



eHealth
FORUM 2016

ATHENS
25-26
OCTOBER
MEGARON
ATHENS INTERNATIONAL
CONFERENCE CENTRE

▲▲▲ **eHealth: Catalyst for reform
Enabler for growth**



CARRE

Personalized patient empowerment and shared decision
support for cardiorenal disease and comorbidities

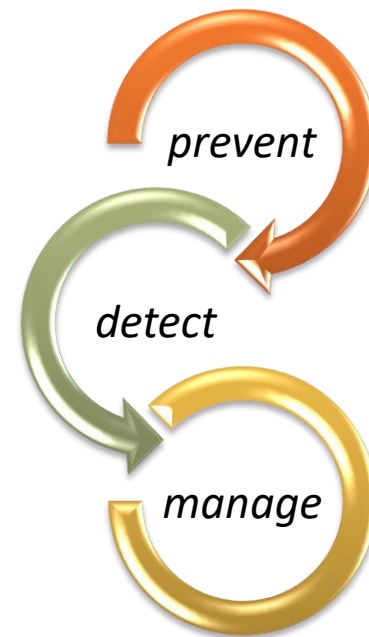
FP7-ICT-61440 Project Presentation

eHealth Forum 2016, Athens, Greece, 25-26 October 2016

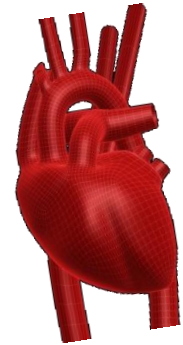


motivation

- significant **increase** in the **prevalence** and **incidence** of chronic disease
- ½ of all chronic patients present **comorbidities**
- the chronic patient is mostly an **outpatient**
 - ↳ needs to care for herself at home
 - ↳ mainly away from continuous professional care
 - ↳ while trying to lead a normal life

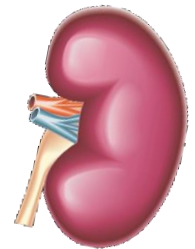


medical domain



chronic **cardiorenal** disease and comorbidities

- ↪ simultaneous (causal) dysfunction of **kidney** and **heart**
- ↪ **diabetes** and/or **hypertension** common underlying causes
- ↪ a number of other serious comorbidities often present
nephrogenic anemia, renal osteodystrophy, malnutrition,
blindness, neuropathy, severe atherosclerosis,
cardiovascular episodes, and eventually
end-stage renal disease and/or **heart failure**,
and **death**
- ↪ deterioration to end stage renal/heart disease is
life threatening, **irreversible** and **expensive** to manage



cardiorenal disease & comorbidities

some numbers...



- ⇒ hypertension ⇒ 1/3 of adults (US 2008)
- ⇒ diabetes ⇒ 8% of overall population
- ⇒ chronic kidney disease ⇒ 9-16% of overall population
- ⇒ 44% of chronic kidney disease is due to diabetes
- ⇒ 86% of chronic kidney disease has at least 1 comorbidity
- ⇒ most patients with chronic kidney disease develop cardiovascular disease
- ⇒ chronic heart failure ⇒ 1-2% of total healthcare costs
- ⇒ end-stage renal disease (dialysis) ⇒ >2% of total healthcare costs



FP7-ICT-2013-611140

consortium: 6 partners from 4 EU countries

coordinator: Eleni Kaldoudi (DUTH)

duration: Nov 2013 – Oct 2016

budget: 3,210,470€

<http://carre-project.eu/>

CARRE

Cardiorenal
comorbidity management
via **empowerment** and
shared informed decision



Democritus Univ. of Thrace
DUTH, GR



The Open
University, UK



Univ. of Bedfordshire, UK



Vilnius Univ. Hospital, LT

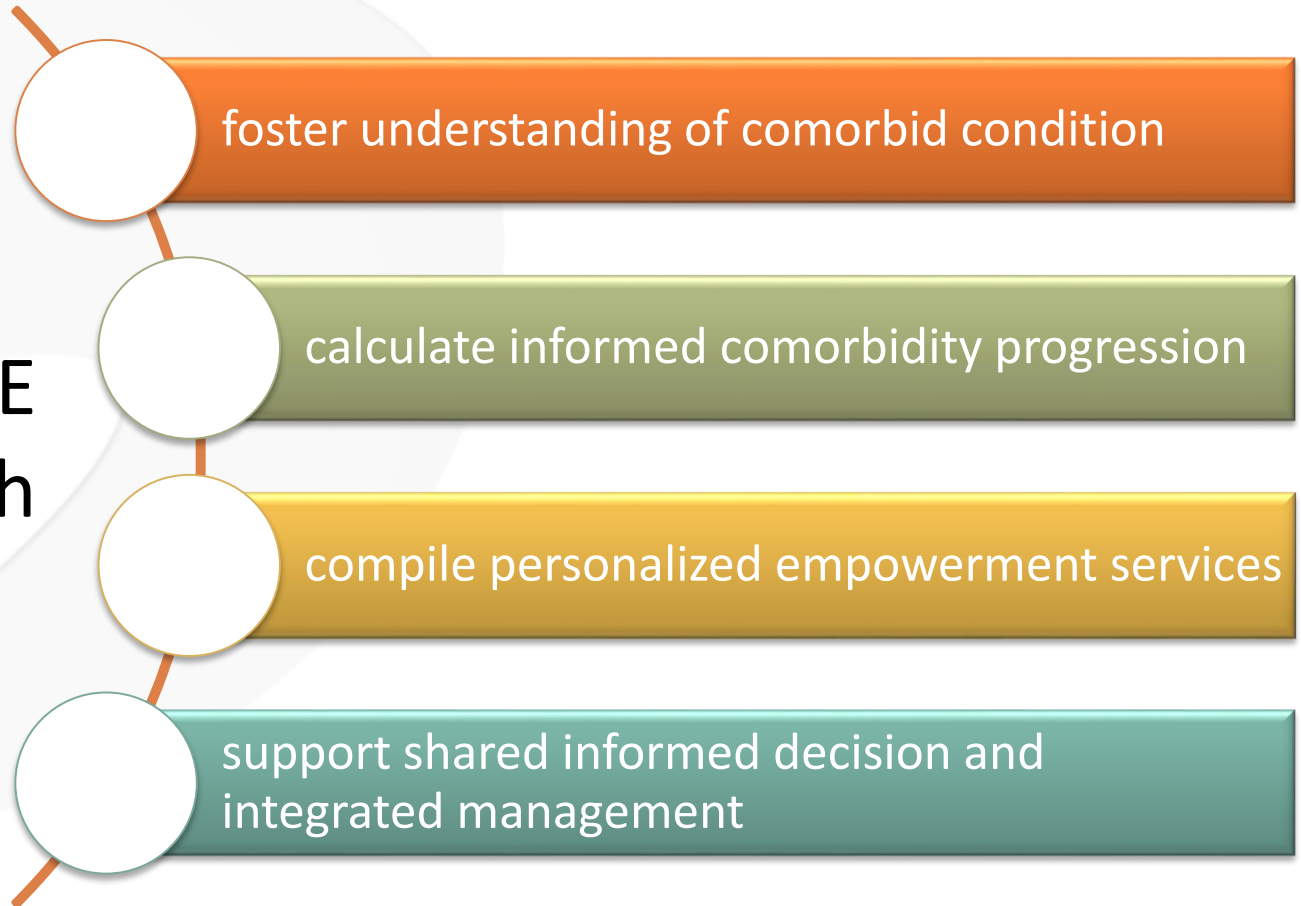


Kaunas Univ., LT



Industrial Research Institute
for Automation & Measurements, PL

CARRE approach



what?

CARRE

EU FP7-ICT-2013-611140

3.2M, 2013-2016

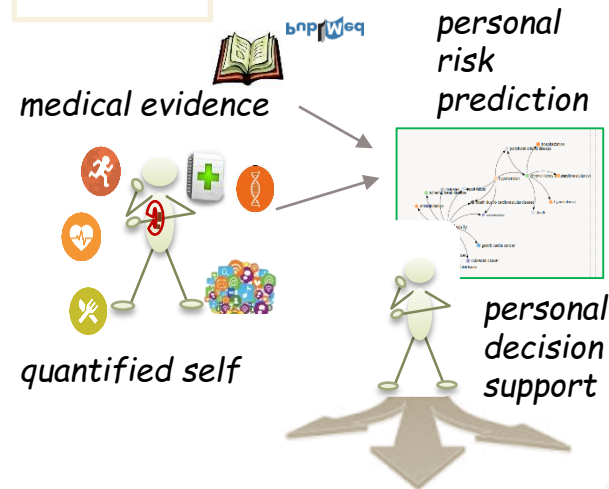
DUTH, OU, BED, VULSK, KTU, PIAP

why?

cardiorenal disease

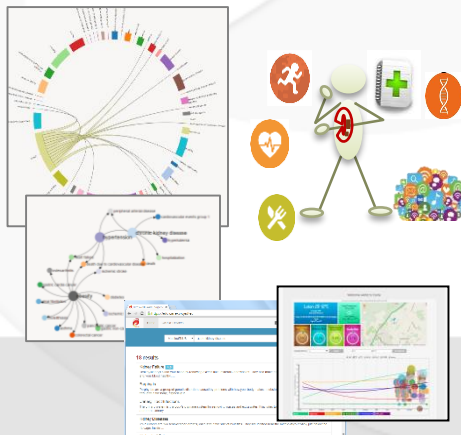
chronic, common, dangerous,
expensive, with many causing
factors and complex progression

how?

