HealthInf 2016: 9th International Conference on Health Informatics
BIOSTEC, Rome, Italy, 21-23 February, 2016

CARRE

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

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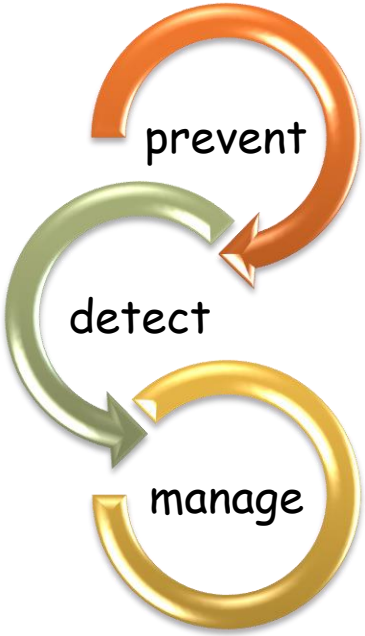
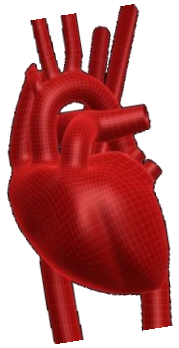
School of Medicine, Democritus University of Thrace, Greece

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



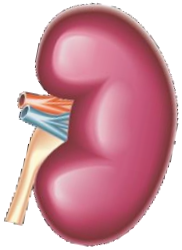
medical domain



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

CARRE

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

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/

Democritus Univ. of Thrace
DUTH, GR

The Open University, UK

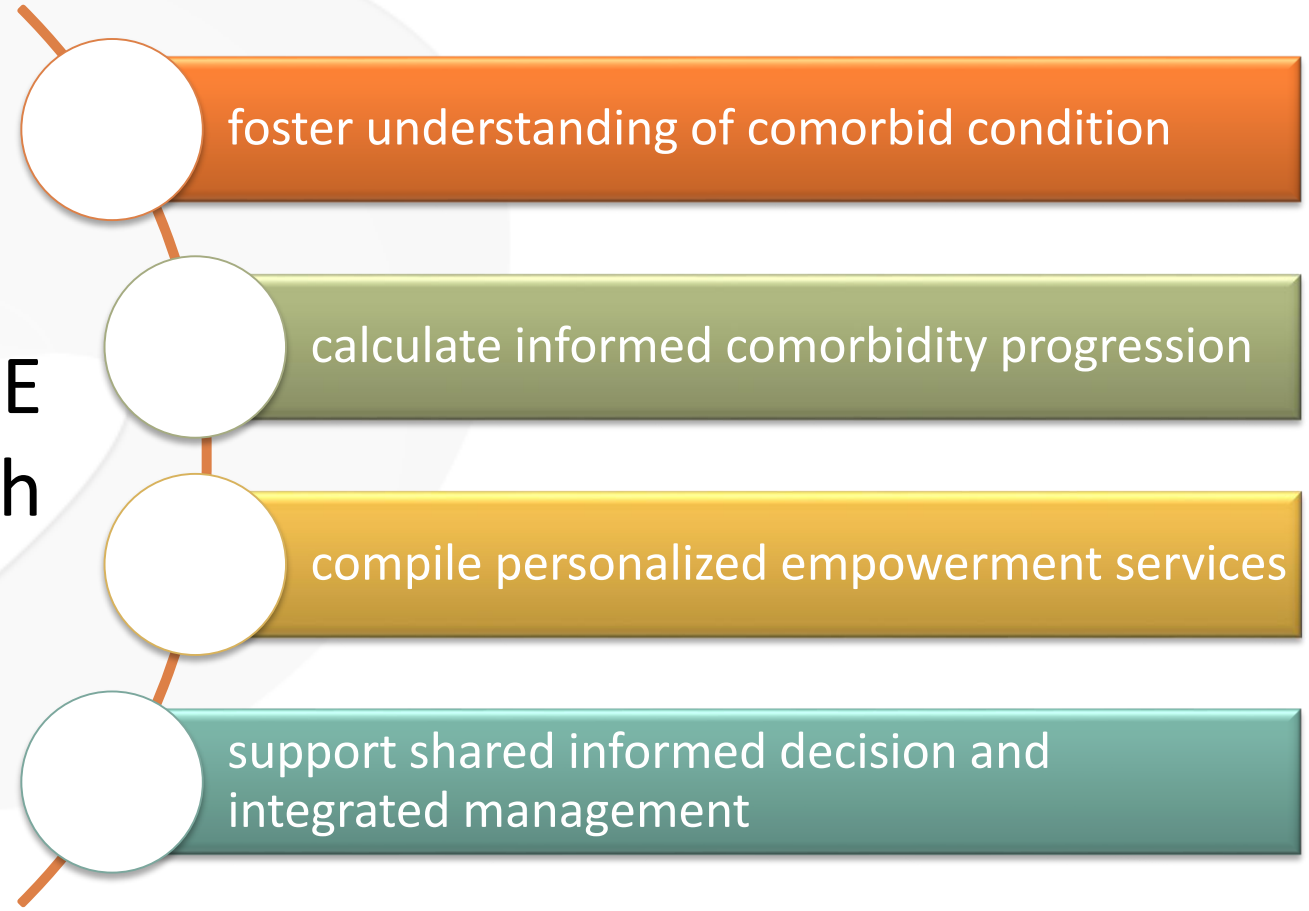
Univ. of Bedfordshire, UK

Vilnius Univ. Hospital, LT

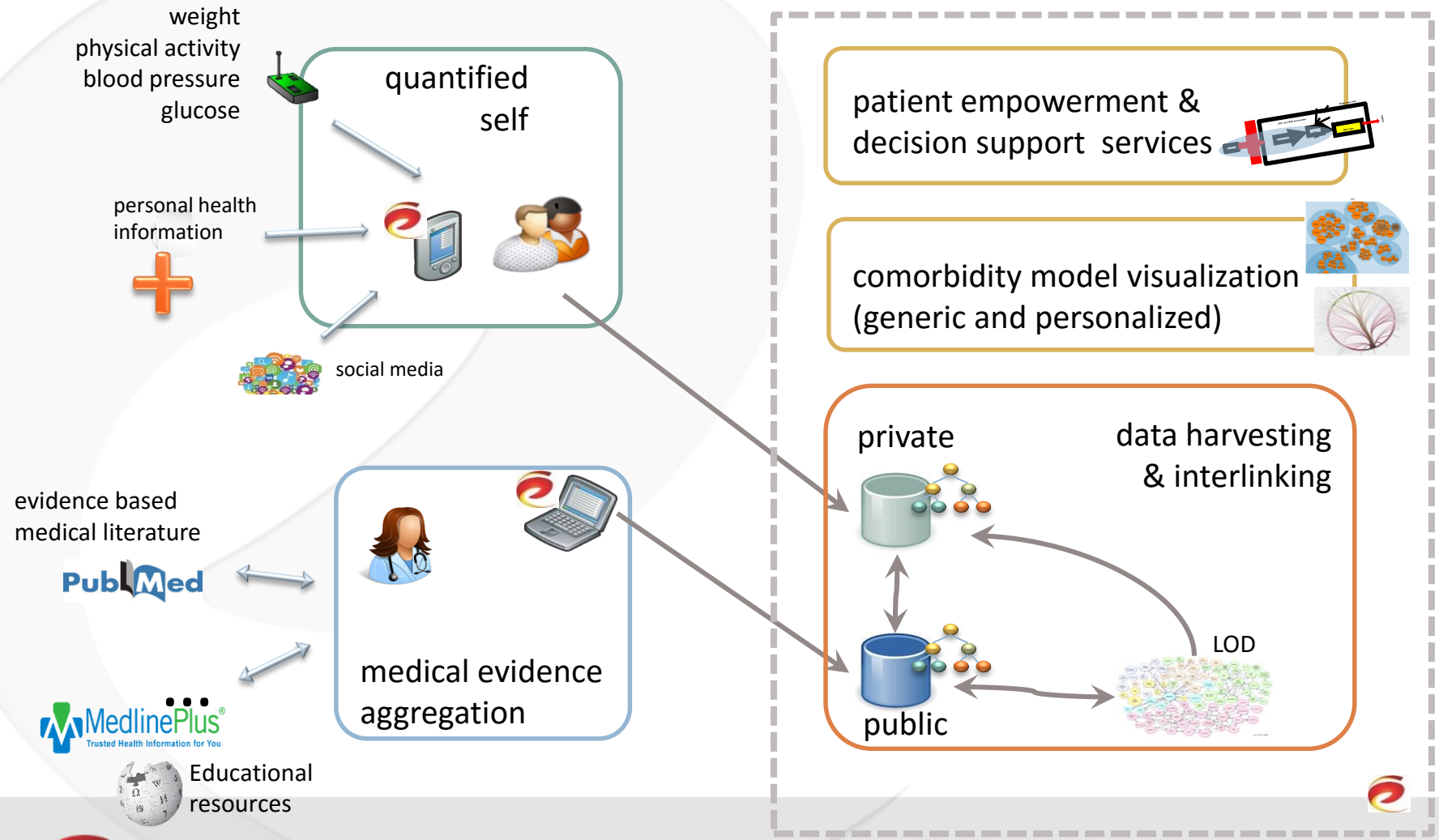
Kaunas Univ., LT

Industrial Research Institute for Automation & Measurements, PL

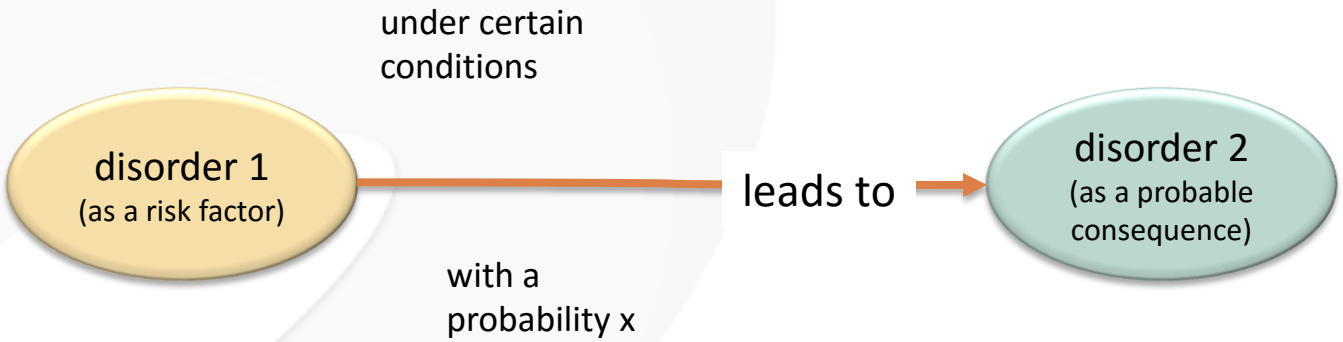
CARRE approach



CARRE approach



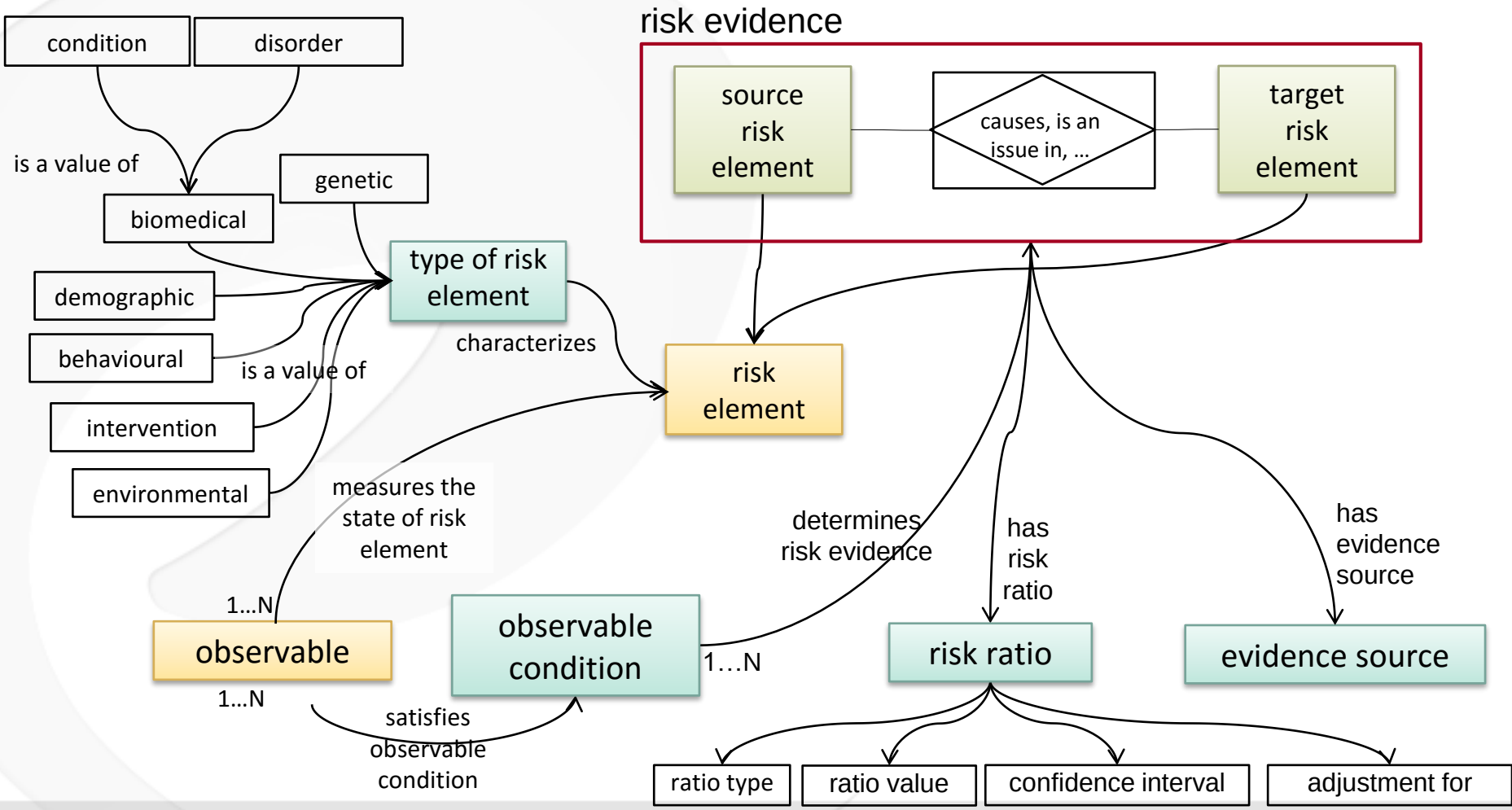
risk factor as a central concept



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

E. Kaldoudi, et al. CARRE D.2.1, 2014, www.carre-project.eu

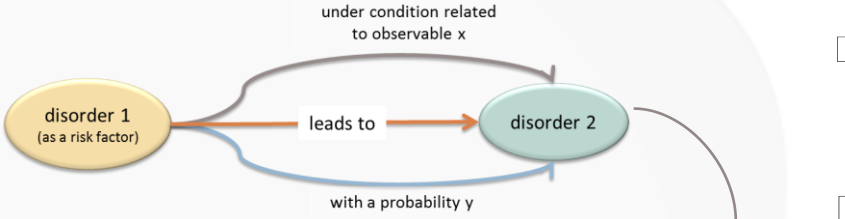
risk factor as a central concept



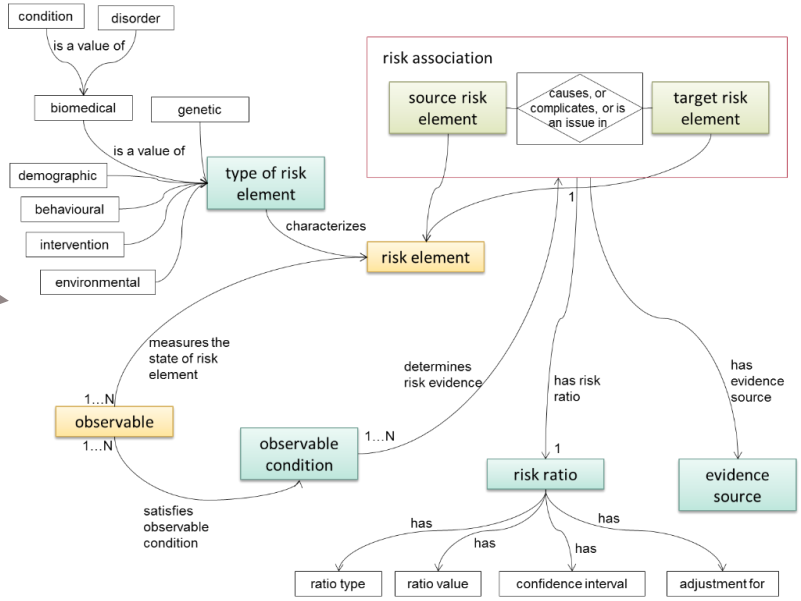
A. Third, E. Kaldoudi, G. Gotsis, S. Roumeliotis, K. Pafili, J. Domingue, Capturing Scientific Knowledge on Medical Risk Factors, K-CAP2015, ACM, NY, USA, Oct. 7-10, 2015

