontology

• Versatile protocol ‘meta-repository’
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Work in progress

- Extensive ontology and system evaluation
  Structured interviews and focus groups of different types of system users, including experts, nurses, residents, and medical students

- Support relationships between doctors, patients, and protocols for clinical protocol evaluation based on the assessment of
  - The extent of clinical protocol use
  - Type and number of clinical protocol modifications
  - Outcomes of protocol clinical application
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