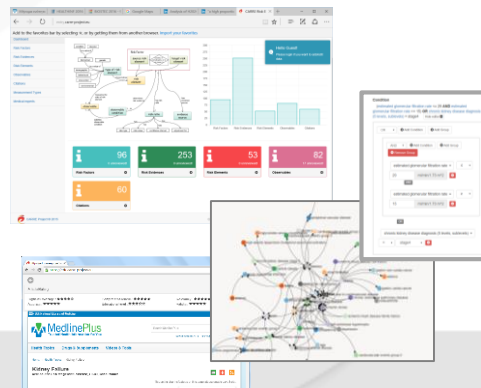


<http://carre-project.eu>

for the patient



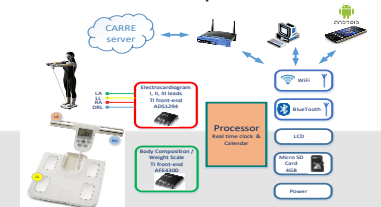
for the medical expert



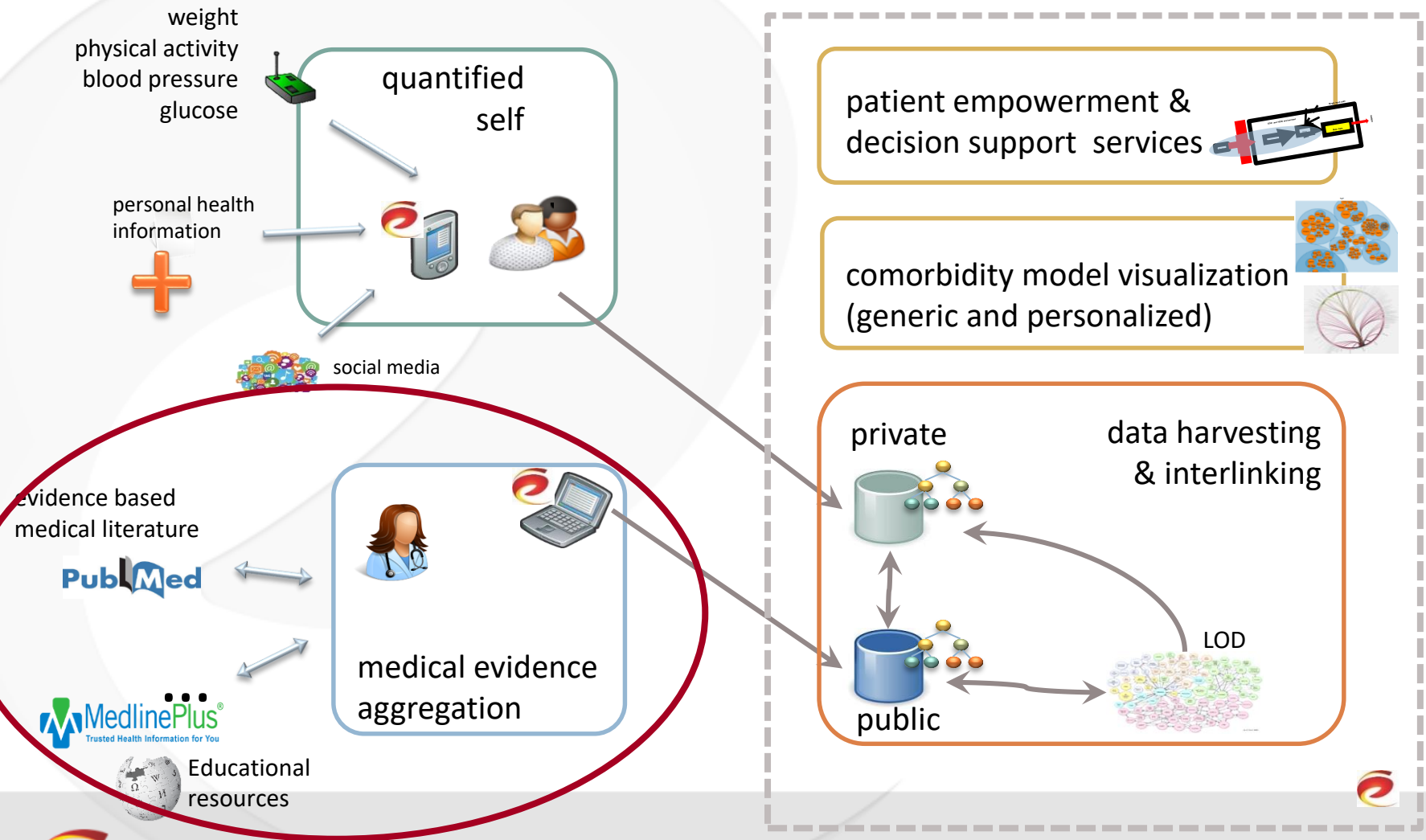
for the ICT expert



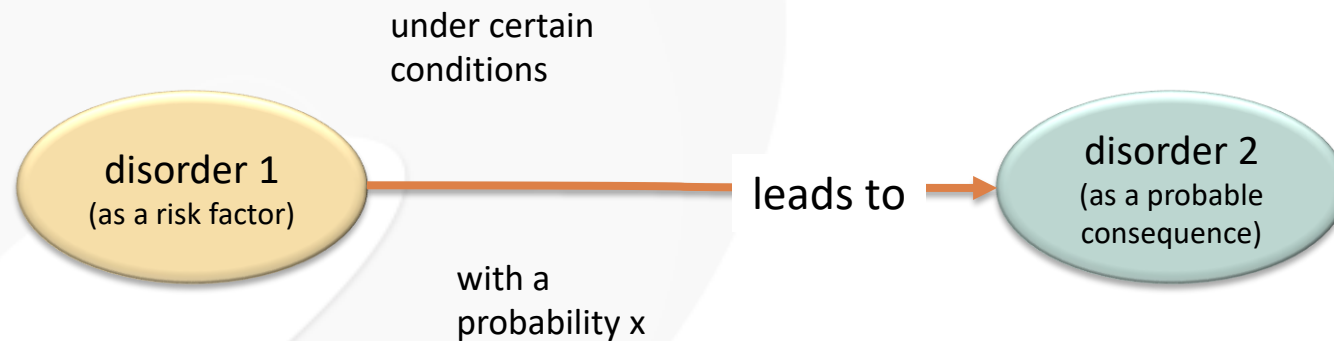
sensor developments



CARRE approach



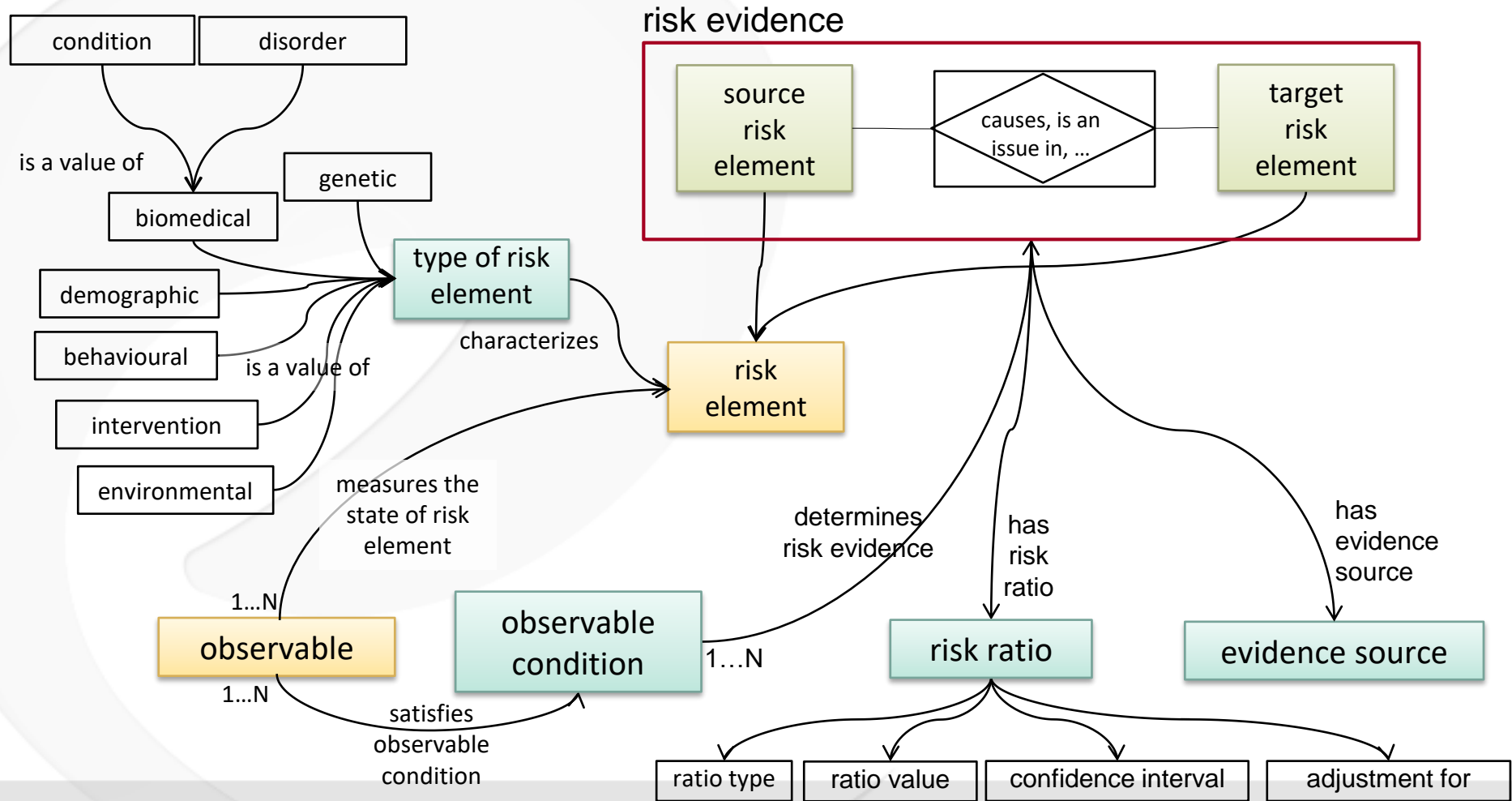
modelling health risk factors



risk factors are reported in medical literature
(top level evidence: systematic reviews with meta-analysis)

E. Kaldoudi, et al. CARRE D.2.1, 2014

modelling health risk factors



http://bioportal.bioontology.org/ontologies/CARRE

BioPortal Browse Search Mappings Recommender Annotator Resource Index Projects Sign In Help Feedback

CARRE Risk Factor ontology

Summary Classes Properties Notes Mappings Widgets

Details

ACRONYM	CARRE
VISIBILITY	Public
BIOPORTAL PURL	http://purl.bioontology.org/ontology/CARRE
DESCRIPTION	Clinical risk factors, evidence and observables
STATUS	Beta
FORMAT	OWL
CONTACT	Allan Third, allan.third@open.ac.uk
HOME PAGE	http://www.carre-project.eu
PUBLICATIONS PAGE	
DOCUMENTATION PAGE	
CATEGORIES	Health
GROUPS	

Metrics

We have not yet calculated metrics for this ontology.

Visits

Download as CSV

Month	Visits
Oct 2013	0
Nov 2013	0
Dec 2013	0
Jan 2014	0
Feb 2014	0
Mar 2014	0
Apr 2014	0
May 2014	0
Jun 2014	0
Jul 2014	0
Aug 2014	0
Sep 2014	5
Oct 2014	0
Nov 2014	0
Dec 2014	20
Jan 2015	0
Feb 2015	28
Mar 2015	25

Reviews

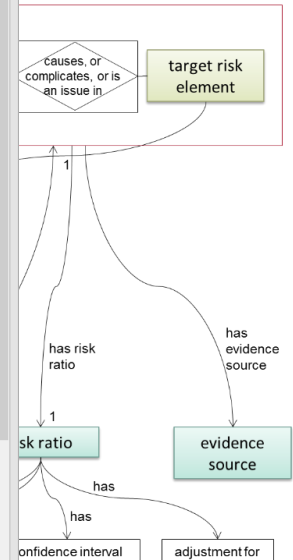
Add your review

No reviews available.

Submissions

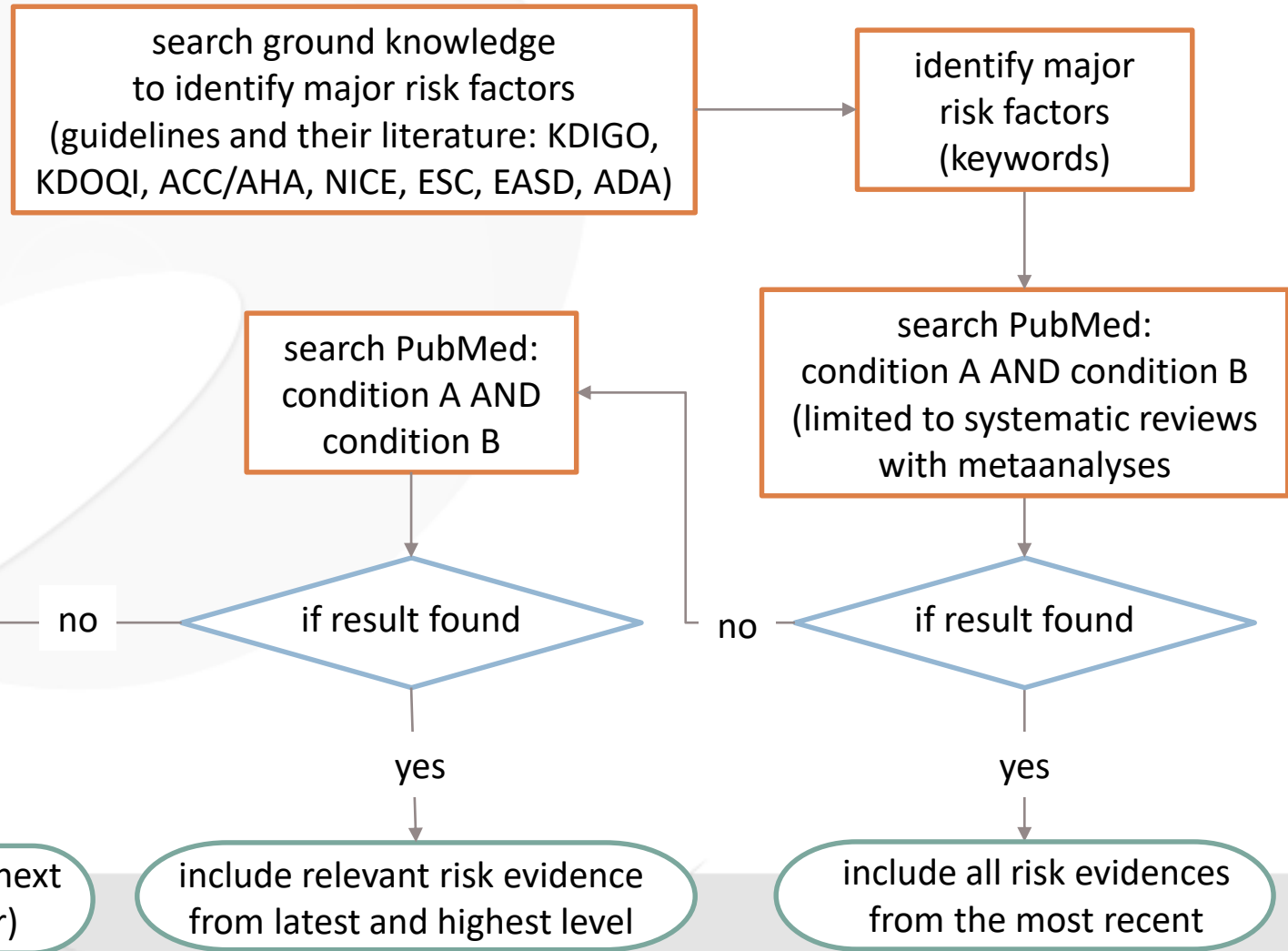
SUBMISSION	RELEASE DATE	UPLOAD DATE	DOWNLOADS
0.2 (Parsed, Indexed, Metrics, Annotator)	09/30/2014	12/08/2014	OWL CSV RDF/XML Diff
0.1 (Archived)	09/30/2014	12/08/2014	OWL Diff
0.1 (Archived)	09/30/2014	09/30/2014	OWL

ceptual model



CARRE ontology published in NCBO BioPortal
<http://bioportal.bioontology.org/ontologies/CARRE>

risk factor identification methodology

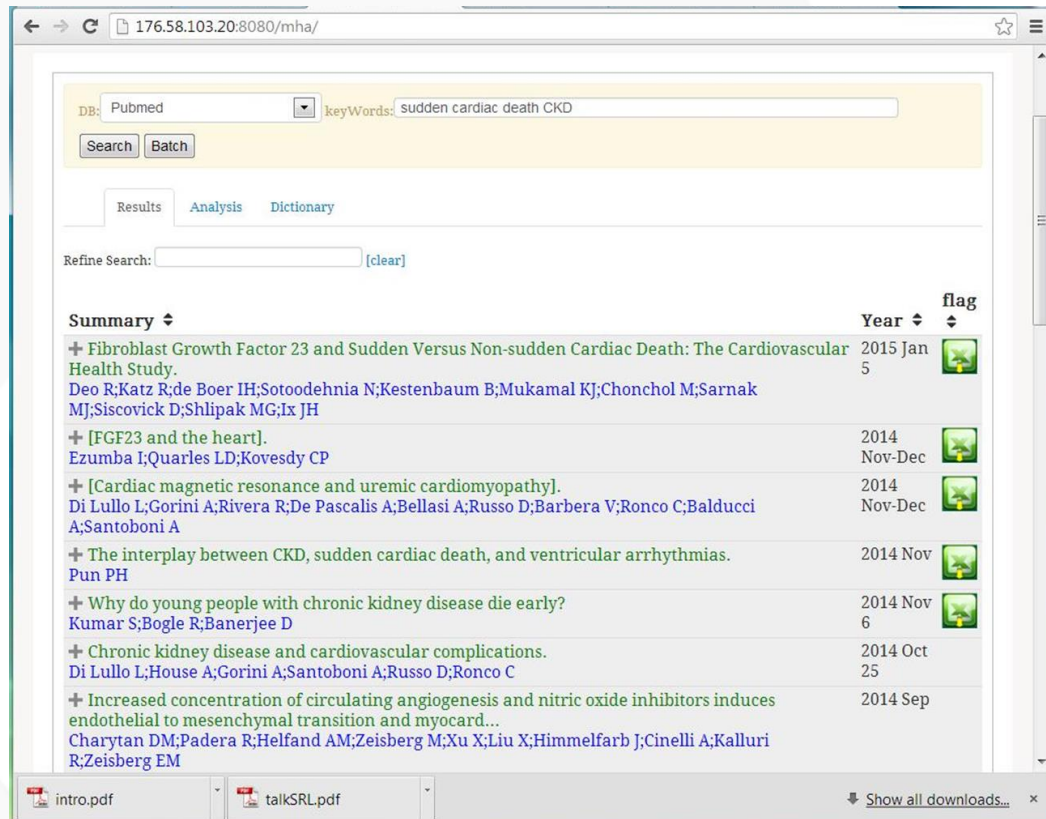


some of the **major** related conditions

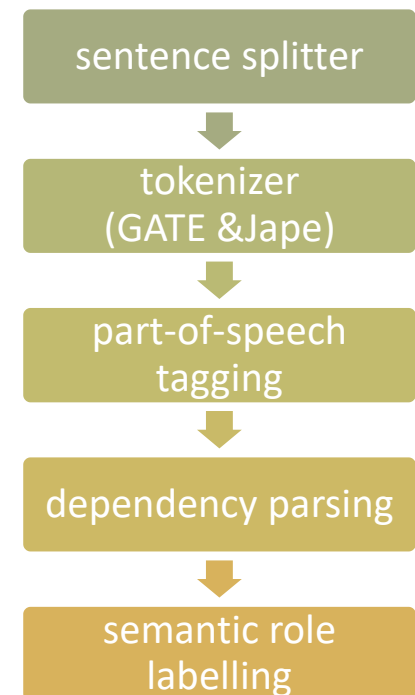
1. *Acute kidney injury*
2. *Acute myocardial infarction*
3. *Age*
4. *Albuminuria*
5. *Anaemia*
6. *Angina pectoris*
7. *Asthma*
8. *Atrial fibrillation*
9. *Chronic kidney disease*
10. *Chronic obstructive pulmonary disease*
11. *Cholelithiasis*
12. *Colorectal Cancer*
13. *Coronary and carotid revascularisation*
14. *Death*
15. *Depression*
16. *Diabetes*
17. *Diabetic nephropathy*
18. *Drugs*
19. *Dyslipidemia*
20. *Family history*
21. *Heart Failure*
22. *Hyperkalemia*
23. *Hypertension*
24. *Hyperuricemia*
25. *Hypoglycaemia*
26. *Ischemic heart disease*
27. *Ischemic stroke*
28. *Left ventricular hypertrophy*
29. *Obesity*
30. *Obstructive Sleep Apnoea*
31. *Myocardial infarction*
32. *Osteoarthritis*
33. *Pancreatic Cancer*
34. *Peripheral Arterial Disease*
35. *Physical activity*
36. *Smoking*
37. *...*