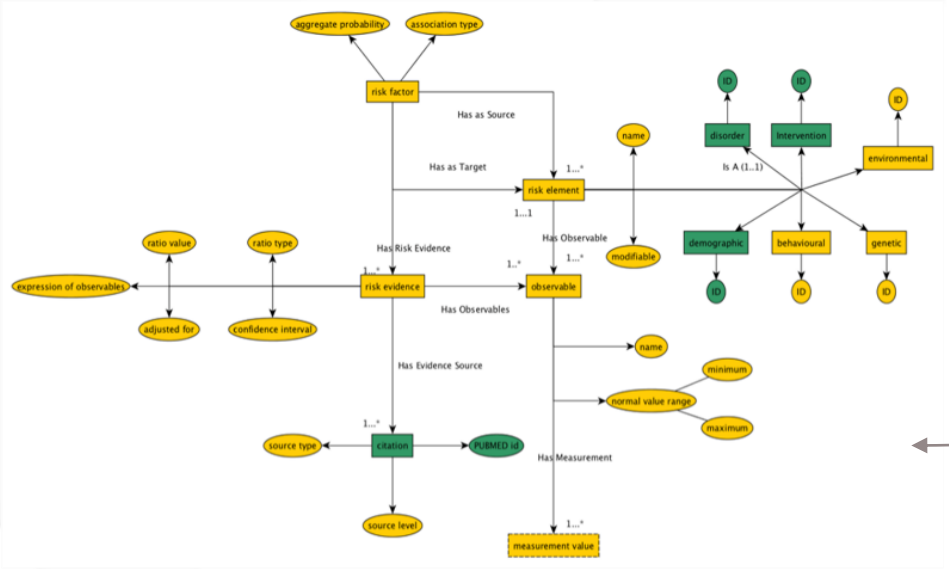
E. Kaldoudi, et al. CARRE D.2.2, 2014

CARRE risk factor ontology

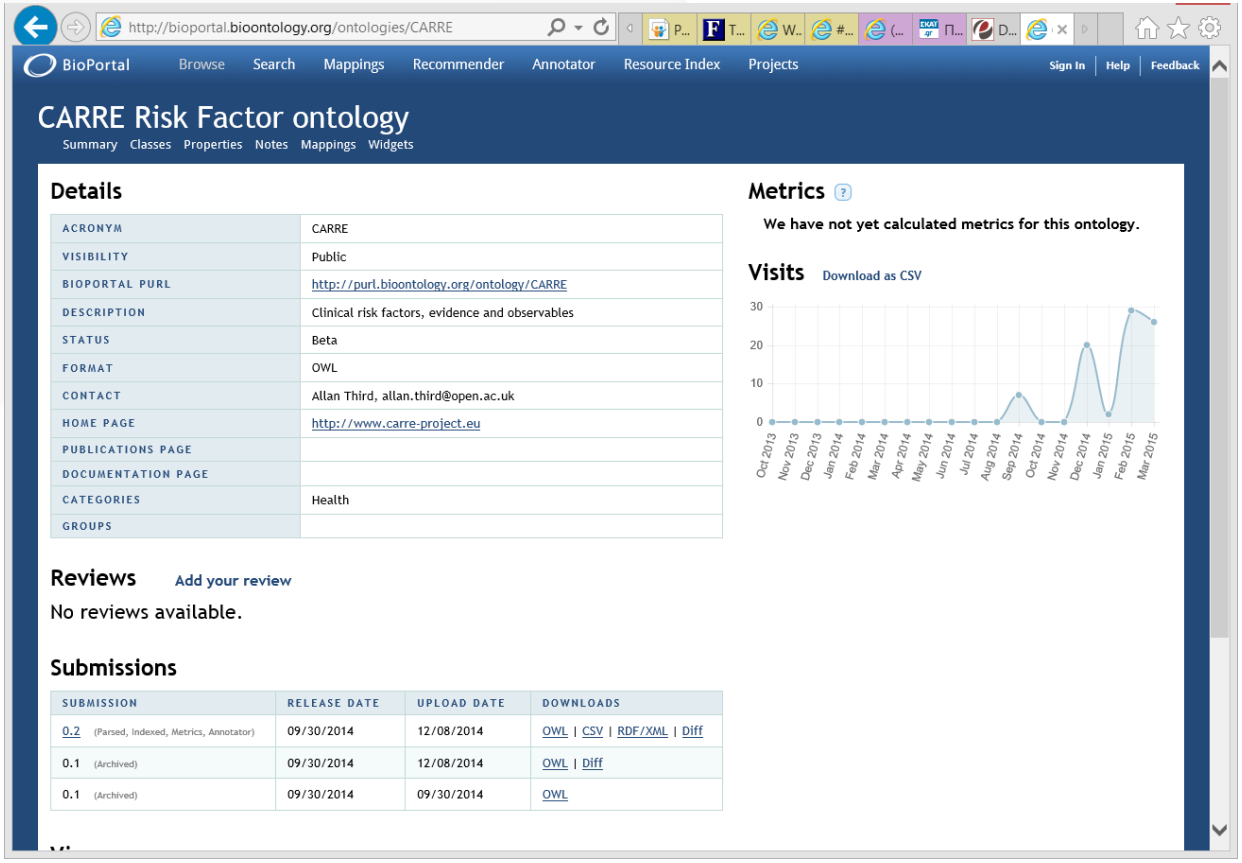


conceptual model



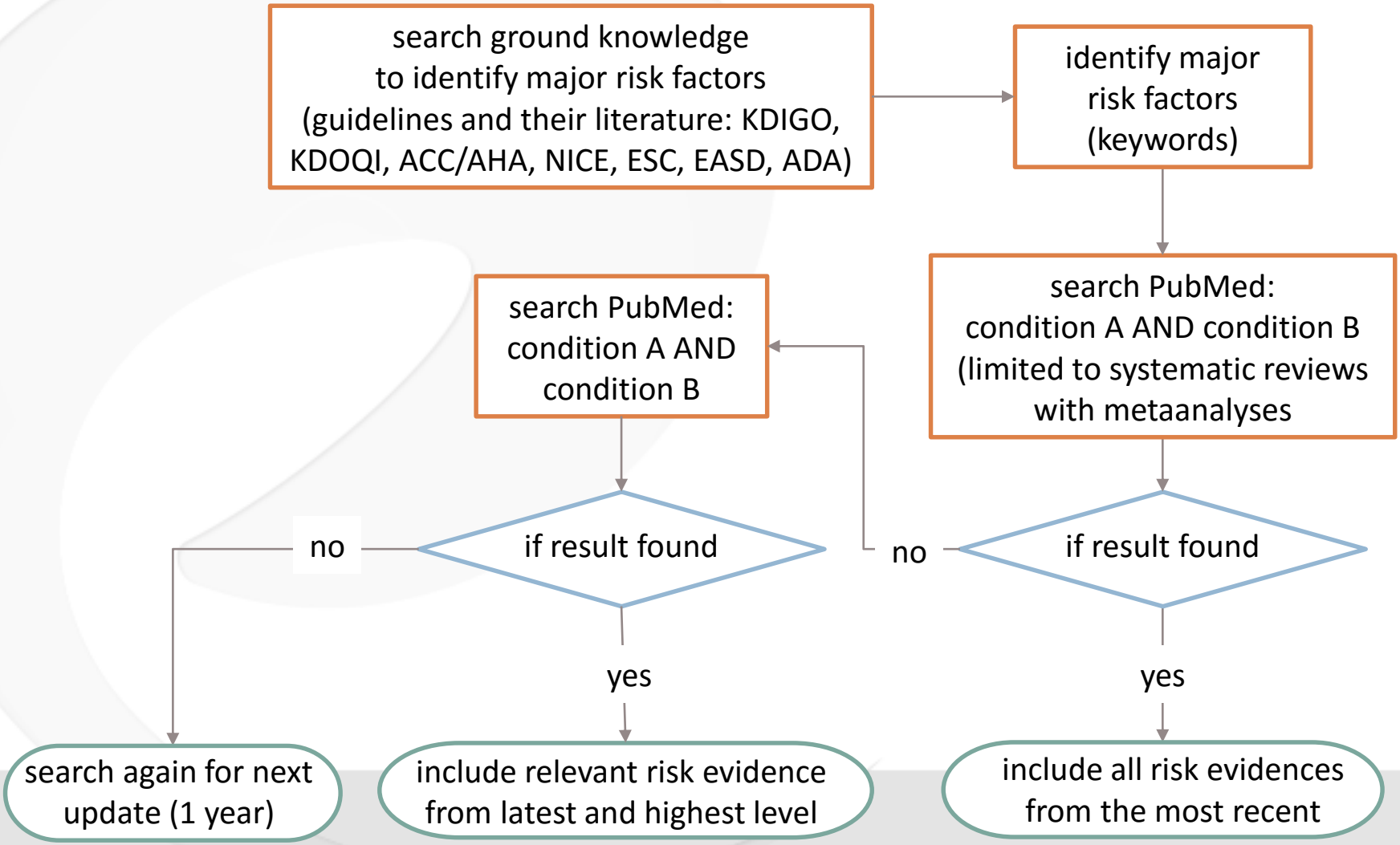


CARRE risk factor ontology



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

risk factor identification methodology



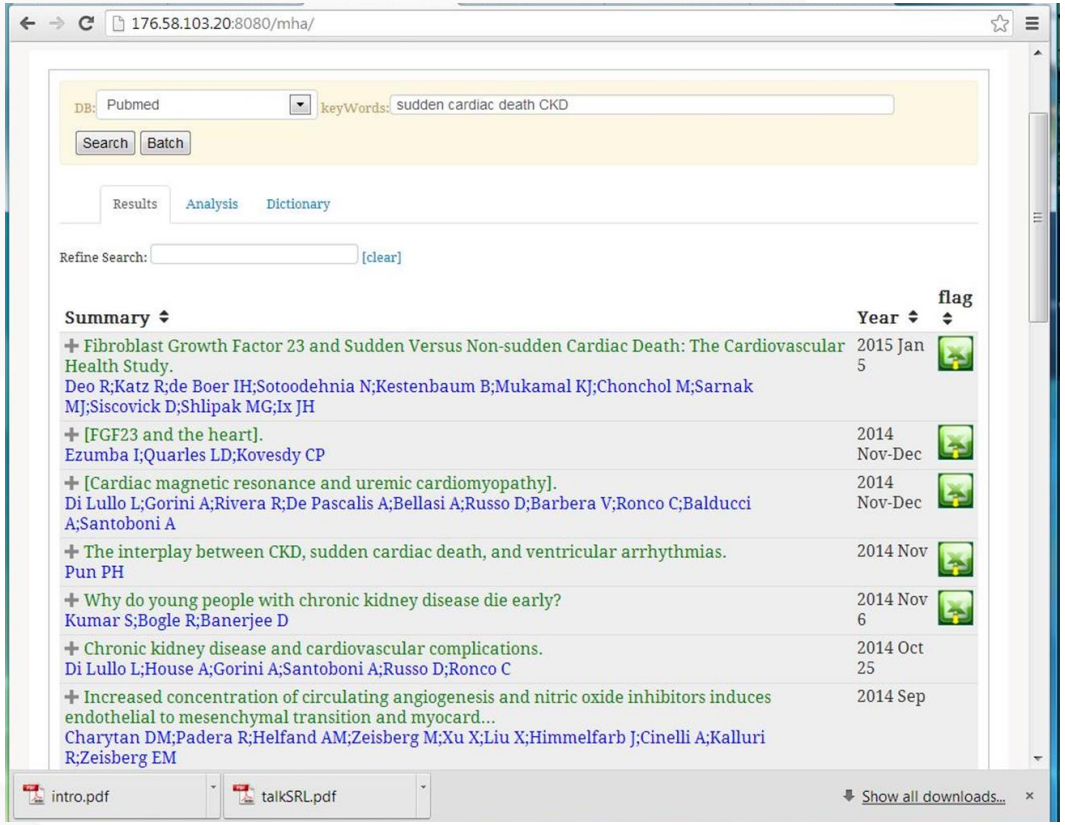
E. Kaldoudi, et al. CARRE D.2.2, 2014

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/



sentence splitter

↓

tokenizer (GATE &Jape)

↓

part-of-speech tagging

↓

dependency parsing

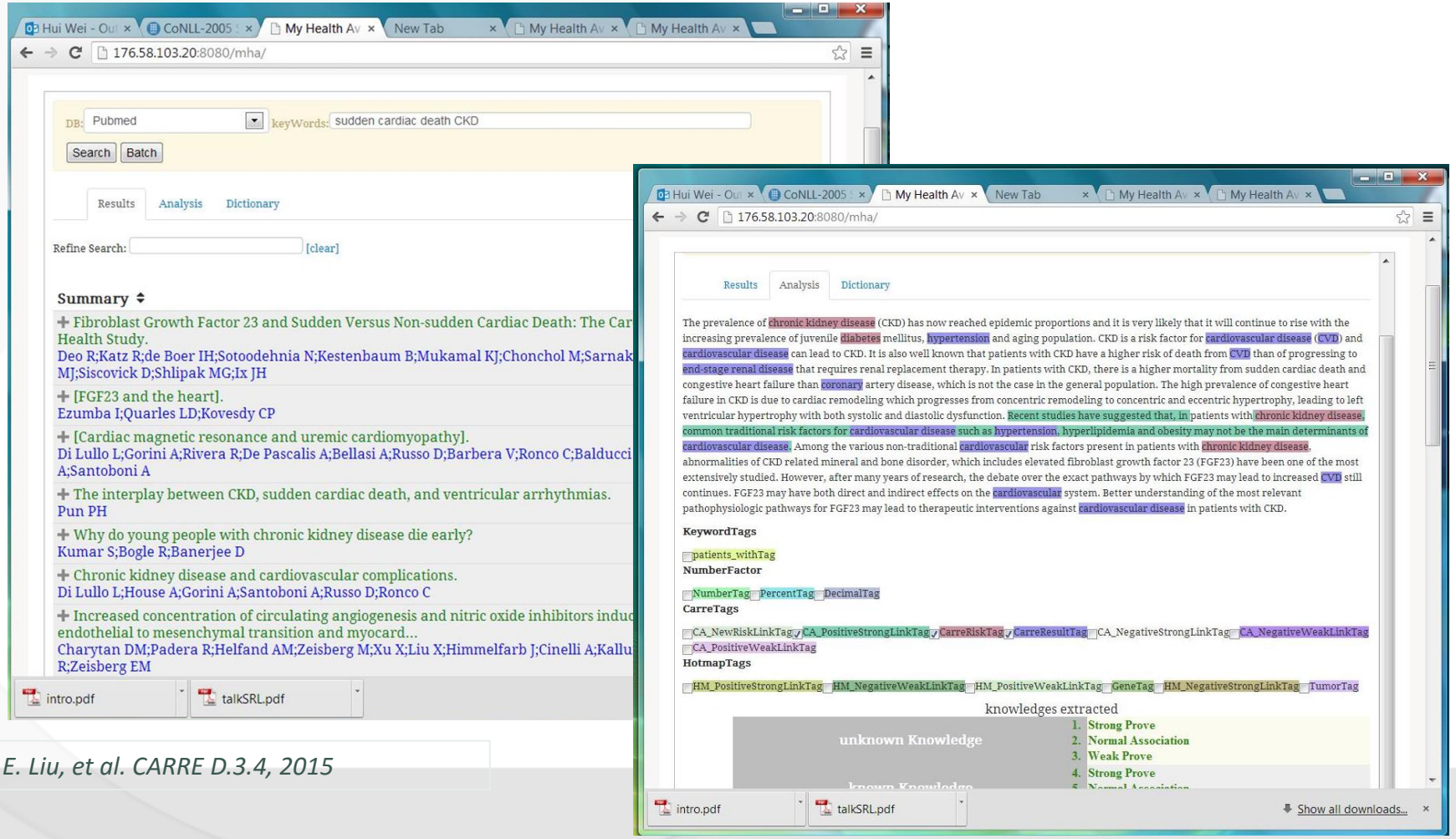
↓

semantic role labelling

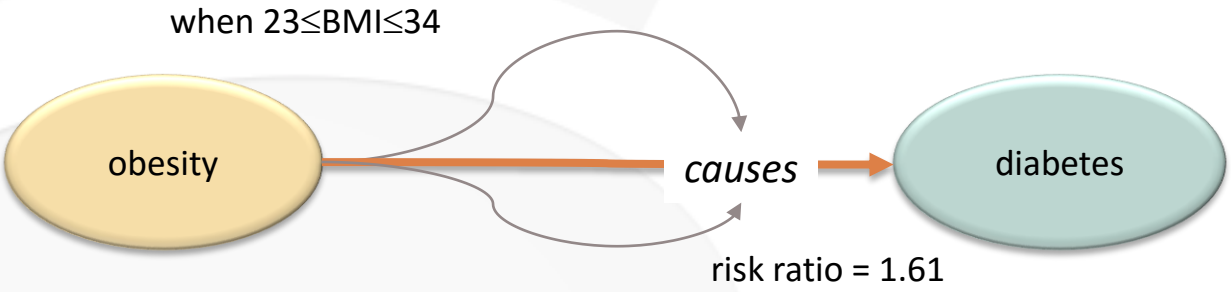
E. Liu, et al. CARRE D.3.4, 2015

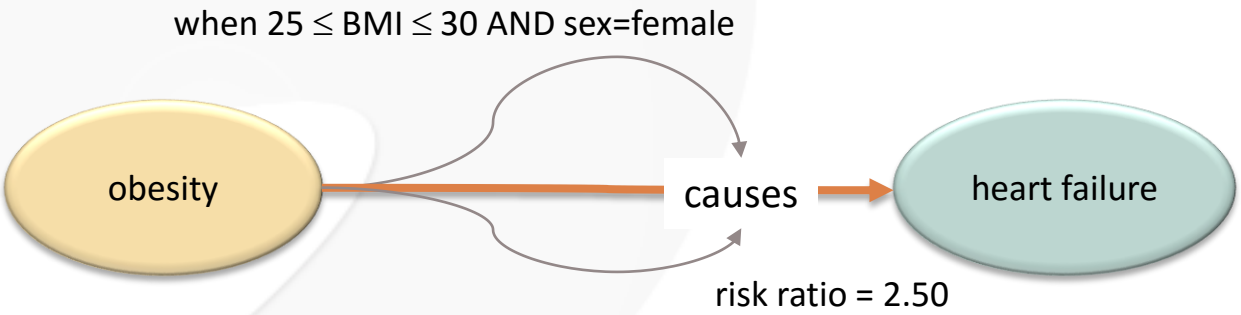
medical evidence aggregator

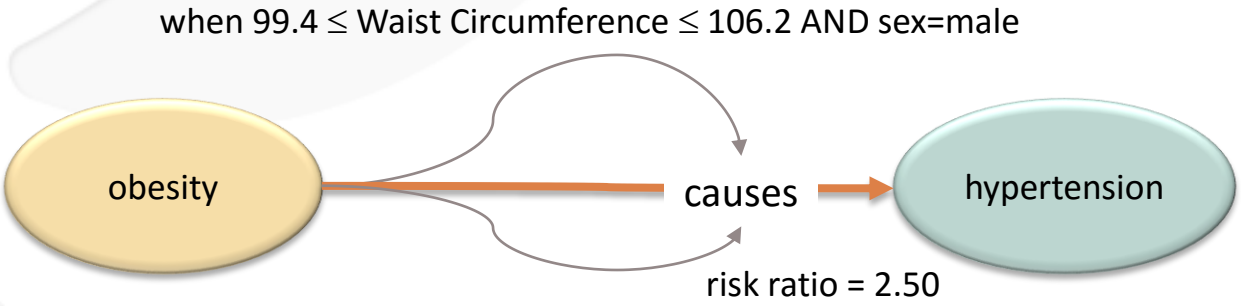
https://www.carre-project.eu/innovation/medical-evidence-aggregator/

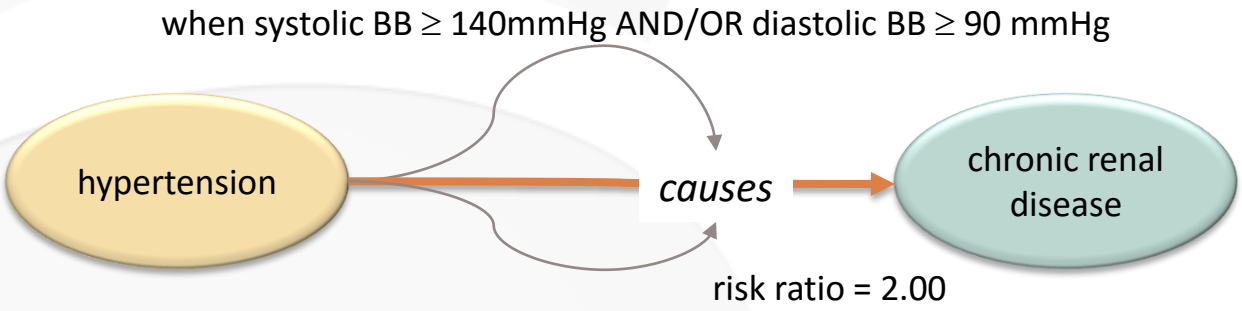


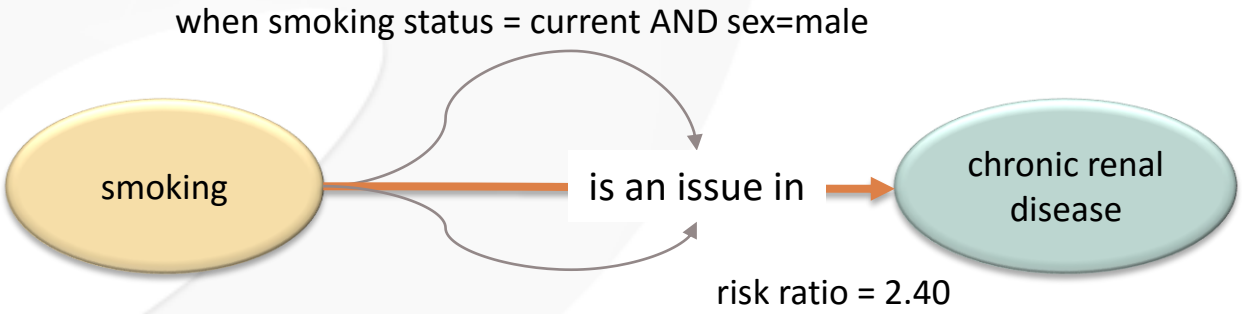
E. Liu, et al. CARRE D.3.4, 2015


when 23≤BMI≤34
obesity
causes
diabetes
risk ratio = 1.61


when 25 ≤ BMI ≤ 30 AND sex=female
obesity
causes
heart failure
risk ratio = 2.50


when 99.4 ≤ Waist Circumference ≤ 106.2 AND sex=male
obesity
causes
hypertension
risk ratio = 2.50