medical evidence aggregator

<https://www.carre-project.eu/innovation/medical-evidence-aggregator/>

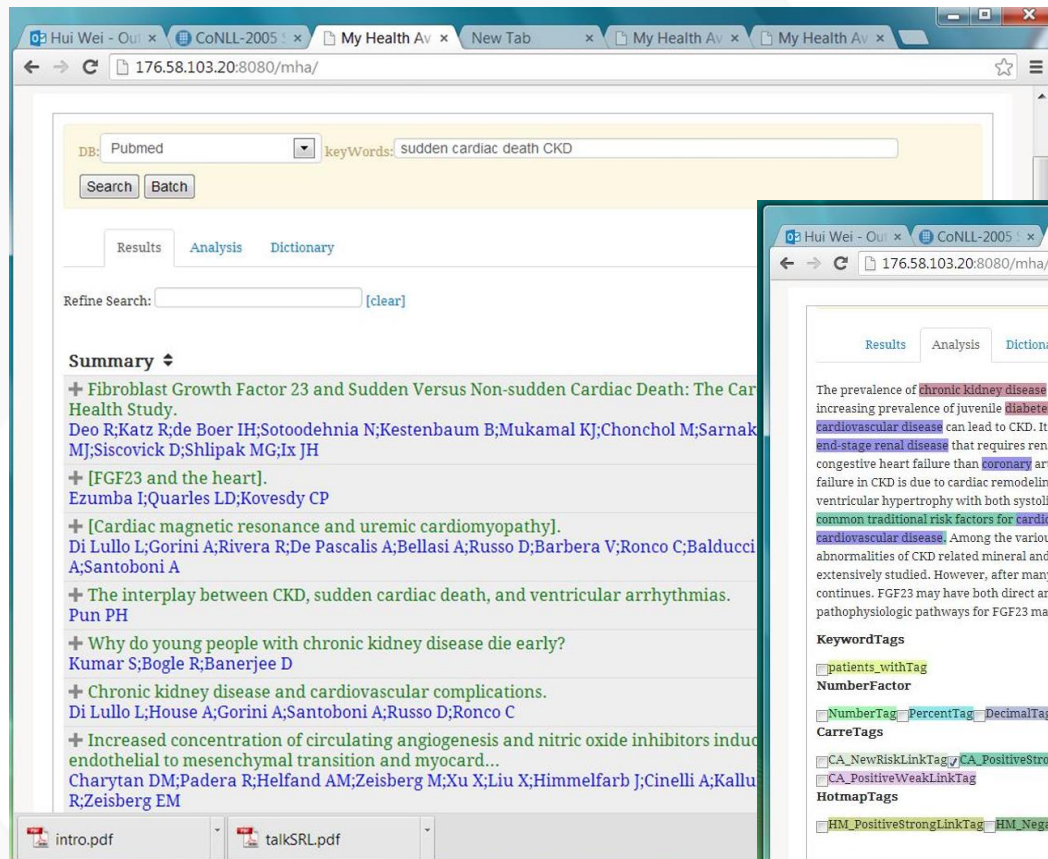


E. Liu, et al. CARRE D.3.4, 2015

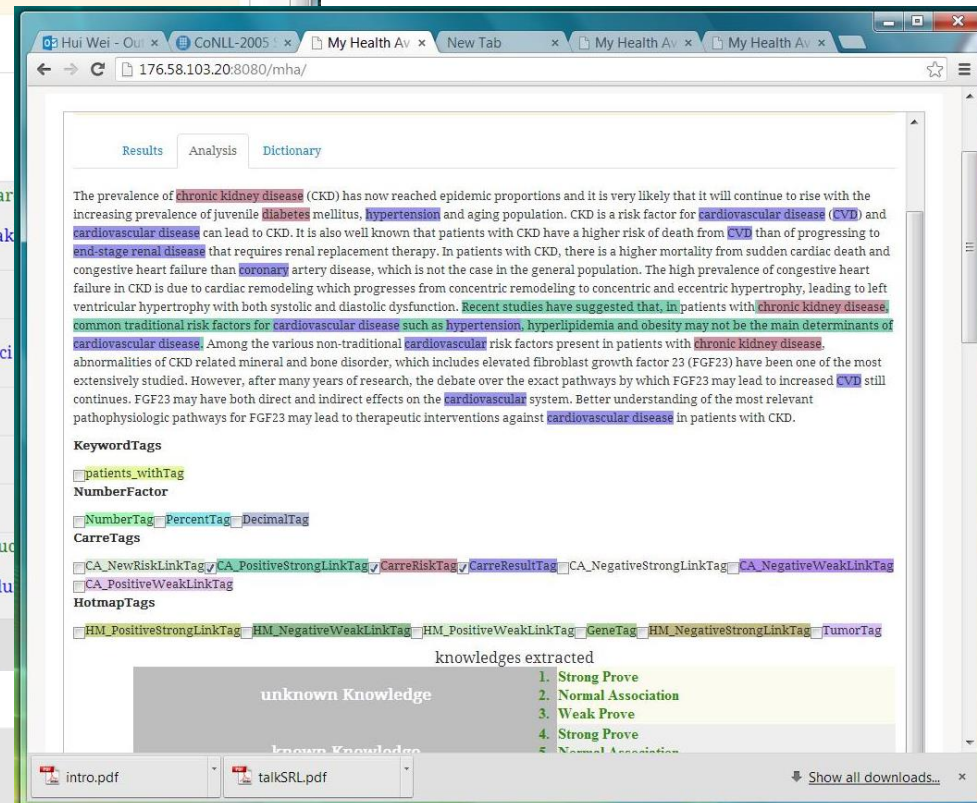


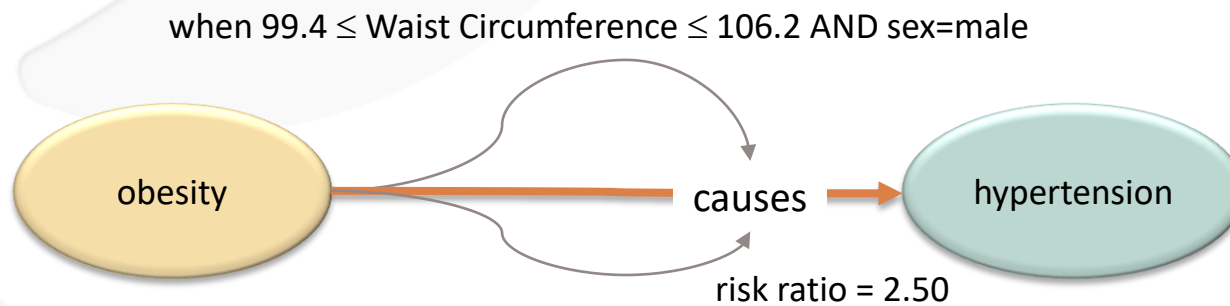
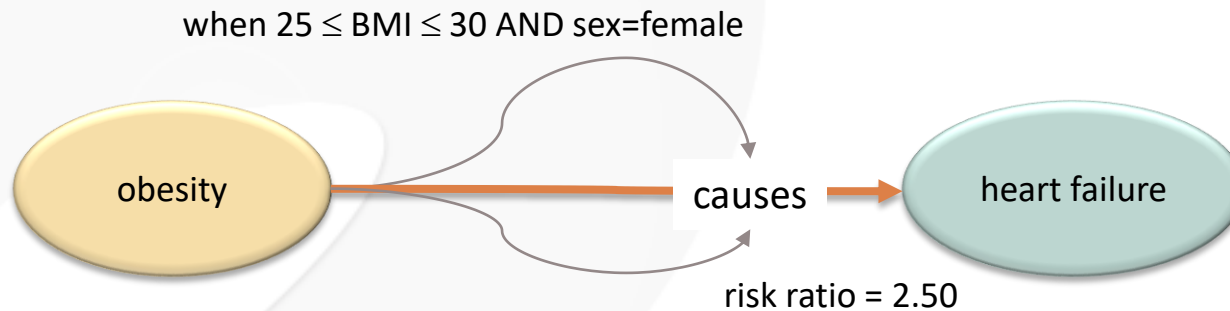
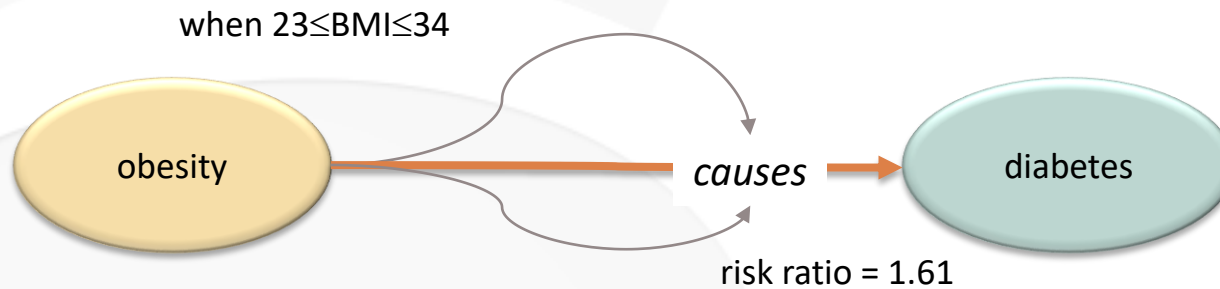
medical evidence aggregator

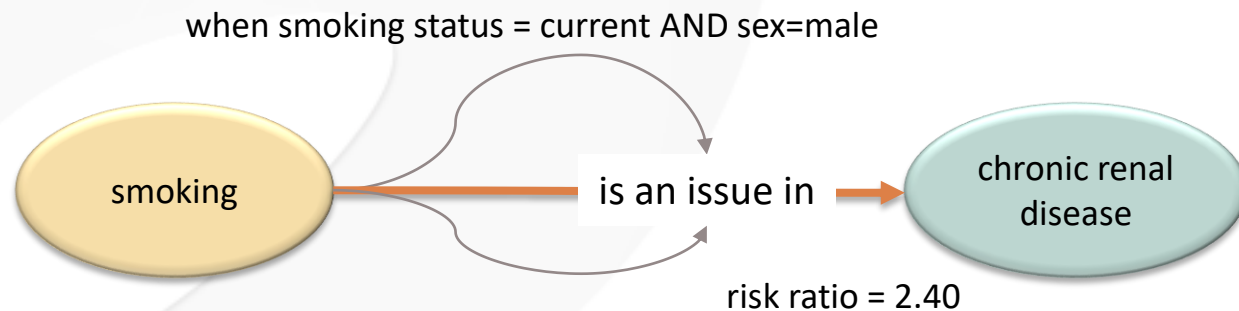
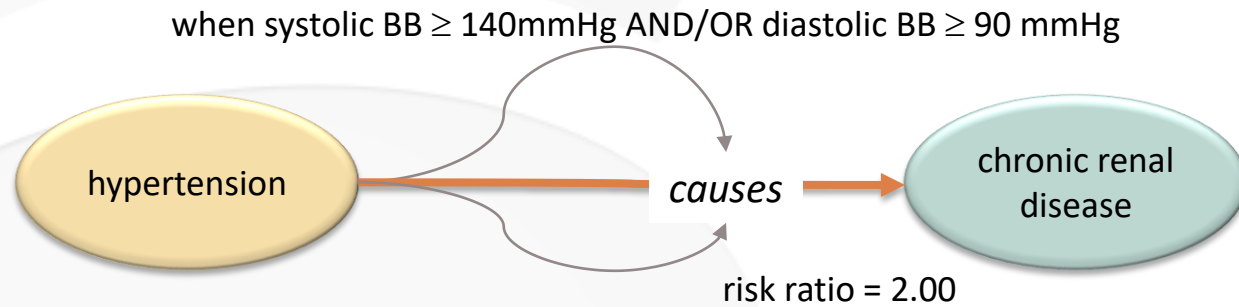
<https://www.carre-project.eu/innovation/medical-evidence-aggregator/>



E. Liu, et al. CARRE D.3.4, 2015

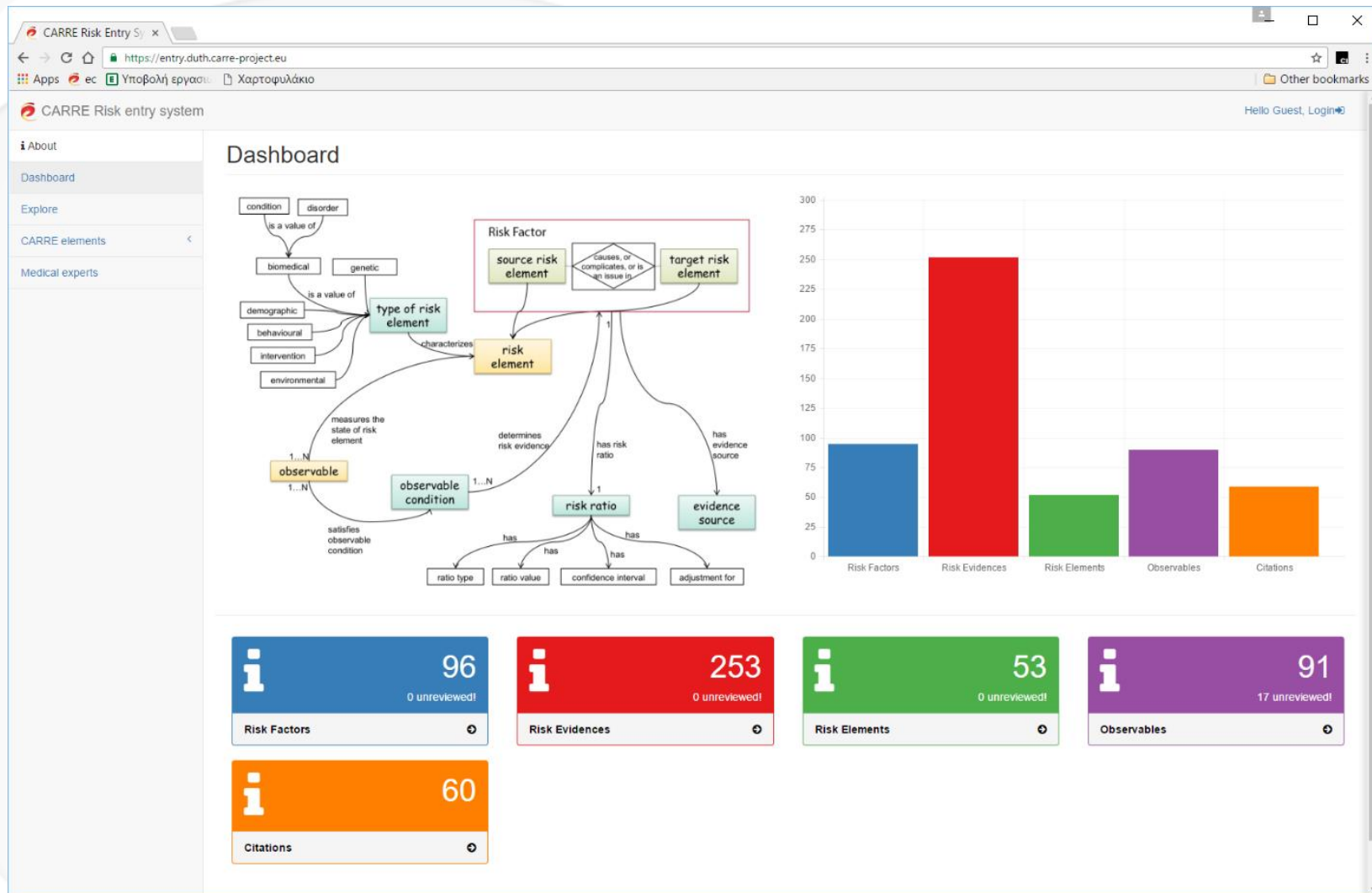






so far... **253** major **risk associations (or evidences)** identified in medical literature
(which involve 53 health conditions and 82 related observables)
as included in the **CARRE risk factor database and predictive model**

risk factor reference repository



risk factor reference repository

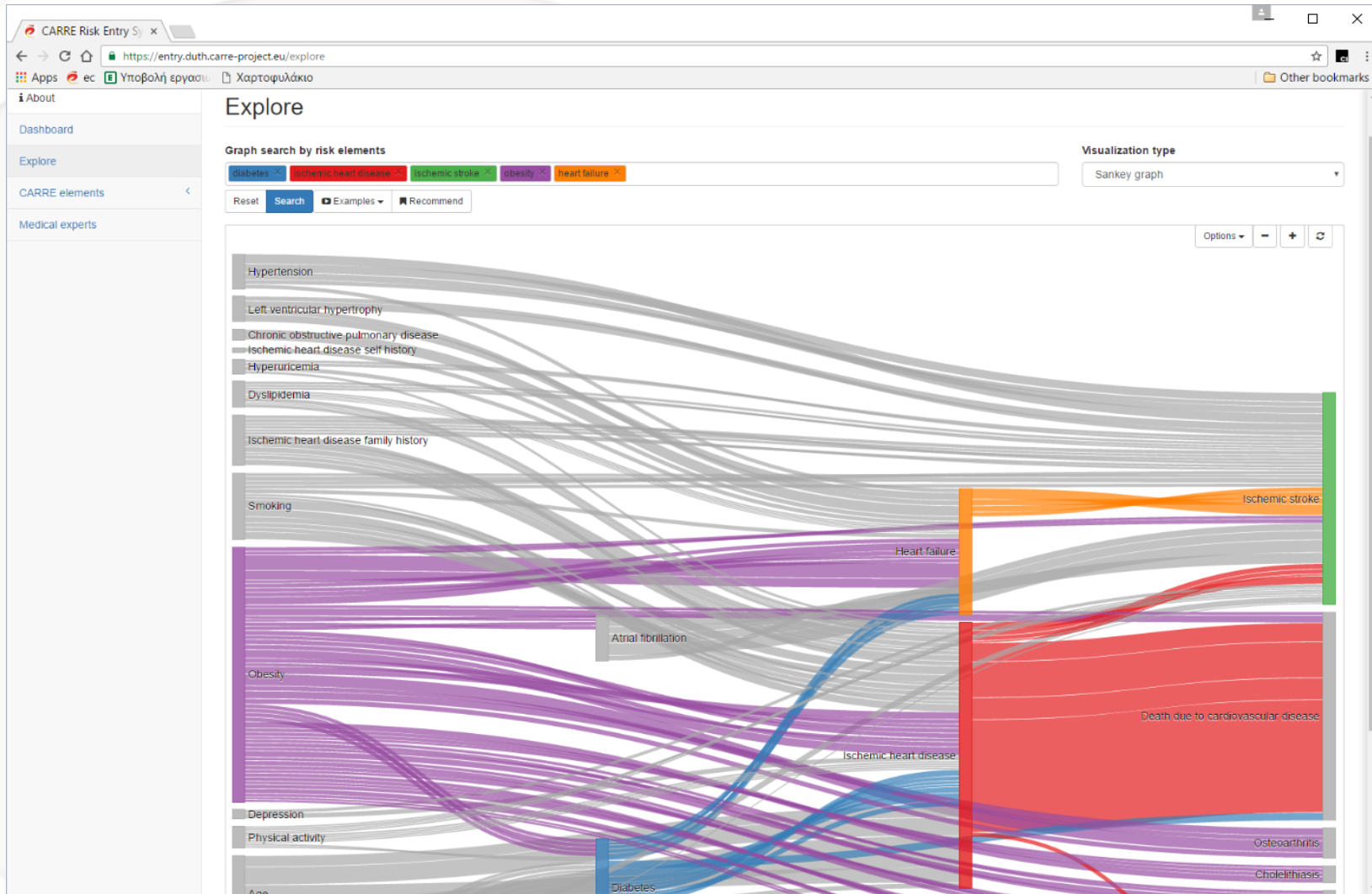
The screenshot displays the CARRE Risk Entry System web application. The browser address bar shows the URL https://entry.duth.carre-project.eu/risk_evidences/RV_8. The page title is "CARRE Risk entry system". A sidebar on the left contains navigation links: About, Dashboard, Explore, CARRE elements (expanded), Risk Factors, Risk Evidences (selected), Risk Elements, Observables, Citations, Measurement Types, and Medical experts. The main content area is titled "Risk evidences" with a "Back" button. It displays a table of risk evidence details for the entry "Risk factor: age [is an issue in] ischemic heart disease".

Risk factor: age [is an issue in] ischemic heart disease
Observable: age (years), sex
Observable condition: age (years) \leq 59 AND age (years) \geq 54 AND sex = 'female'
Ratio type: relative risk
Ratio value: 5.53
Confidence Interval min: 3.36
Confidence Interval max: 9.08
Is adjusted for: age, study year, and area, smoking, HDL cholesterol ratio, systolic blood pressure, BMI, diabetes
Source: 10069784
Entered by: Kalliopi Pafili
Reviewed by: Stefanos Roumeliotis, Gintare Juozalienaitė, Ploumis Passadakis

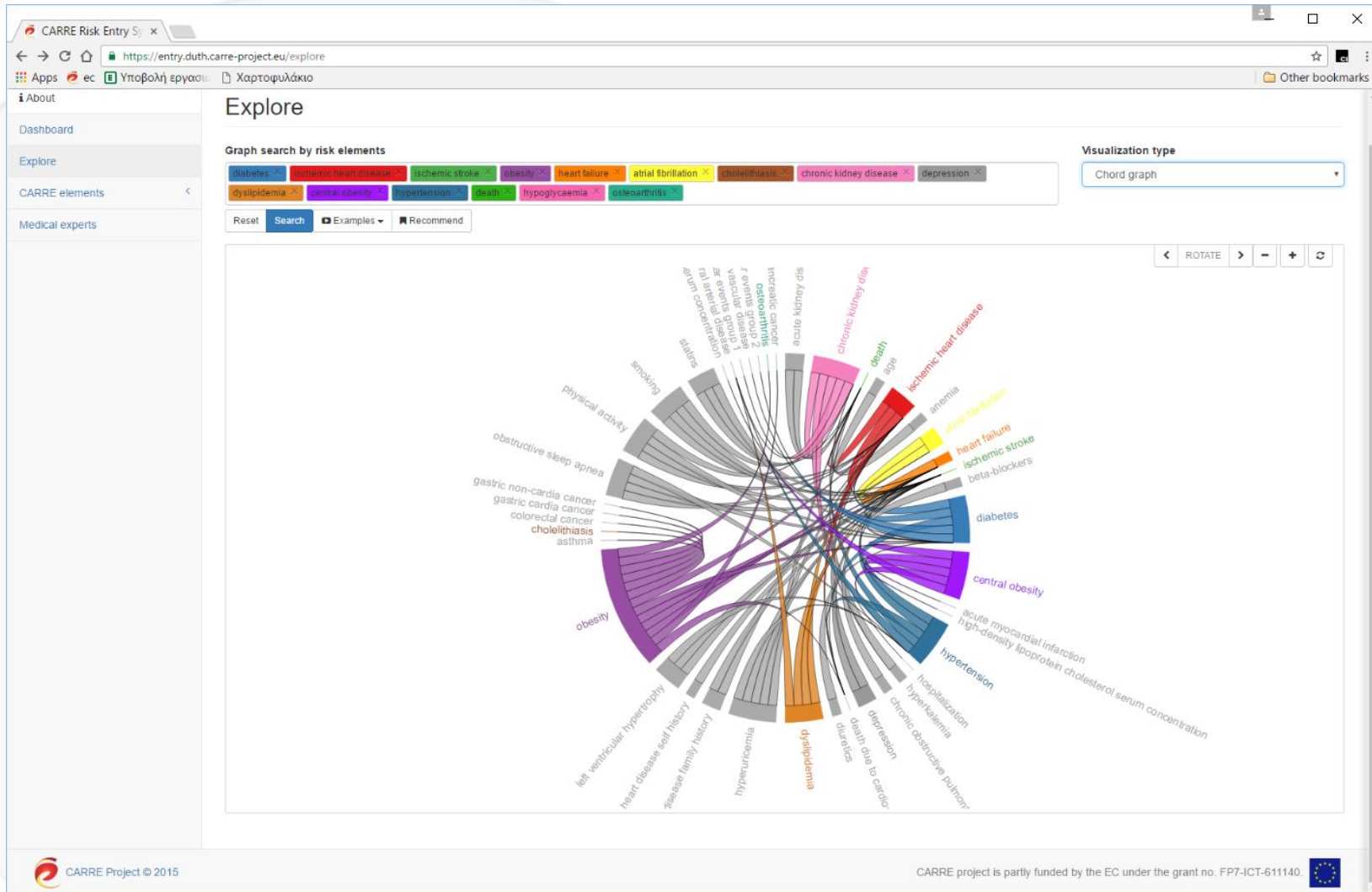
A "View RDF source" button is located below the table. To the right of the table, there is a section for the associated article, "Article : 10069784 link to PubMed". It includes the title "1. Circulation. 1999 Mar 9;99(9):1165-72.", a brief description, author information (Jousilahti P(1), Vartiainen E, Tuomilehto J, Puska P.), and a detailed abstract. The abstract discusses the background, methods, results, and conclusions of the study on cardiovascular risk factors and coronary heart disease in a Finnish cohort.