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

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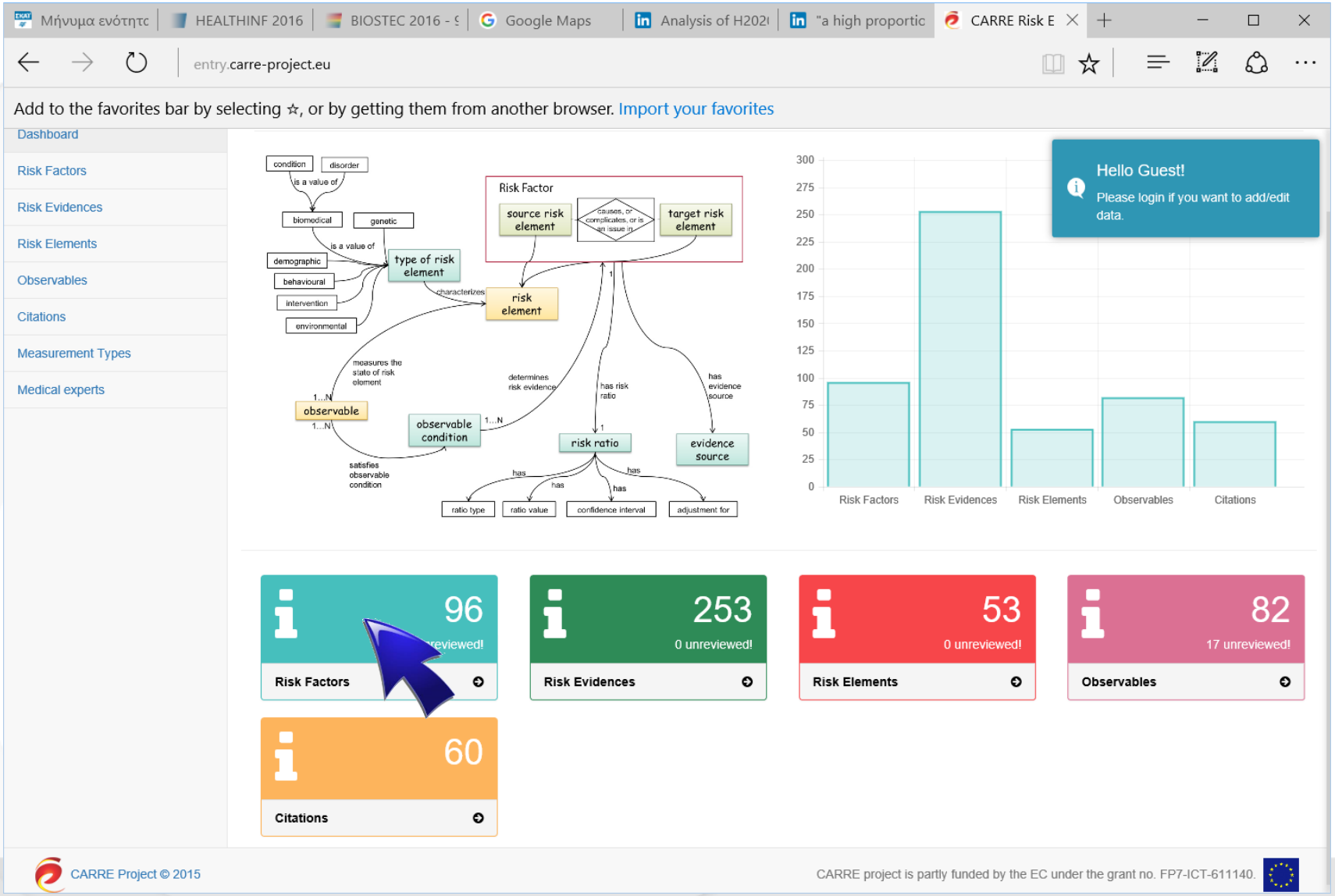

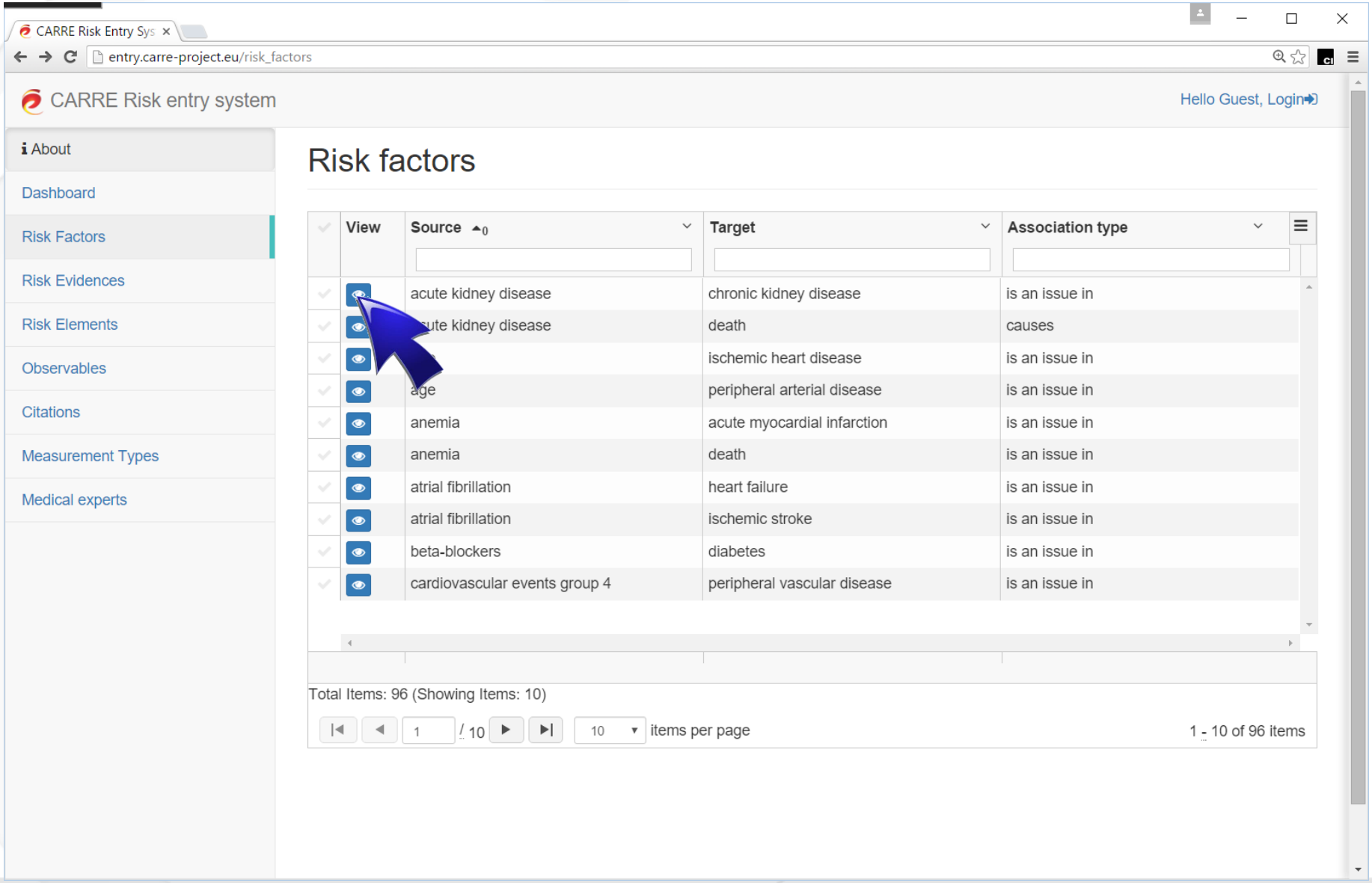

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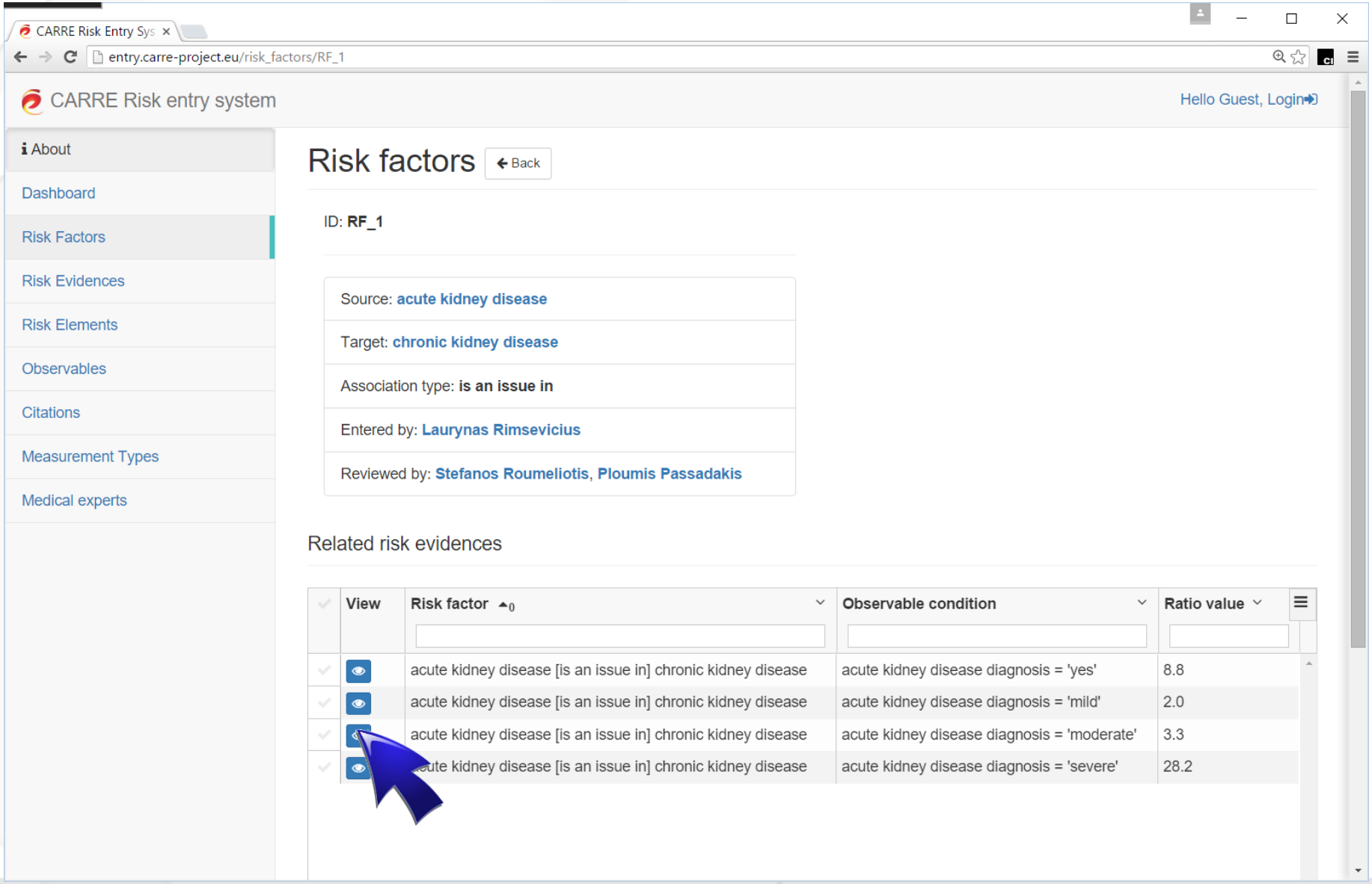