PMID: 10069784 [PubMed - Indexed for MEDLINE]

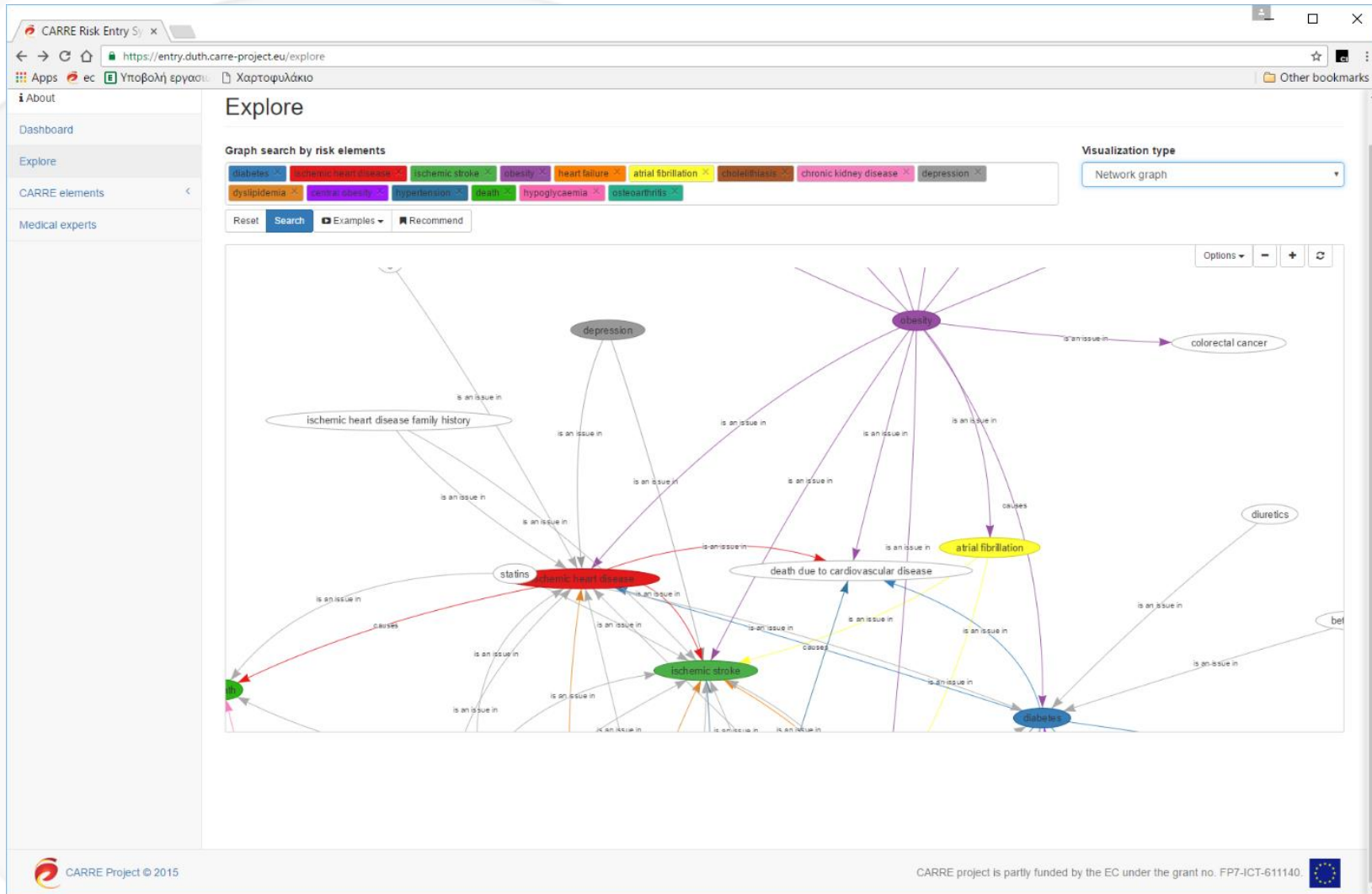
risk factor reference repository



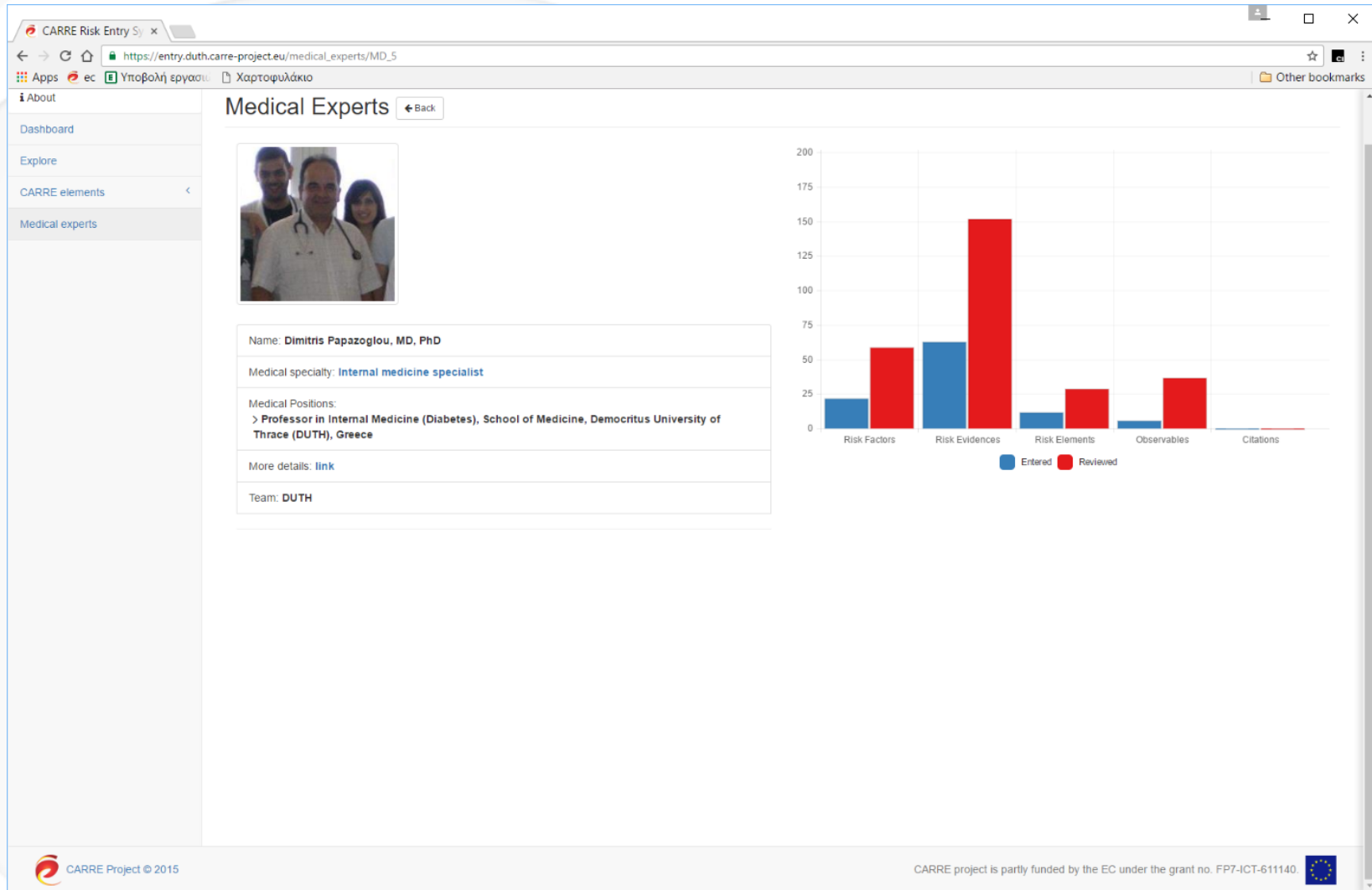
risk factor reference repository



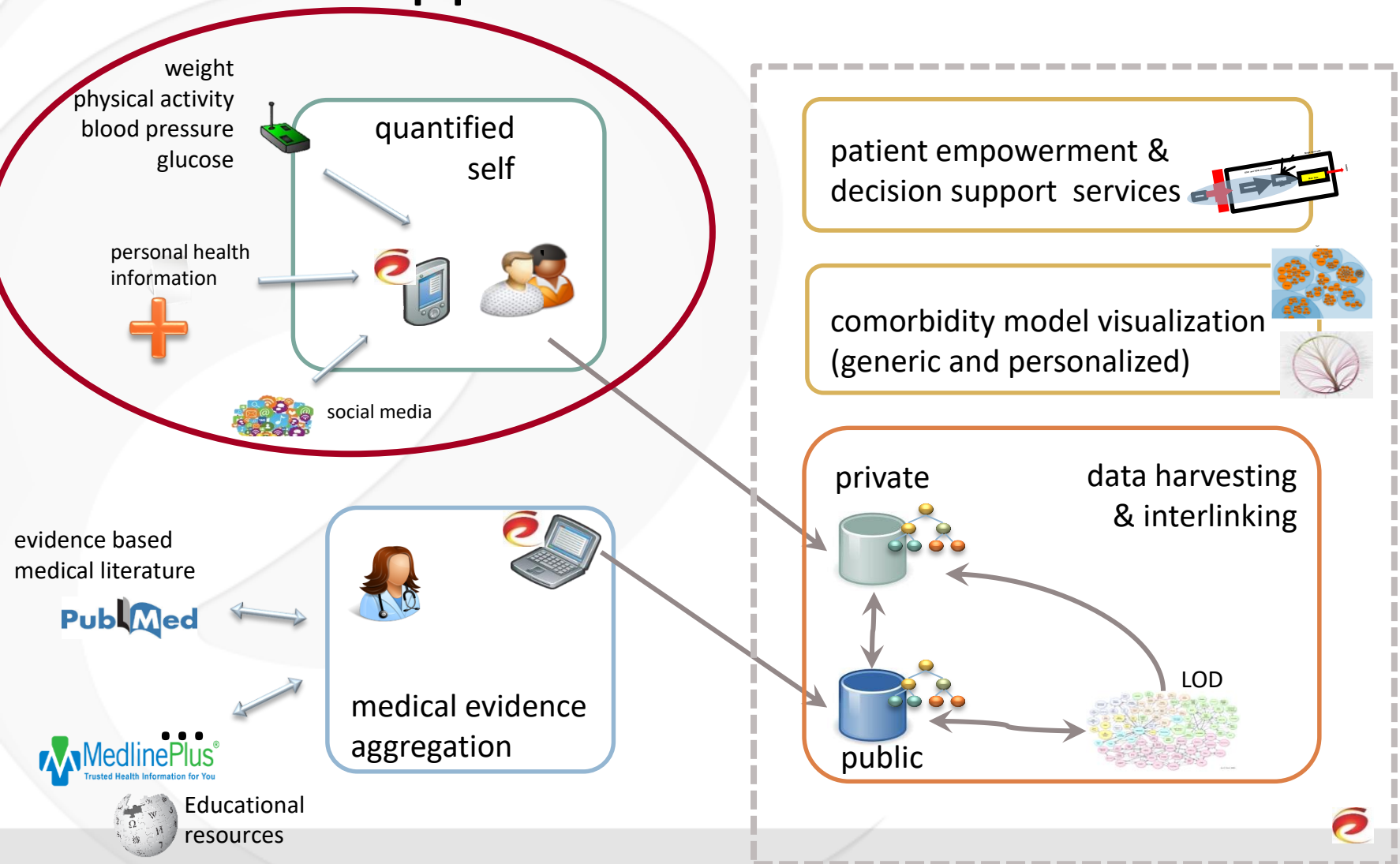
risk factor reference repository



risk factor reference repository



CARRE approach



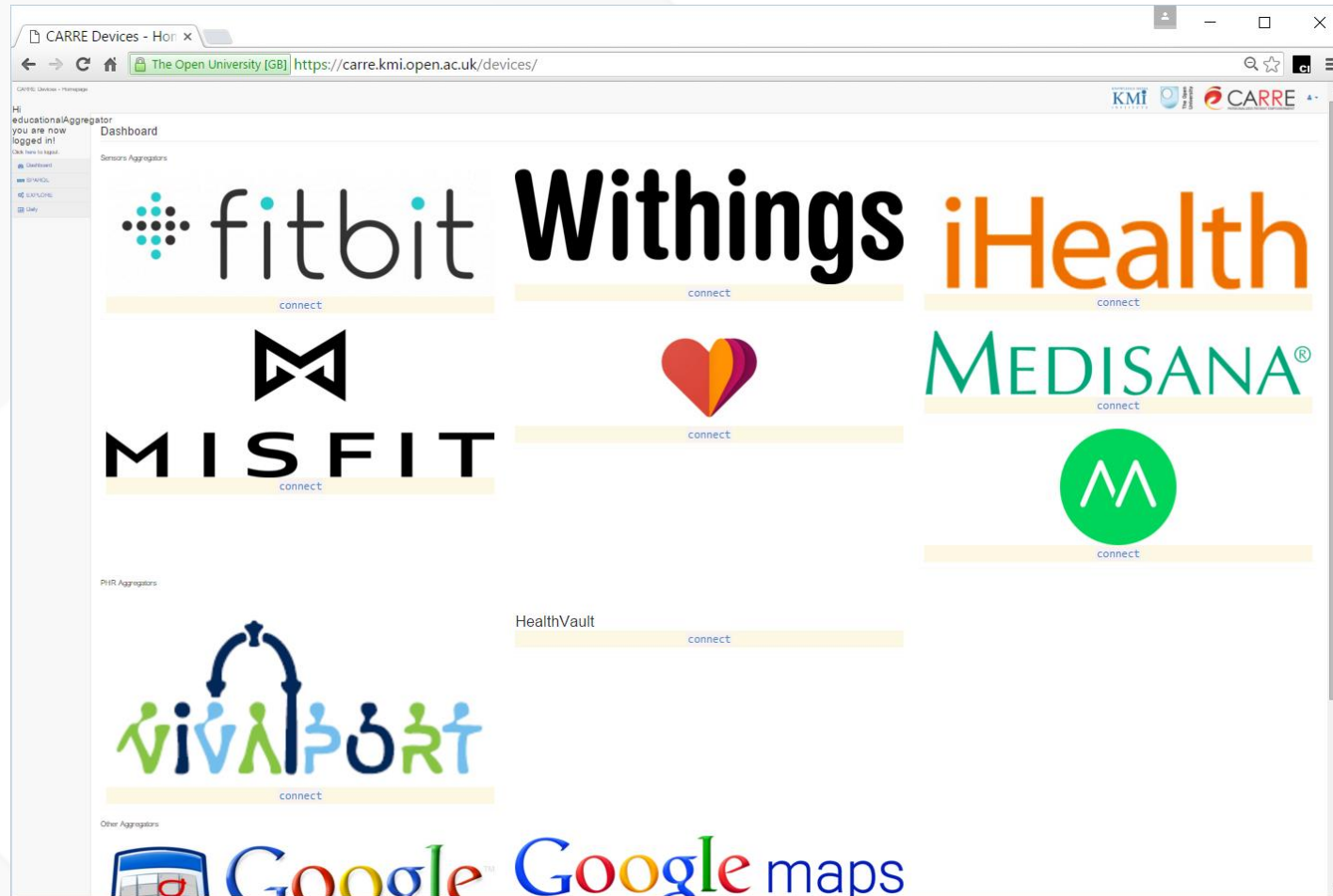
personal data aggregators

- **sensor** aggregators
- medical data aggregators from **personal health record**
- **manual entry** system for personal medical data
- **intention** extraction from **web** searches

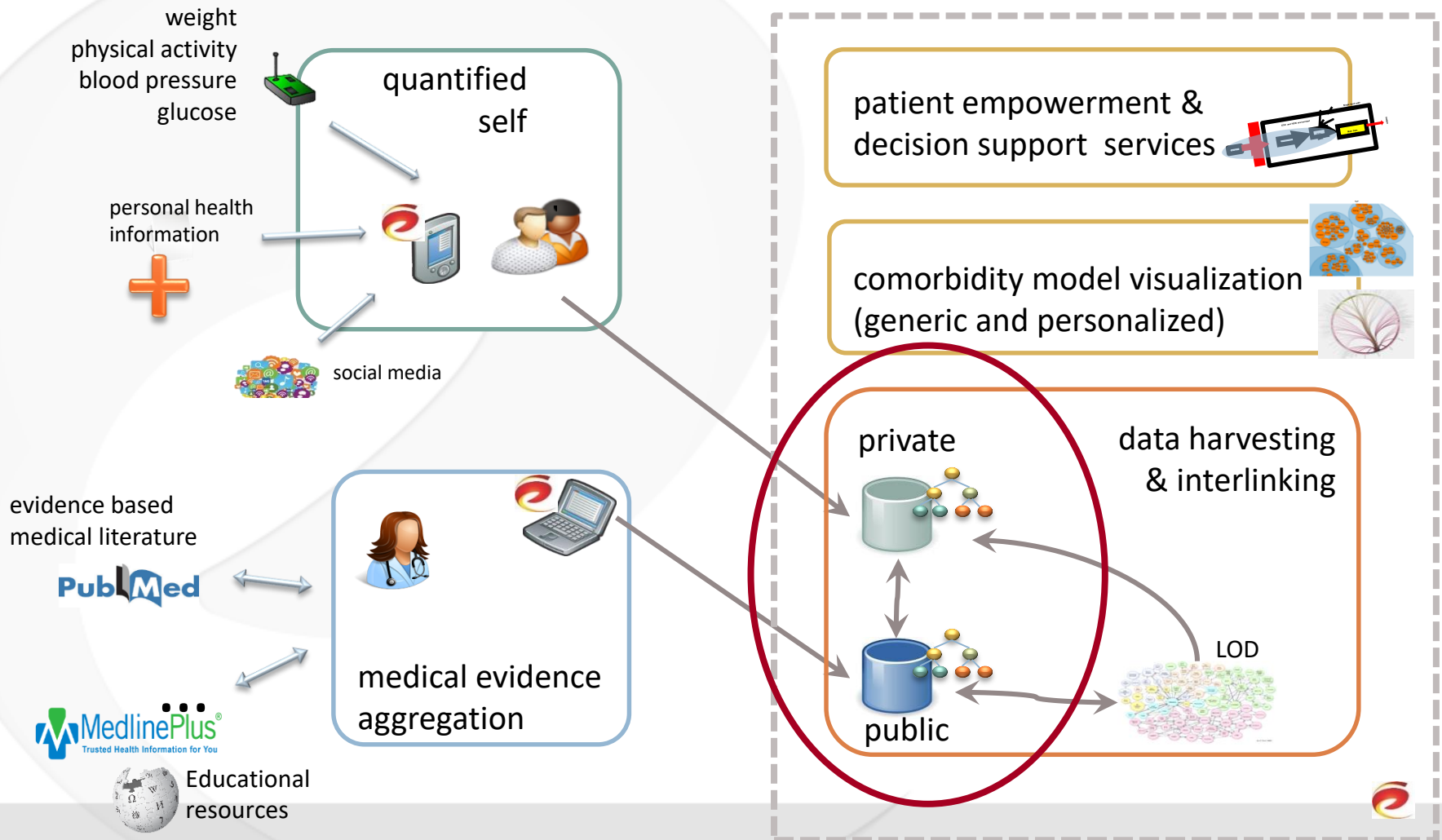
CARRE D.3..2 & D.3.3, 2015

aggregator integration

<https://carre.kmi.open.ac.uk/devices/>



CARRE approach



public RDF SPARQL endpoint

Breakthroughs | CARRE x Virtuoso SPARQL Query Editor

carre.kmi.open.ac.uk:8890/sparql

Virtuoso SPARQL Query Editor

[About](#) | [Namespace Prefixes](#) | [Inference rules](#) | [iSPARQL](#)

Default Data Set Name (Graph IRI)

Query Text

```
select distinct ?Concept where {[ ] a ?Concept} LIMIT 100
```

Sponging:

Results Format:

Execution timeout: milliseconds (values less than 1000 are ignored)

Options:
☒ Strict checking of void variables

(The result can only be sent back to browser, not saved on the server, see [details](#))

Copyright © 2015 [OpenLink Software](#)
Virtuoso version 06.01.3127 on Linux (x86_64-unknown-linux-gnu), Single Server Edition

CARRE_RESTful_....zip

Virtuoso SPARQL Query Editor

Default Data Set Name (Graph IRI)

Query Text

```
select * where {  
  ?s a <http://carre.kmi.open.ac.uk/ontology/educational.owl#object> .  
  ?s ?p ?o .  
} LIMIT 100
```

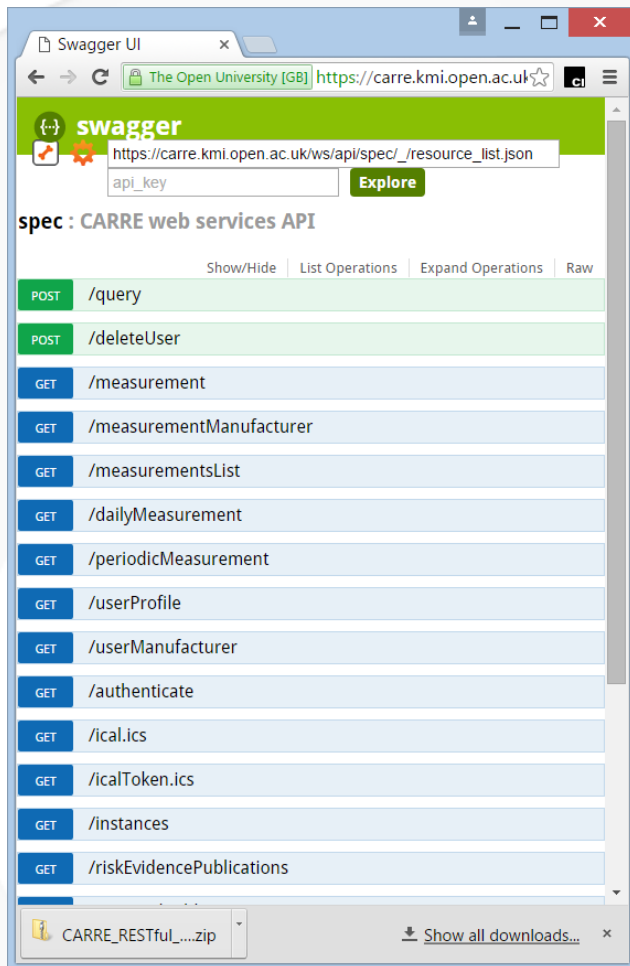
a SPARQL query to retrieve RDF
triples about educational objects

A. Third et al, CARRE D.4.1 & D.4.2, 2015

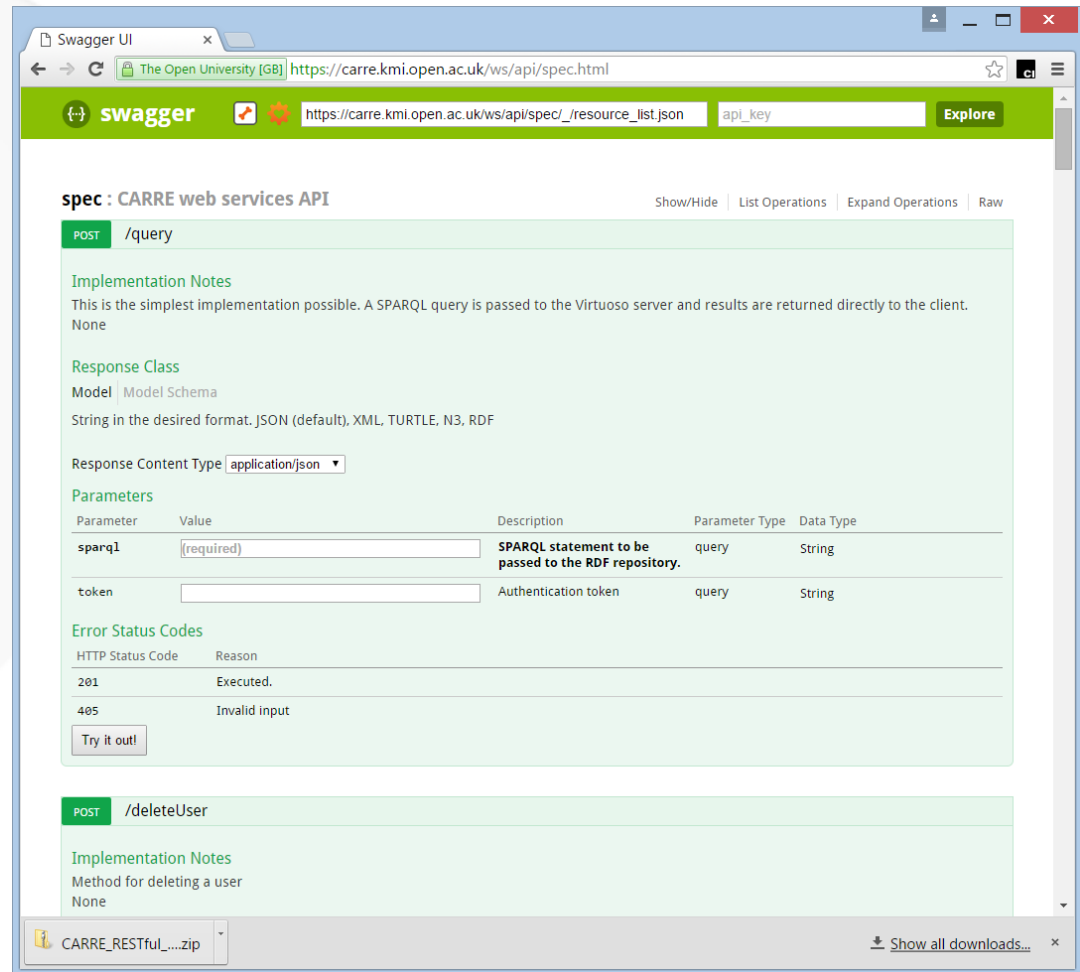
triples about educational objects

http://carre.kmi.open.ac.uk/beta/educational/dcb53878-7a19-4897-9d7c-cfc69bd16140	http://carre.kmi.open.ac.uk/ontology/educational.owl#url	http://en.wikipedia.org/wiki/Metabolic_syndrome
http://carre.kmi.open.ac.uk/beta/educational/dcb53878-7a19-4897-9d7c-cfc69bd16140	http://carre.kmi.open.ac.uk/ontology/educational.owl#title	"Metabolic syndrome"^^<http://www.w3.org/2001/XMLSchema#stri
http://carre.kmi.open.ac.uk/beta/educational/dcb53878-7a19-4897-9d7c-cfc69bd16140	http://carre.kmi.open.ac.uk/ontology/educational.owl#views	2
http://carre.kmi.open.ac.uk/beta/educational/dcb53878-7a19-4897-9d7c-cfc69bd16140	http://carre.kmi.open.ac.uk/ontology/educational.owl#date_accepted	2015-04-26
http://carre.kmi.open.ac.uk/beta/educational/dcb53878-7a19-4897-9d7c-cfc69bd16140	http://carre.kmi.open.ac.uk/ontology/educational.owl#snippet	"tissue, ultimately promoting visceral adiposity, insulin resistance, dy effects on the bone, causing "low turnover""^^<http://ww
http://carre.kmi.open.ac.uk/beta/educational/dcb53878-7a19-4897-9d7c-cfc69bd16140	http://carre.kmi.open.ac.uk/ontology/educational.owl#language	"English"^^<http://www.w3.org/2001/XMLSchema#string>
http://carre.kmi.open.ac.uk/beta/educational/dcb53878-7a19-4897-9d7c-cfc69bd16140	http://carre.kmi.open.ac.uk/ontology/educational.owl#wordcount	5690
http://carre.kmi.open.ac.uk/beta/educational/dcb53878-7a19-4897-9d7c-cfc69bd16140	http://carre.kmi.open.ac.uk/ontology/educational.owl#webservice	"wikipedia"^^<http://www.w3.org/2001/XMLSchema#string>
http://carre.kmi.open.ac.uk/beta/educational/bedc4c16-ad7e-4052-bf69-156dfd60e136	http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://carre.kmi.open.ac.uk/ontology/educational.owl#object
http://carre.kmi.open.ac.uk/beta/educational/bedc4c16-ad7e-4052-bf69-156dfd60e136	http://carre.kmi.open.ac.uk/ontology/educational.owl#url	http://www.nlm.nih.gov/medlineplus/angina.html
http://carre.kmi.open.ac.uk/beta/educational/bedc4c16-ad7e-4052-bf69-156dfd60e136	http://carre.kmi.open.ac.uk/ontology/educational.owl#title	"Angina"^^<http://www.w3.org/2001/XMLSchema#string>
http://carre.kmi.open.ac.uk/beta/educational/bedc4c16-ad7e-4052-bf69-156dfd60e136	http://carre.kmi.open.ac.uk/ontology/educational.owl#views	5
http://carre.kmi.open.ac.uk/beta/educational/bedc4c16-ad7e-4052-bf69-156dfd60e136	http://carre.kmi.open.ac.uk/ontology/educational.owl#date_accepted	2015-03-03
http://carre.kmi.open.ac.uk/beta/educational/bedc4c16-ad7e-4052-bf69-156dfd60e136		"Angina is chest pain or discomfort you feel when there is not enough heart muscle needs the oxygen that the blood carries. Angina may fee chest. It may feel like indigestion. You may also feel pain in your shou a symptom of coronary artery disease (CAD), the most common heart substance called plaque builds up in the arteries that supply blood to t three types of angina:Stable angina is the most common type. It happ