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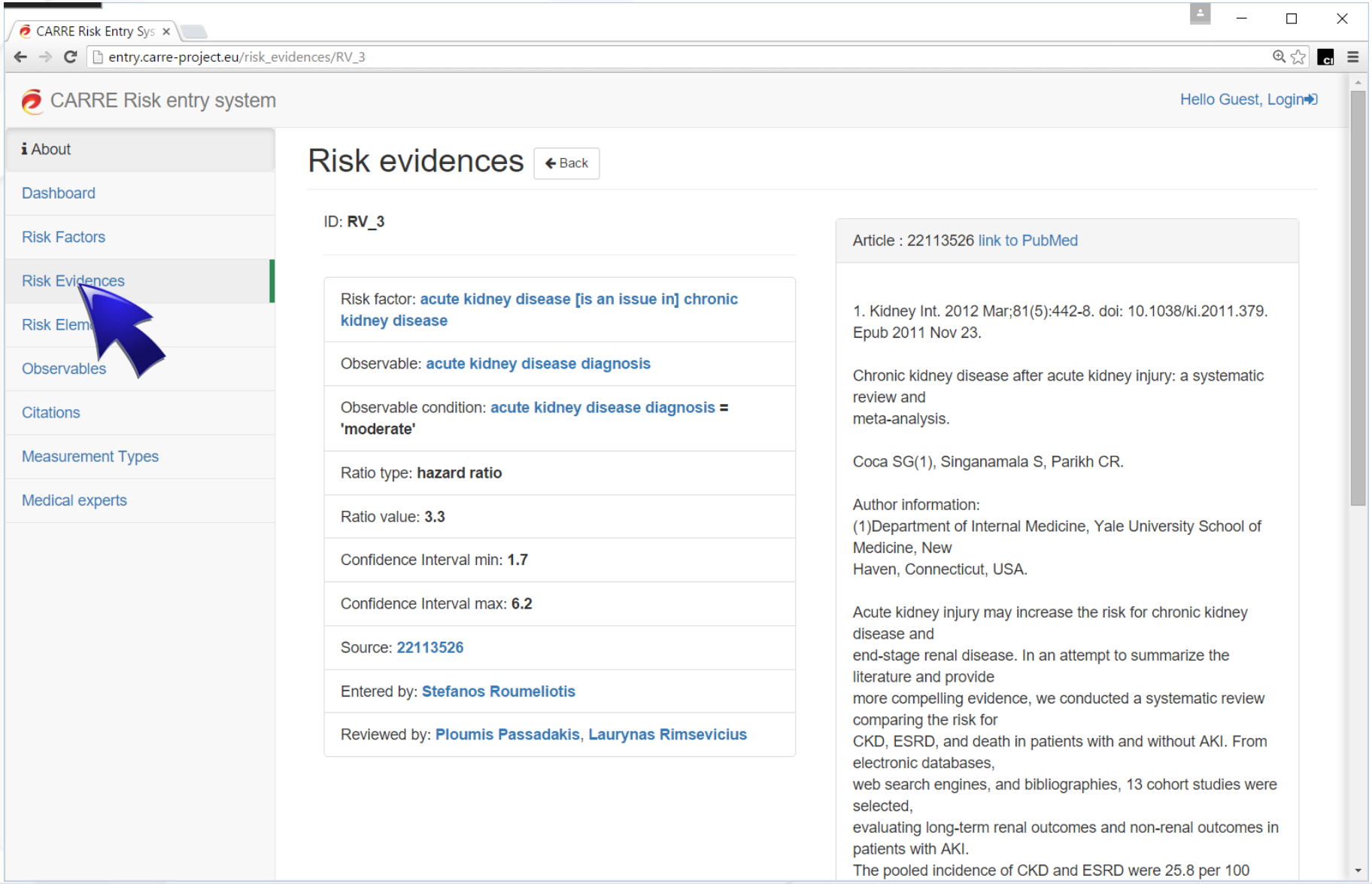

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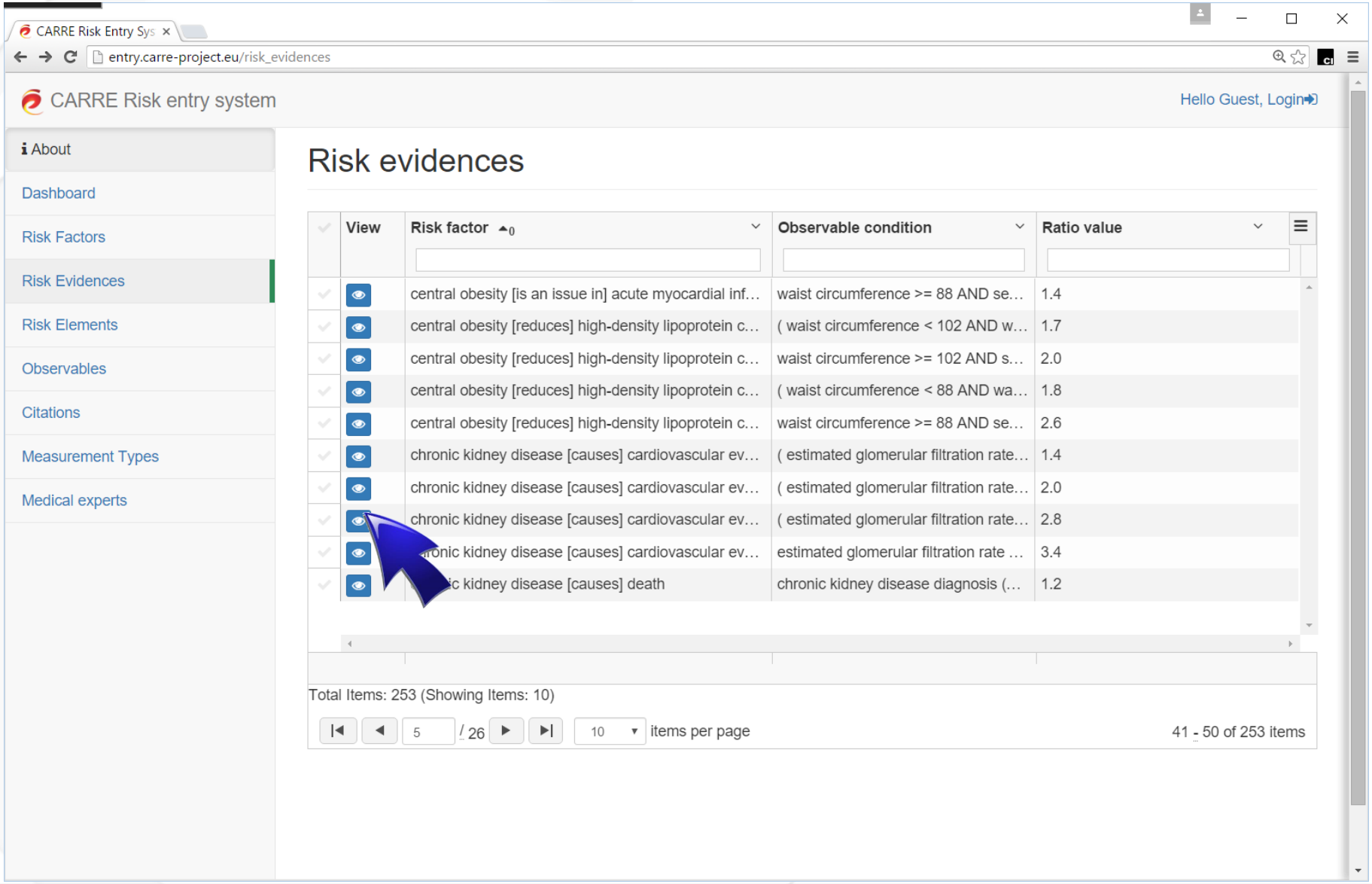

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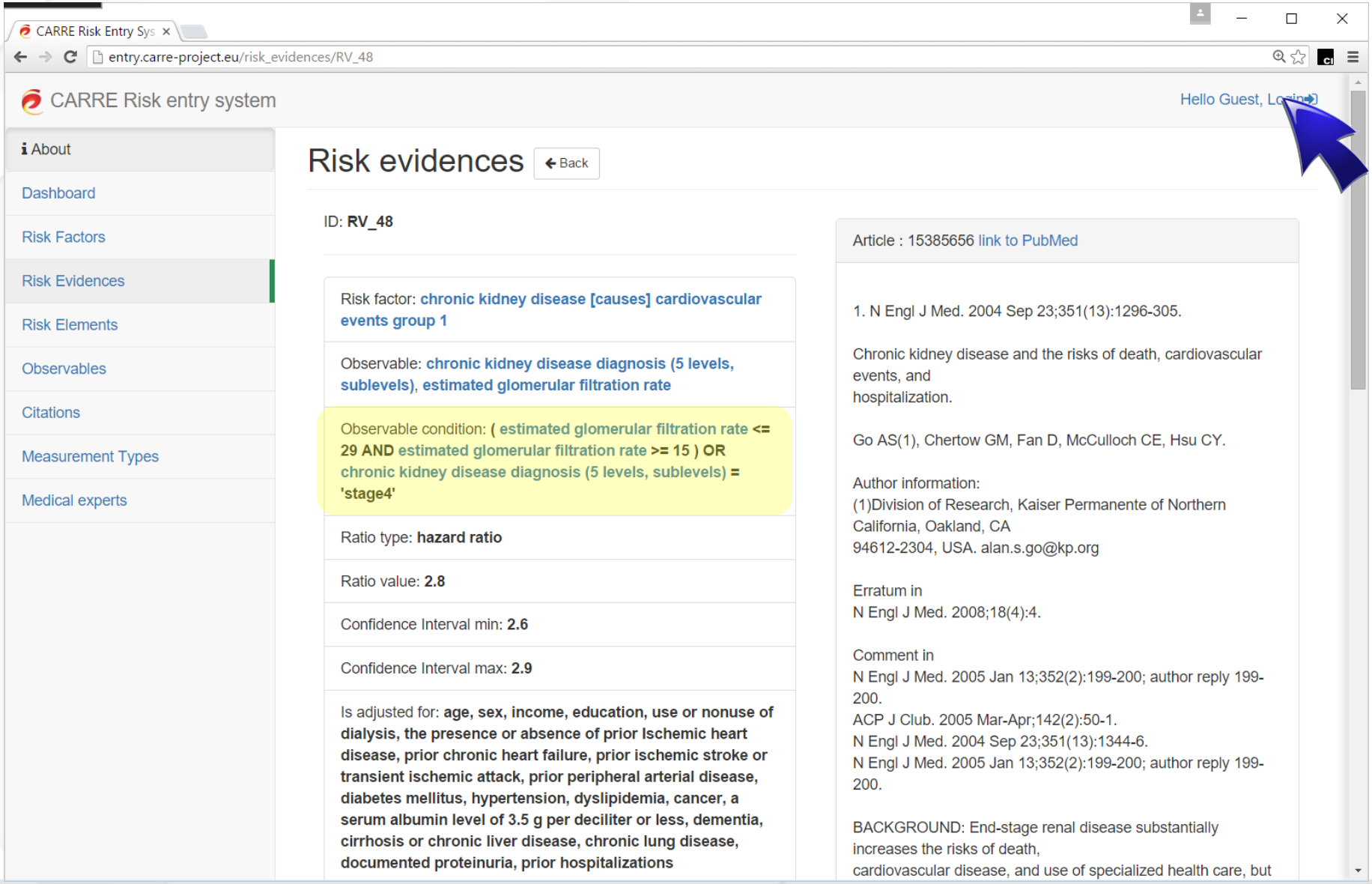

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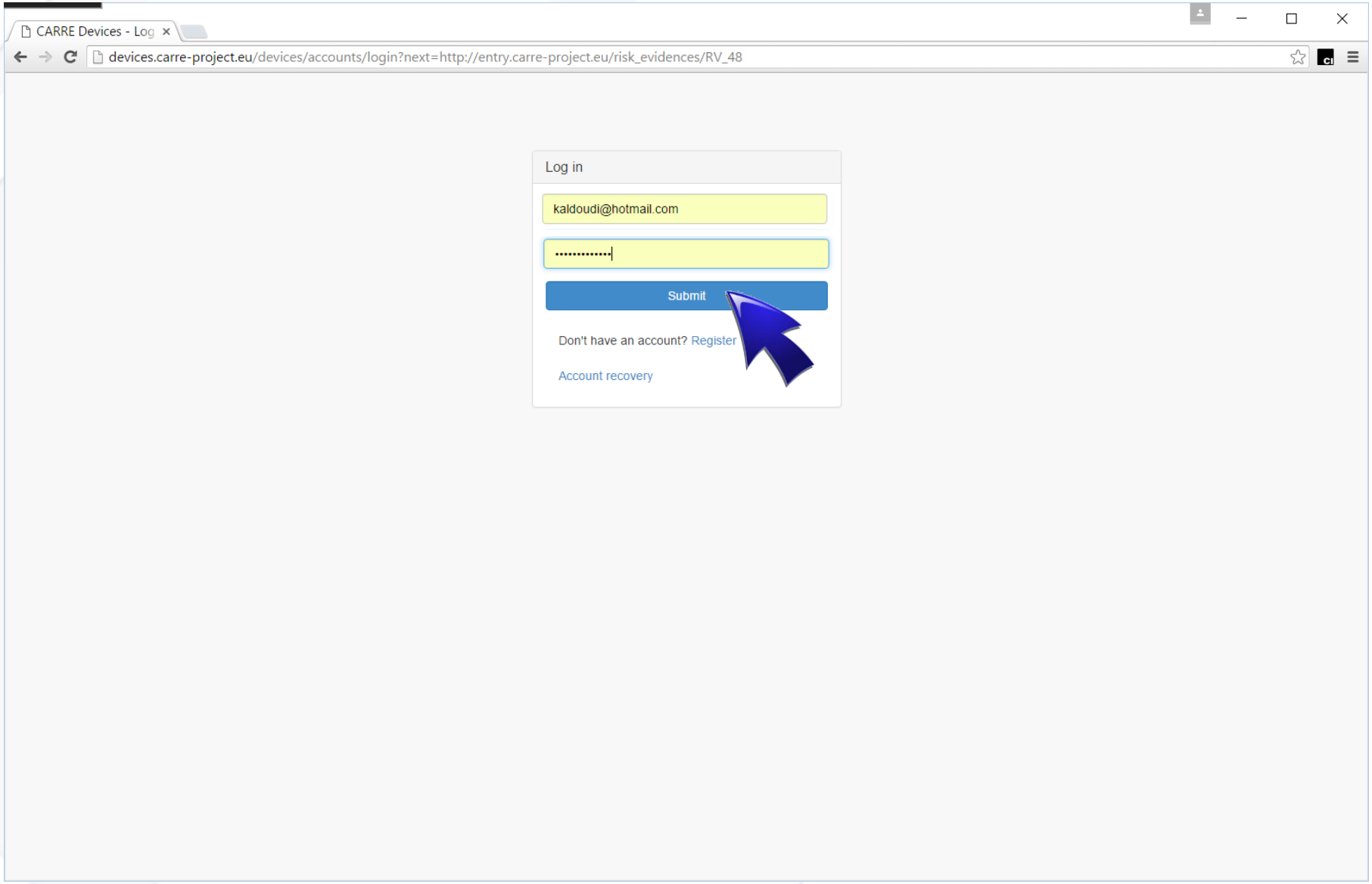

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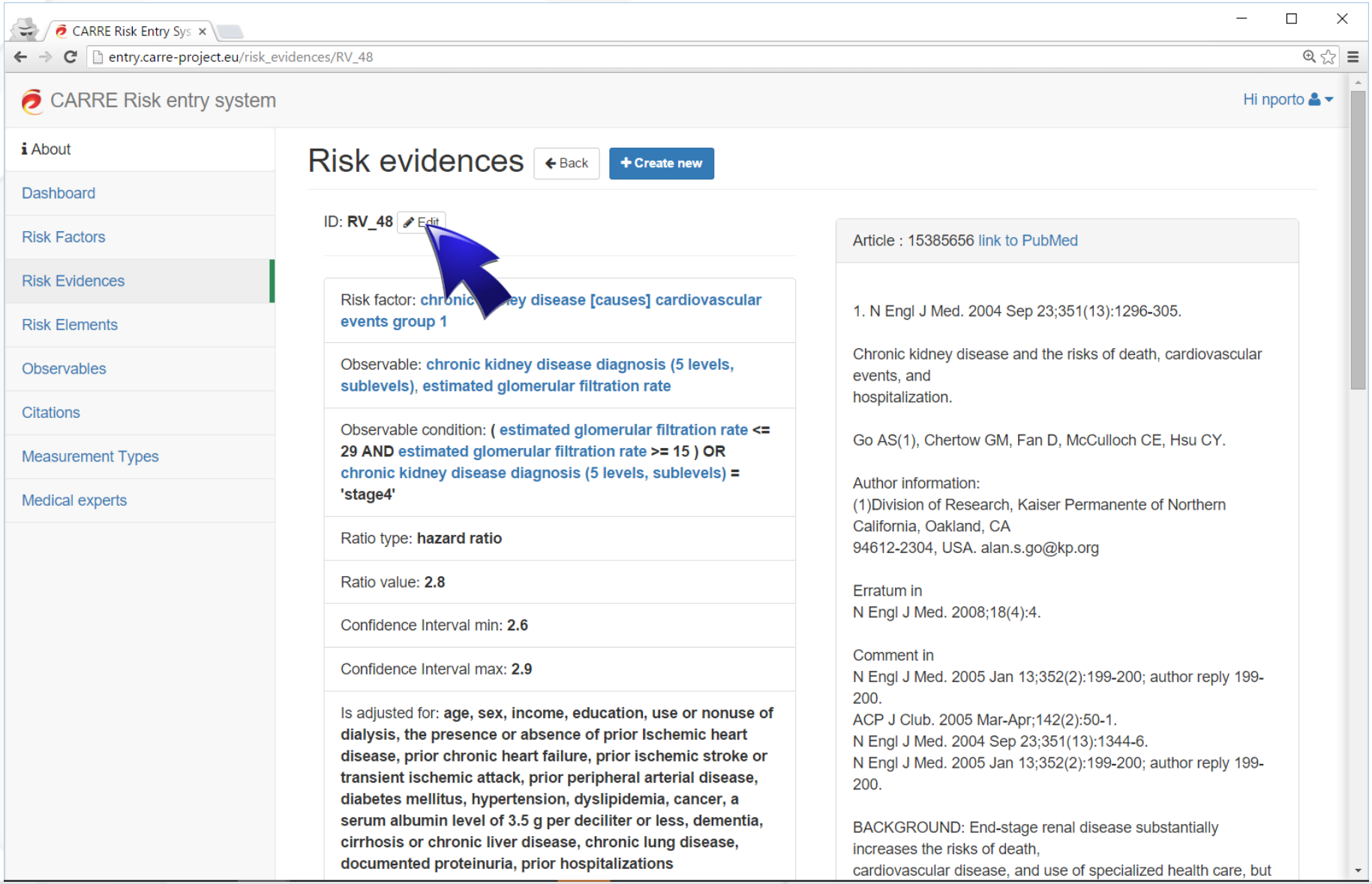

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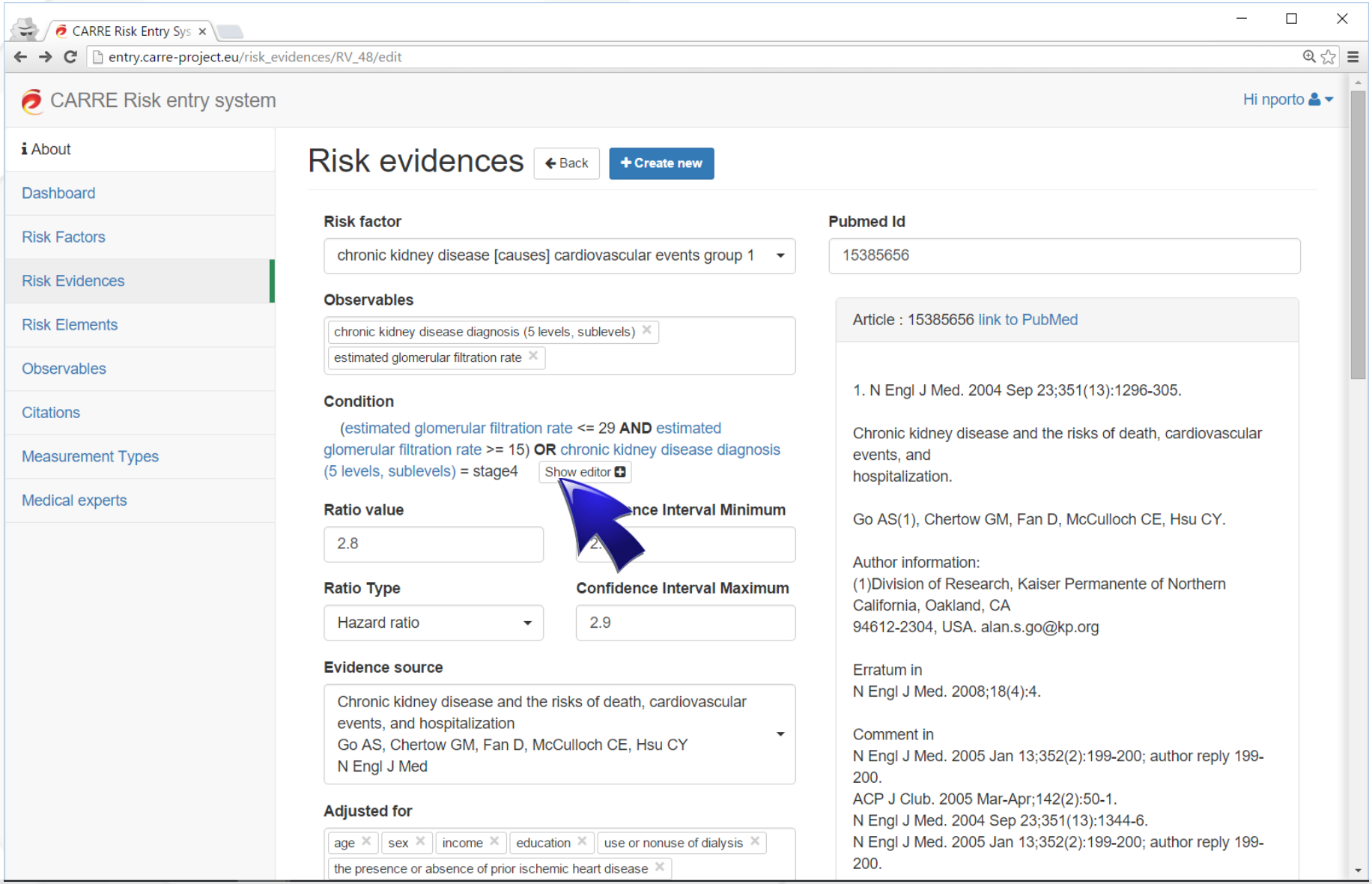

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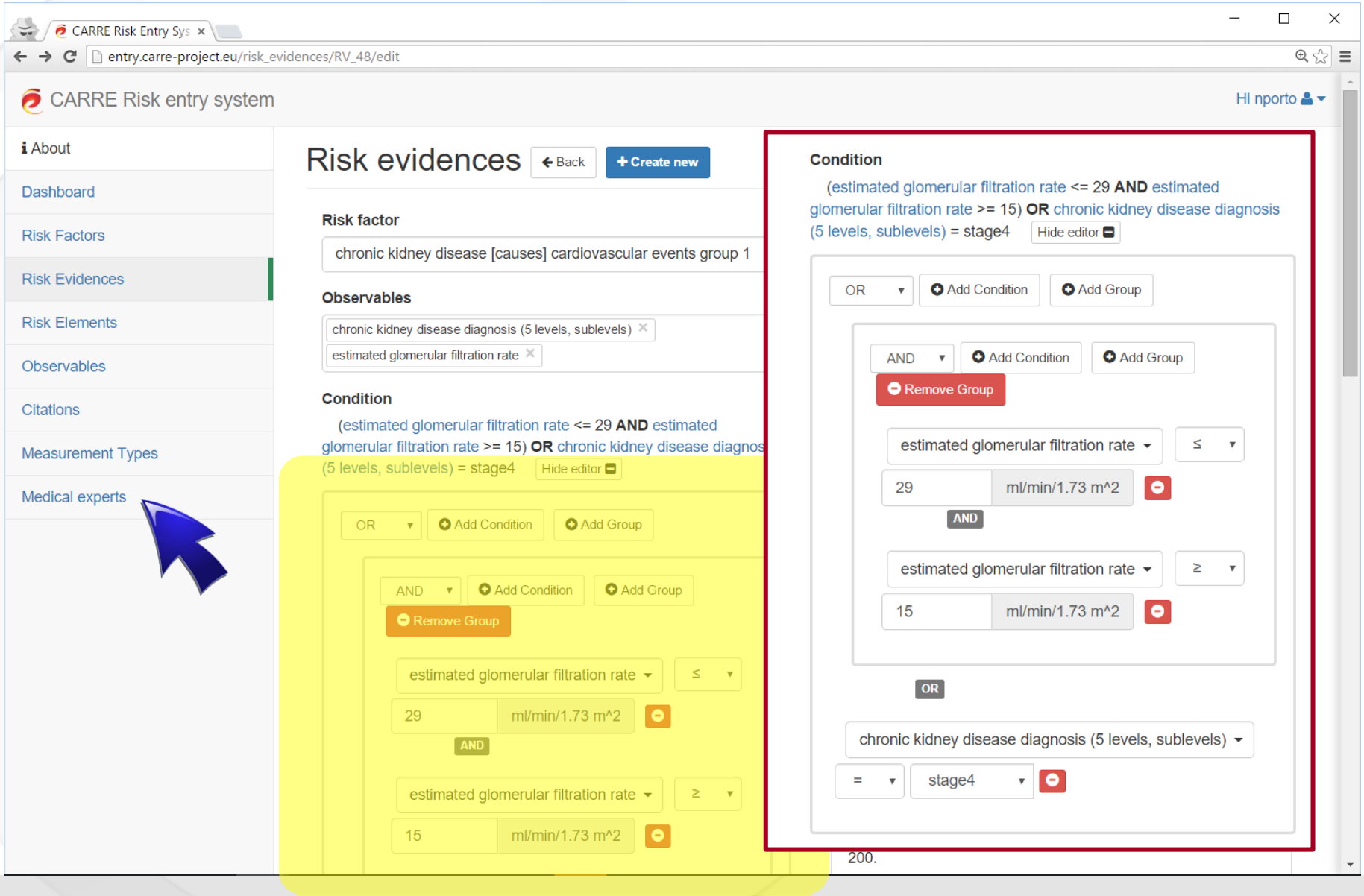