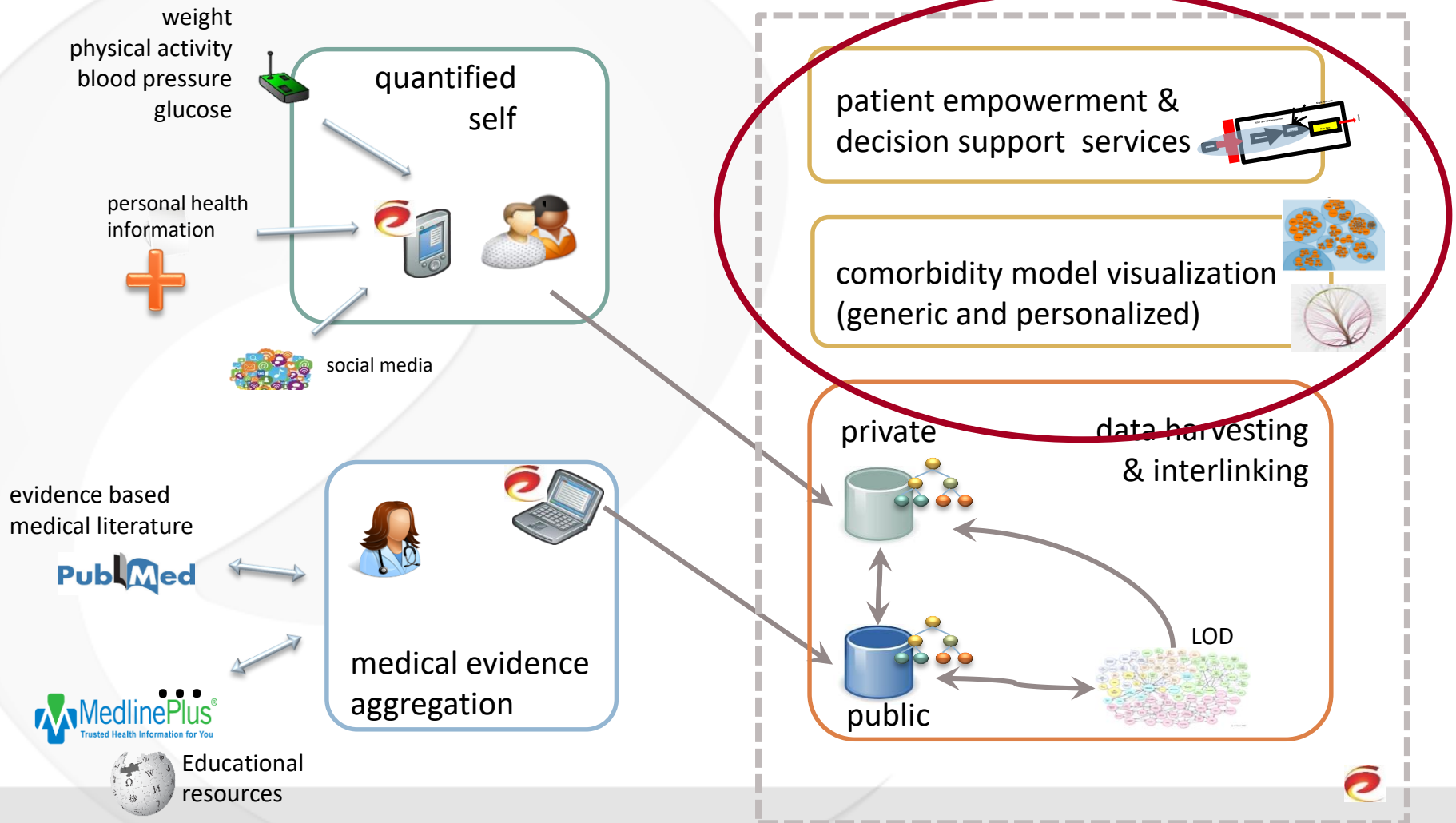
restful API



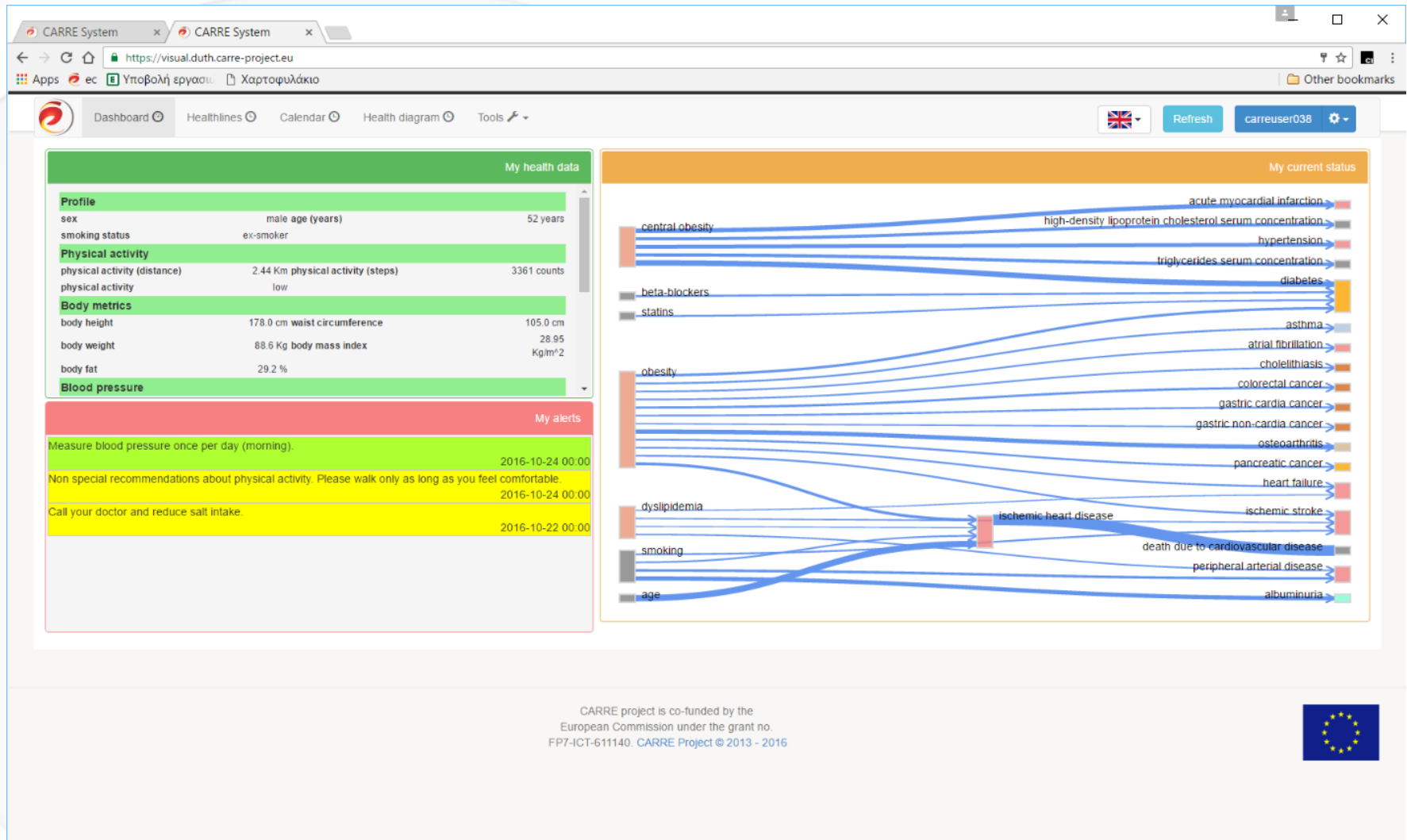
A. Third et al, CARRE D.4.1 & D.4.2, 2015



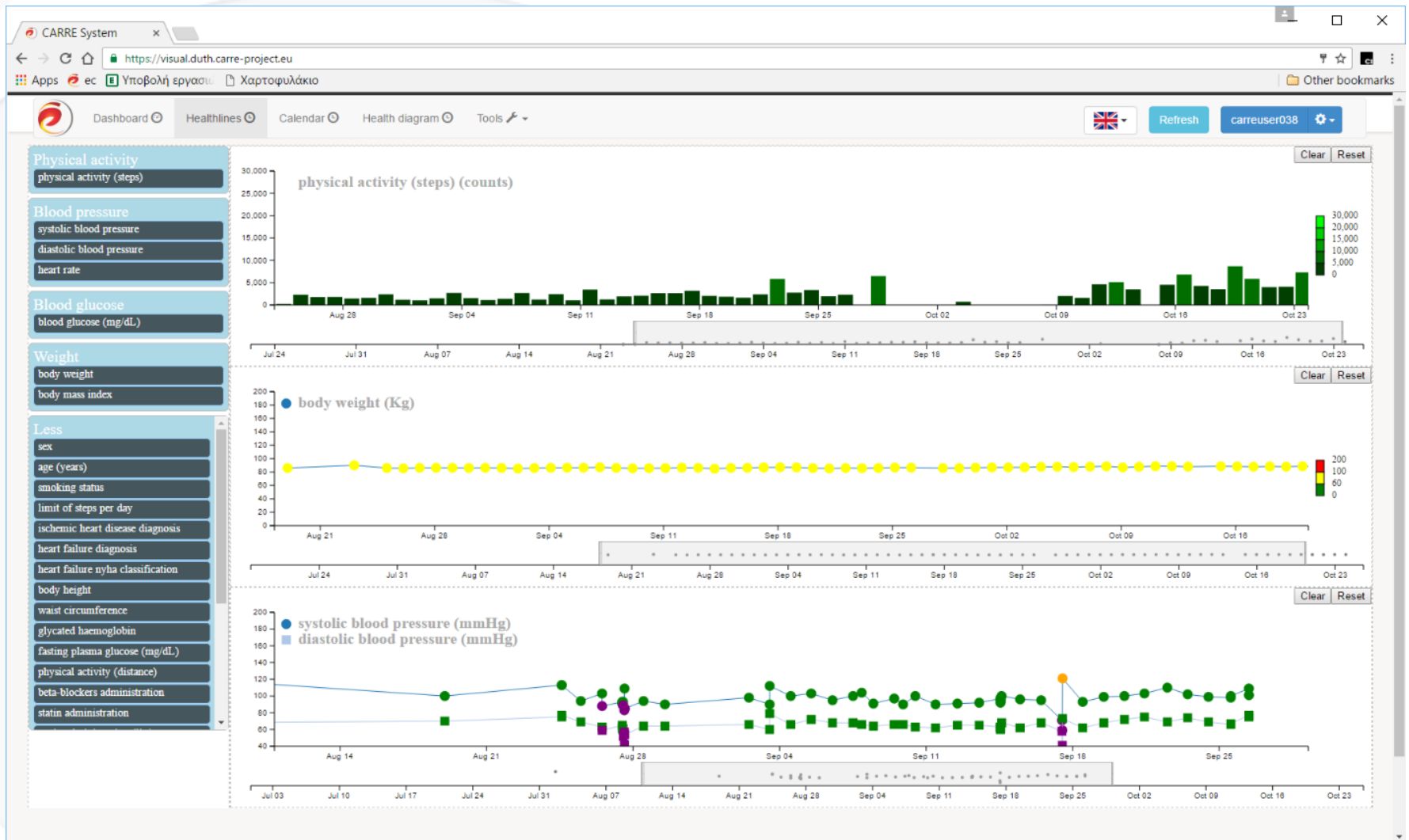
CARRE approach



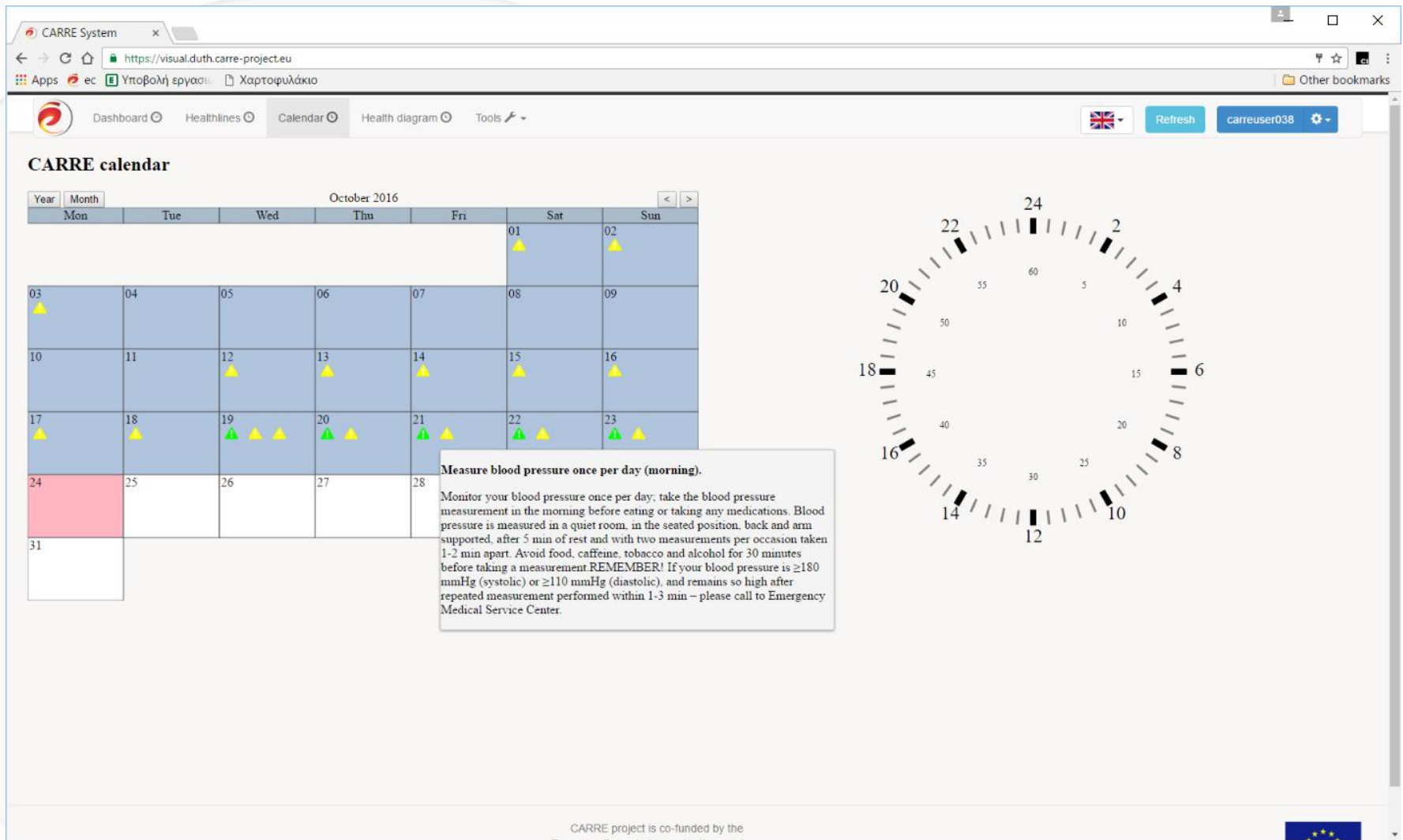
visual analytics for the patient



visual analytics for the patient



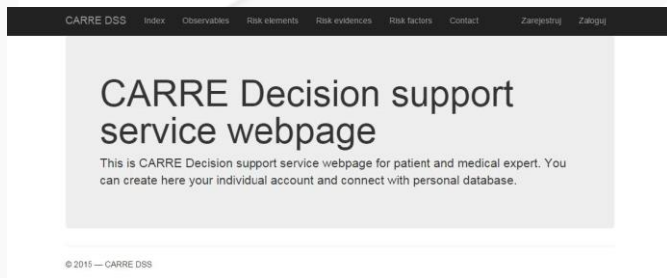
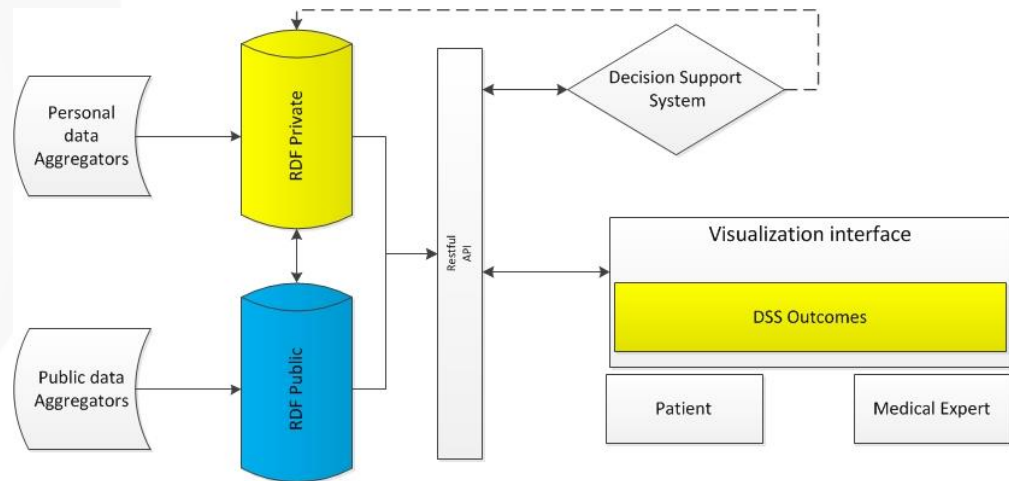
visual analytics for the patient



decision support services

interlace **personal data** and **medical evidence** for personalized services to

- plan
- monitor
- alert
- educate



CARRE D.6.2 & D.6.3, 2016

visual analytics for the patient



educational aggregator

<https://edu.carre-project.eu/>

educational repositories

semantic web

The screenshot shows the homepage of the educational aggregator. The search bar contains 'acute kidney disease'. Below the search bar, there are two tabs: 'MedlinePLUS' and 'Wikipedia'. The 'MedlinePLUS' tab is selected, showing 18 results. The first result is 'Kidney Failure' with a rating of 4.5. The second result is 'Porphyria'. The third result is 'Urinary Tract Infections'.