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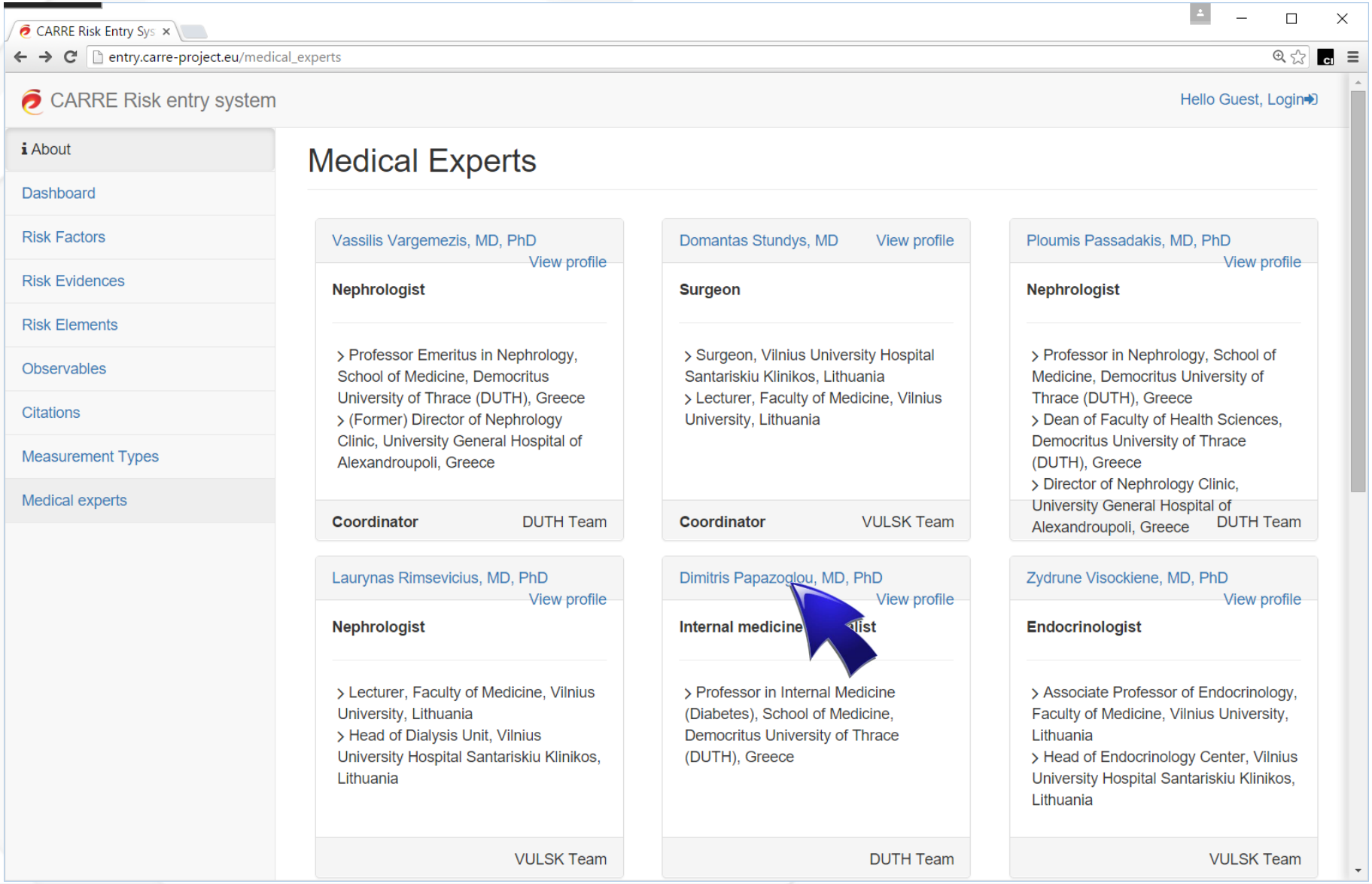
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About
Dashboard
Risk Factors
Risk Evidences
Risk Elements
Observables
Citations
Measurement Types
Medical experts
Medical Experts
Vassilis Vargemezis, MD, PhD
View profile
Nephrologist
› Professor Emeritus in Nephrology, School of Medicine, Democritus University of Thrace (DUTH), Greece
› (Former) Director of Nephrology Clinic, University General Hospital of Alexandroupoli, Greece
Coordinator
DUTH Team
Domantas Stundys, MD
View profile
Surgeon
› Surgeon, Vilnius University Hospital Santariskiu Klinikos, Lithuania
› Lecturer, Faculty of Medicine, Vilnius University, Lithuania
Coordinator
VULSK Team
Ploumis Passadakis, MD, PhD
View profile
Nephrologist
› Professor in Nephrology, School of Medicine, Democritus University of Thrace (DUTH), Greece
› Dean of Faculty of Health Sciences, Democritus University of Thrace (DUTH), Greece
› Director of Nephrology Clinic, University General Hospital of Alexandroupoli, Greece
DUTH Team
Laurynas Rimsevicius, MD, PhD
View profile
Nephrologist
› Lecturer, Faculty of Medicine, Vilnius University, Lithuania
› Head of Dialysis Unit, Vilnius University Hospital Santariskiu Klinikos, Lithuania
VULSK Team
Dimitris Papazoglou, MD, PhD
View profile
Internal medicine
› Professor in Internal Medicine (Diabetes), School of Medicine, Democritus University of Thrace (DUTH), Greece
DUTH Team
Zydrune Visockiene, MD, PhD
View profile
Endocrinologist
› Associate Professor of Endocrinology, Faculty of Medicine, Vilnius University, Lithuania
› Head of Endocrinology Center, Vilnius University Hospital Santariskiu Klinikos, Lithuania
VULSK Team

CARRE Risk Entry Sys

entry.carre-project.eu/medical_experts/MD_5

CARRE Risk entry system

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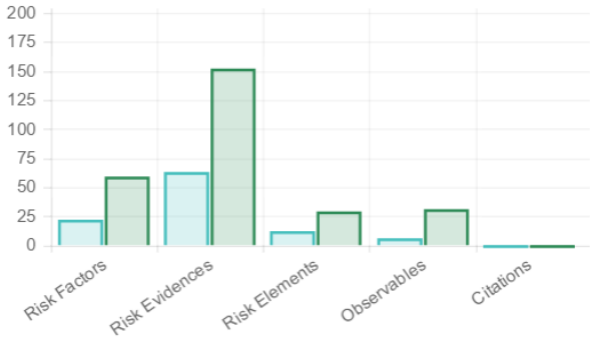
- About
- Dashboard
- Risk Factors
- Risk Evidences
- Risk Elements
- Observables
- Citations
- Measurement Types
- Medical experts

Medical Experts

Back

ID: **MD_5**



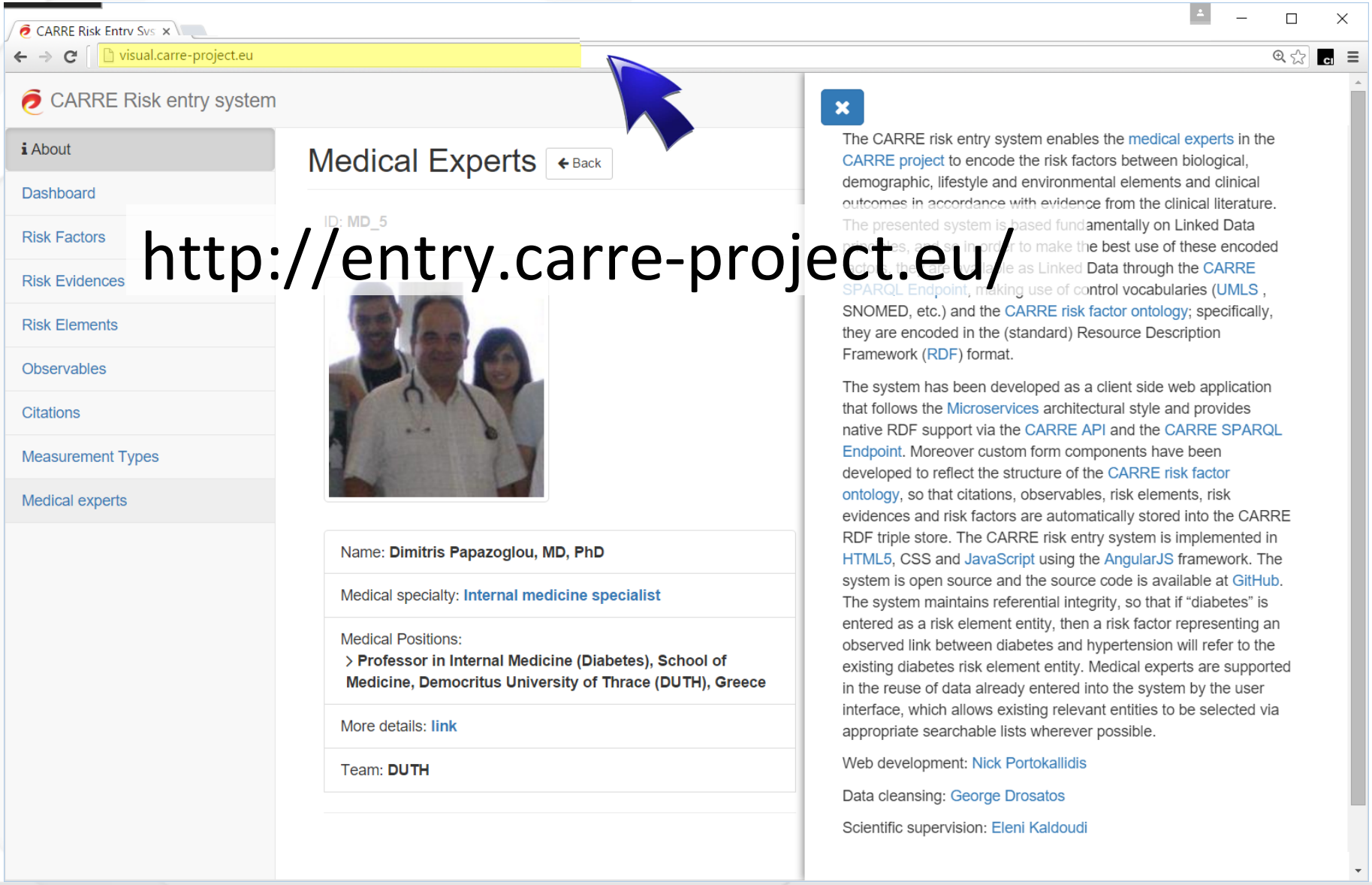
Name: **Dimitris Papazoglou, MD, PhD**

Medical specialty: **Internal medicine specialist**

Medical Positions:
> **Professor in Internal Medicine (Diabetes), School of Medicine, Democritus University of Thrace (DUTH), Greece**