The screenshot shows the same website with the 'Wikipedia' tab selected. It displays 396 results. The first result is 'Renal failure' with a rating of 3.1. The text below the title describes renal failure as a condition where the kidneys are not working properly, leading to a buildup of waste in the blood.

The screenshot shows the MedlinePlus website. The article title is 'Kidney Failure'. Below the title, it says 'Also called: End-stage renal disease, ESRD, Renal failure'. The article is rated 4.5 stars. The rating is shown in a red box. The rating is composed of five stars, with the first four stars filled and the fifth star empty.

CARRE D.3.4, 2015

<http://www.carre-project.eu>

evaluation framework & plan*

	CARRE system functions	Human perspectives			Context and Environment
		Experts	Patients	Admins	
Structure	aggregators and interfaces functioning	changes to working conditions and practices; new skills, & abilities	new skills, and abilities		
Process	service operation correct & valid	induced changes in function and satisfaction	Induced changes in self-management & satisfaction		
Outcome	service usable and reliable	effectiveness	perceived quality of care and life	improving specific clinical parameters	potential to improve the health status and quality of life

* based on the model proposed by Cornford, T., Doukidis, G.I., and Forster, D., *Int. J. Manag. Science*, 22(5), 491-504, 1994

1: component testing

2: service testing & understanding

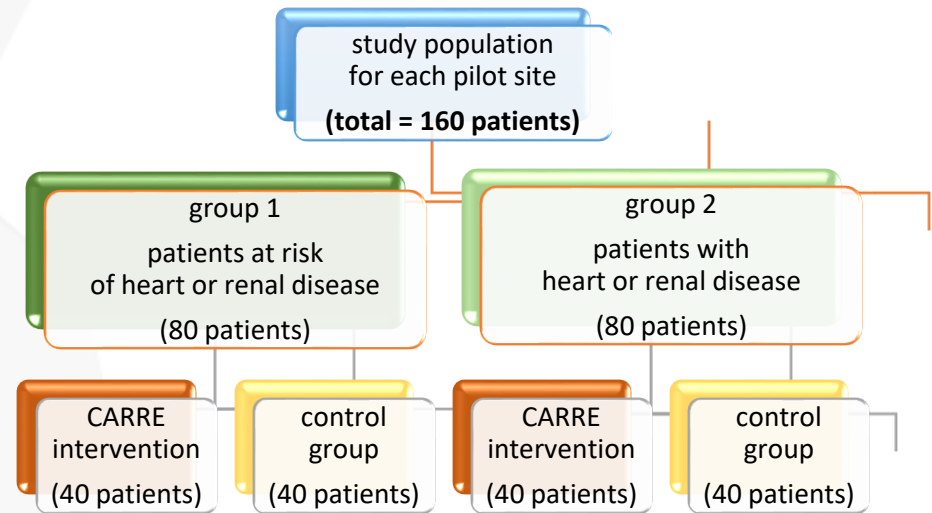
3: service evaluation

evaluation

- 2 center
randomized control trial

- primary objectives

- primary
 - increase health literacy
 - increase level of patient empowerment (*SUSTAINS instrument*)
 - improve quality of life (*SF-36 instrument*)
 - reduce personal risk for cardiorenal disease and comorbidities (*biomarkers & disease prevalence*)
- secondary
 - improve or prevent disease progression (*clinical & laboratory parameters*)
 - improve lifestyle habits (*sensor readings*)
 - limit no. or dose of necessary drugs (*dose of essential drugs*)
 - assess intervention acceptability



what?

CARRE

EU FP7-ICT-2013-611140

3.2M, 2013-2016

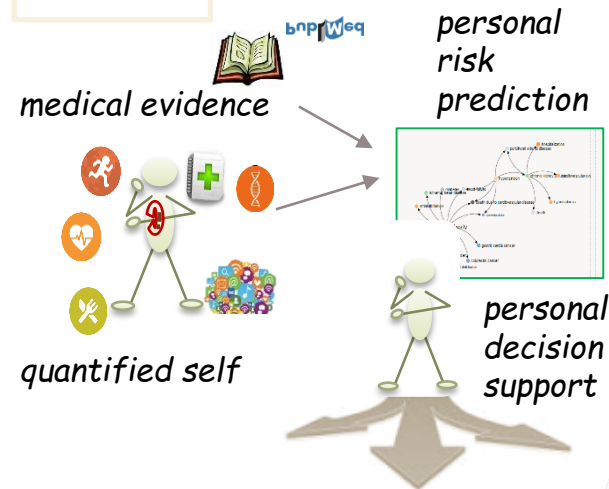
DUTH, OU, BED, VULSK, KTU, PIAP

why?

cardiorenal disease

chronic, common, dangerous,
expensive, with many causing
factors and complex progression

how?

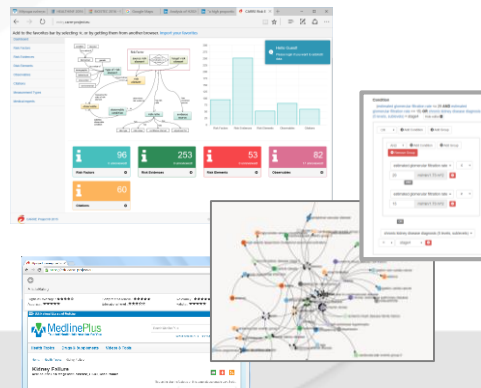


<http://carre-project.eu>

for the patient



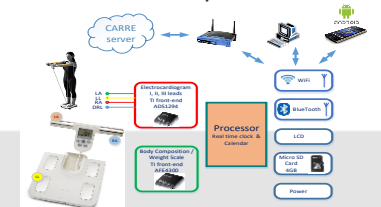
for the medical expert



for the ICT expert



sensor developments



what?

CARRE

EU FP7-ICT-2013-611140

3.2M, 2013-2016

EU FP7-ICT-2013-611140

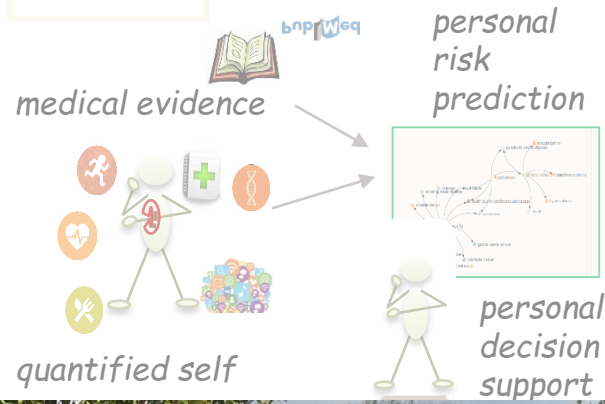
thank you !!!

why?

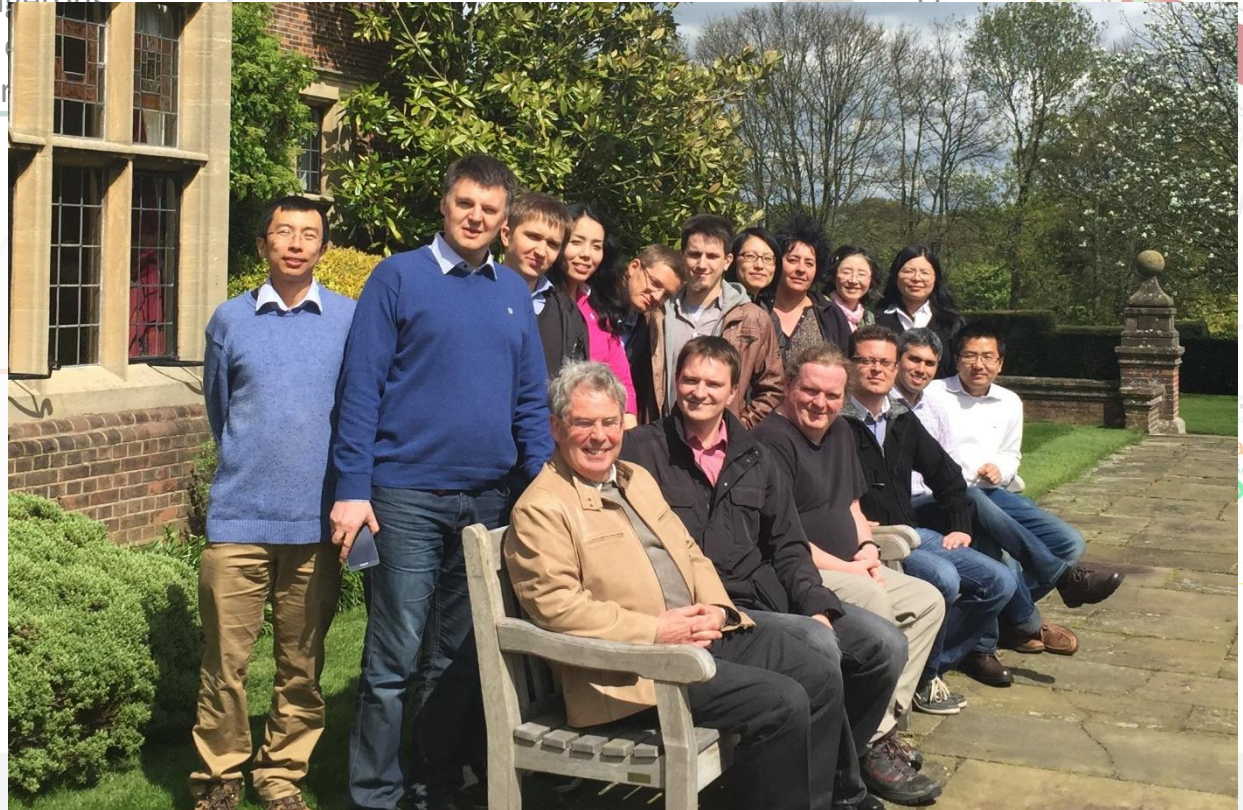
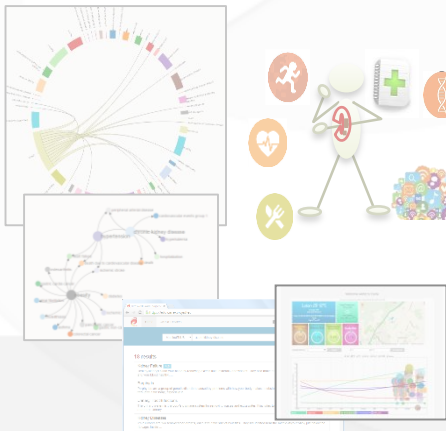
cardiorenal disease

chronic, common, dangerous,
expensive, with many
factors and complex pr

how?



for the patient



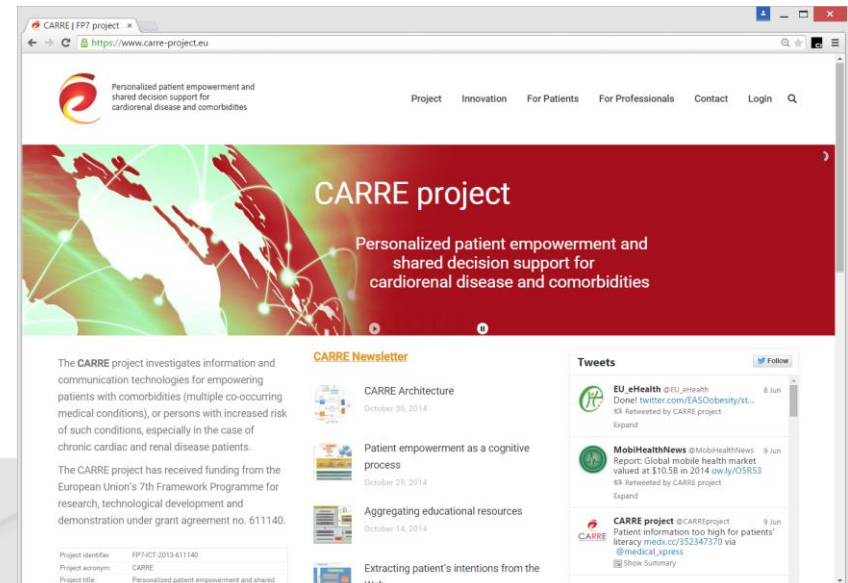
acknowledgment

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Information and Communication Technologies (ICT)
7th Framework Programme
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CARRE: Personalized patient empowerment
and shared decision support
for cardiorenal disease and comorbidities

<http://www.carre-project.eu/>



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