More details: **link**

Team: **DUTH**


CARRE Risk Entry Sys
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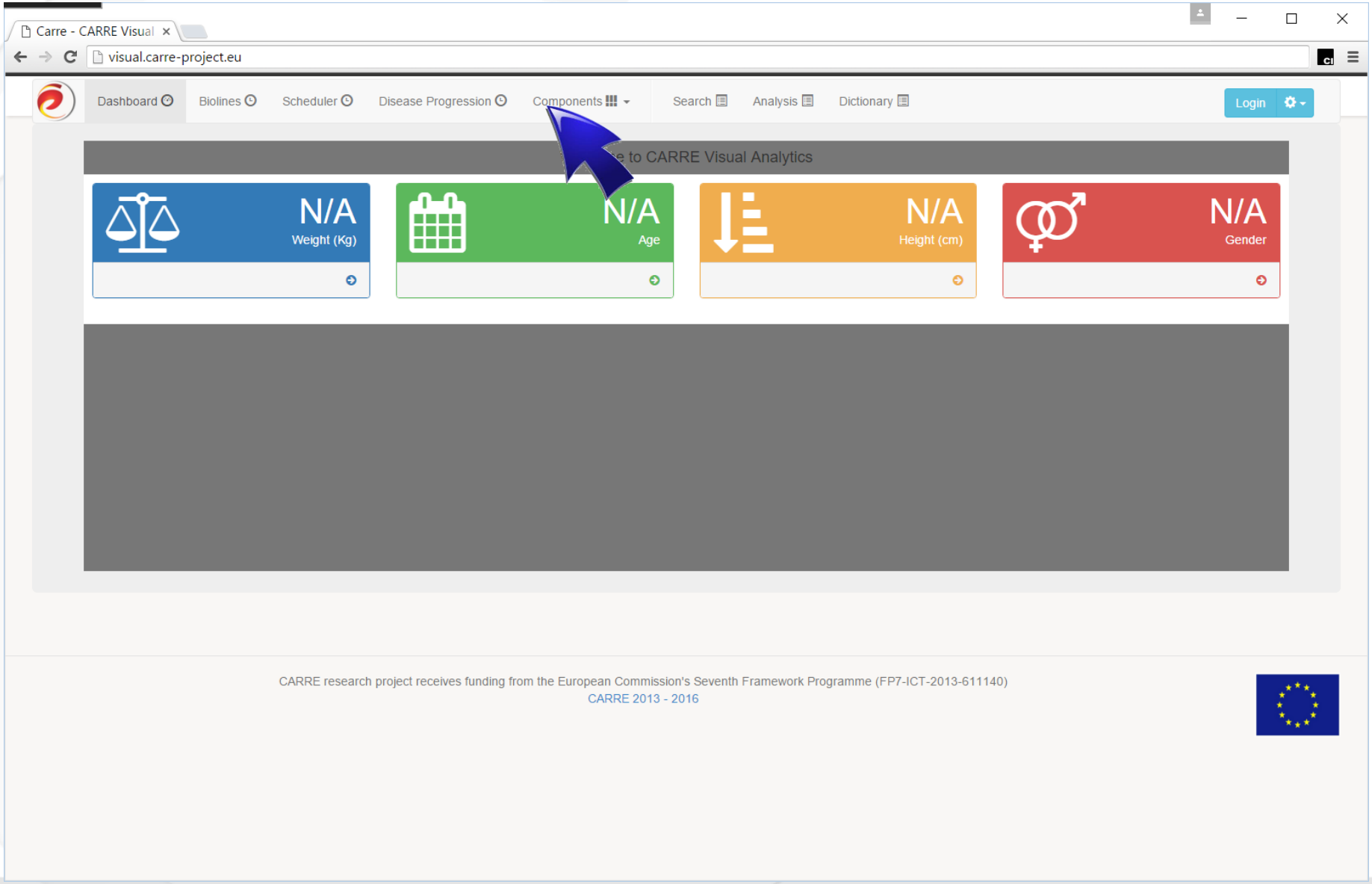
About
Dashboard
Risk Factors
Risk Evidences
Risk Elements
Observables
Citations
Measurement Types
Medical experts
Medical Experts
Back
ID: MD_5
http://entry.carre-project.eu/
Name: Dimitris Papazoglou, MD, PhD
Medical specialty: Internal medicine specialist
Medical Positions:
Professor in Internal Medicine (Diabetes), School of Medicine, Democritus University of Thrace (DUTH), Greece
More details: link
Team: DUTH
The CARRE risk entry system enables the medical experts in the CARRE project to encode the risk factors between biological, demographic, lifestyle and environmental elements and clinical outcomes in accordance with evidence from the clinical literature.
The presented system is based fundamentally on Linked Data
Data through the CARRE SPARQL Endpoint, making use of control vocabularies (UMLS , SNOMED, etc.) and the CARRE risk factor ontology; specifically, they are encoded in the (standard) Resource Description Framework (RDF) format.
The system has been developed as a client side web application that follows the Microservices architectural style and provides native RDF support via the CARRE API and the CARRE SPARQL Endpoint. Moreover custom form components have been developed to reflect the structure of the CARRE risk factor ontology, so that citations, observables, risk elements, risk evidences and risk factors are automatically stored into the CARRE RDF triple store. The CARRE risk entry system is implemented in HTML5, CSS and JavaScript using the AngularJS framework. The system is open source and the source code is available at GitHub. The system maintains referential integrity, so that if "diabetes" is entered as a risk element entity, then a risk factor representing an observed link between diabetes and hypertension will refer to the existing diabetes risk element entity. Medical experts are supported in the reuse of data already entered into the system by the user interface, which allows existing relevant entities to be selected via appropriate searchable lists wherever possible.
Web development: Nick Portokallidis
Data cleansing: George Drosatos
Scientific supervision: Eleni Kaldoudi


Carre - CARRE Visual
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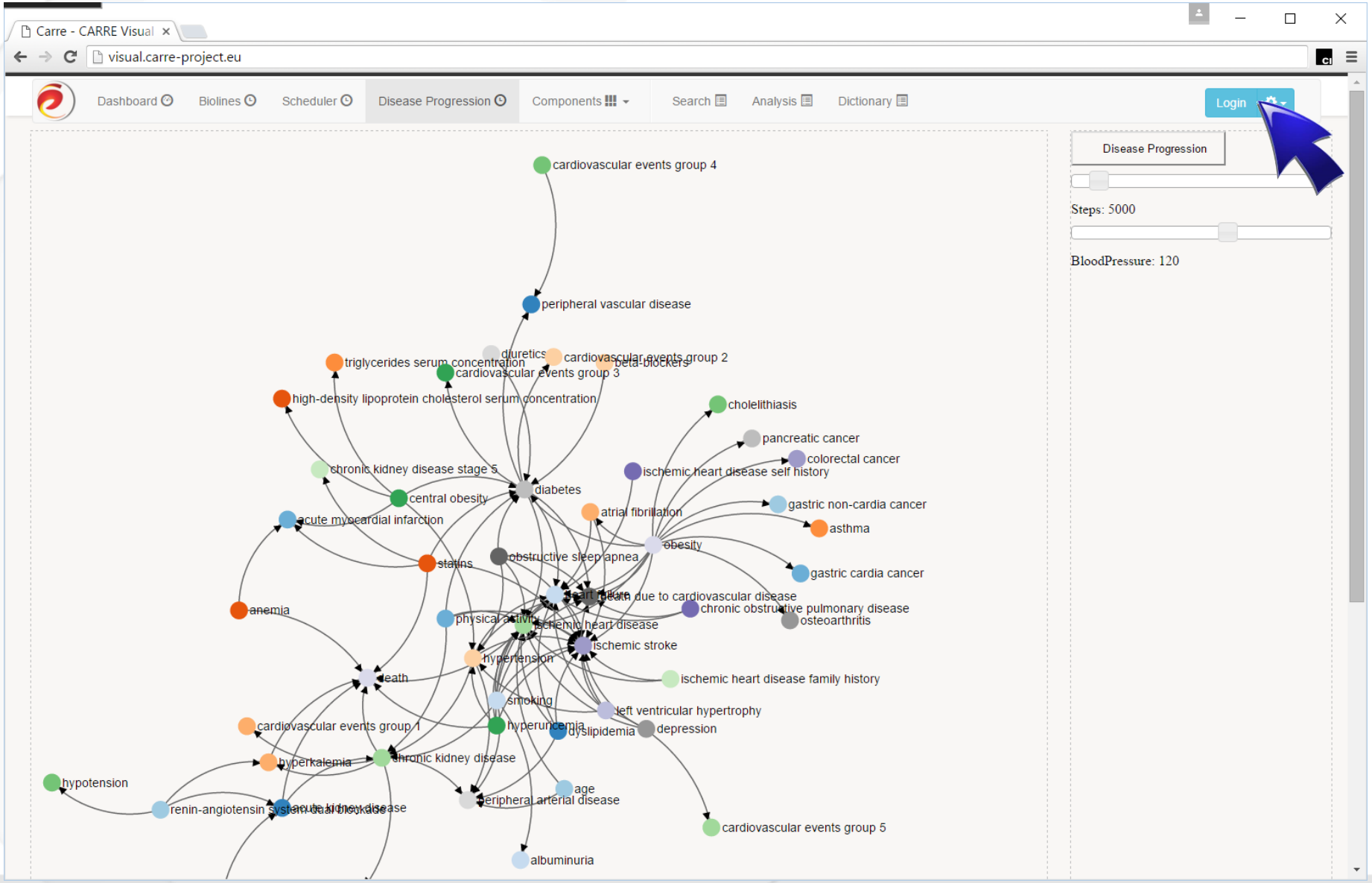
Dashboard
Biolines
Scheduler
Disease Progression
Components
Search
Analysis
Dictionary
Login
to CARRE Visual Analytics
N/A
Weight (Kg)
N/A
Age
N/A
Height (cm)
N/A
Gender
CARRE research project receives funding from the European Commission's Seventh Framework Programme (FP7-ICT-2013-611140)
CARRE 2013 - 2016



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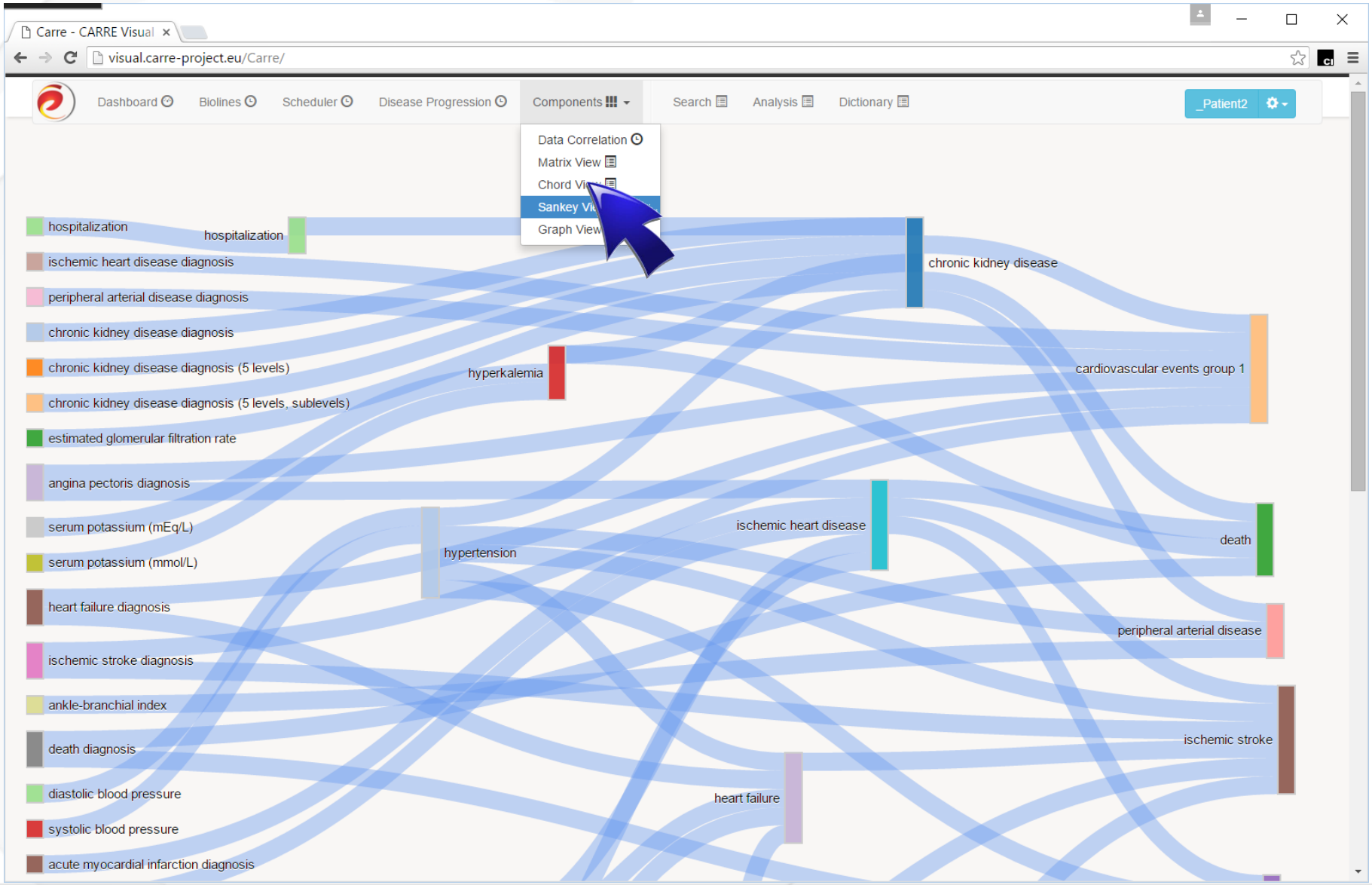
Dashboard
Biolines
Scheduler
Disease Progression
Components
Search
Analysis
Dictionary
_Patient2
Data Correlation
Matrix View
Chord View
Sankey View
Graph View
Disease Progression
Steps: 5000
BloodPressure: 120
hyperkalemia
cardiovascular events group 1
peripheral arterial disease
chronic kidney disease
hospitalization
hypertension
death
heart failure
death due to cardiovascular disease
ischemic stroke
ischemic heart disease
colorectal cancer
gastric non-cardia cancer
obesity
diabetes
pancreatic cancer
asthma
atrial fibrillation
osteoarthritis
Welcome _Patient2 to CARRE Visual Analytics
94
Weight (Kg)
70
Age
160
Height (cm)
female
Gender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Biolines
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Disease Progression
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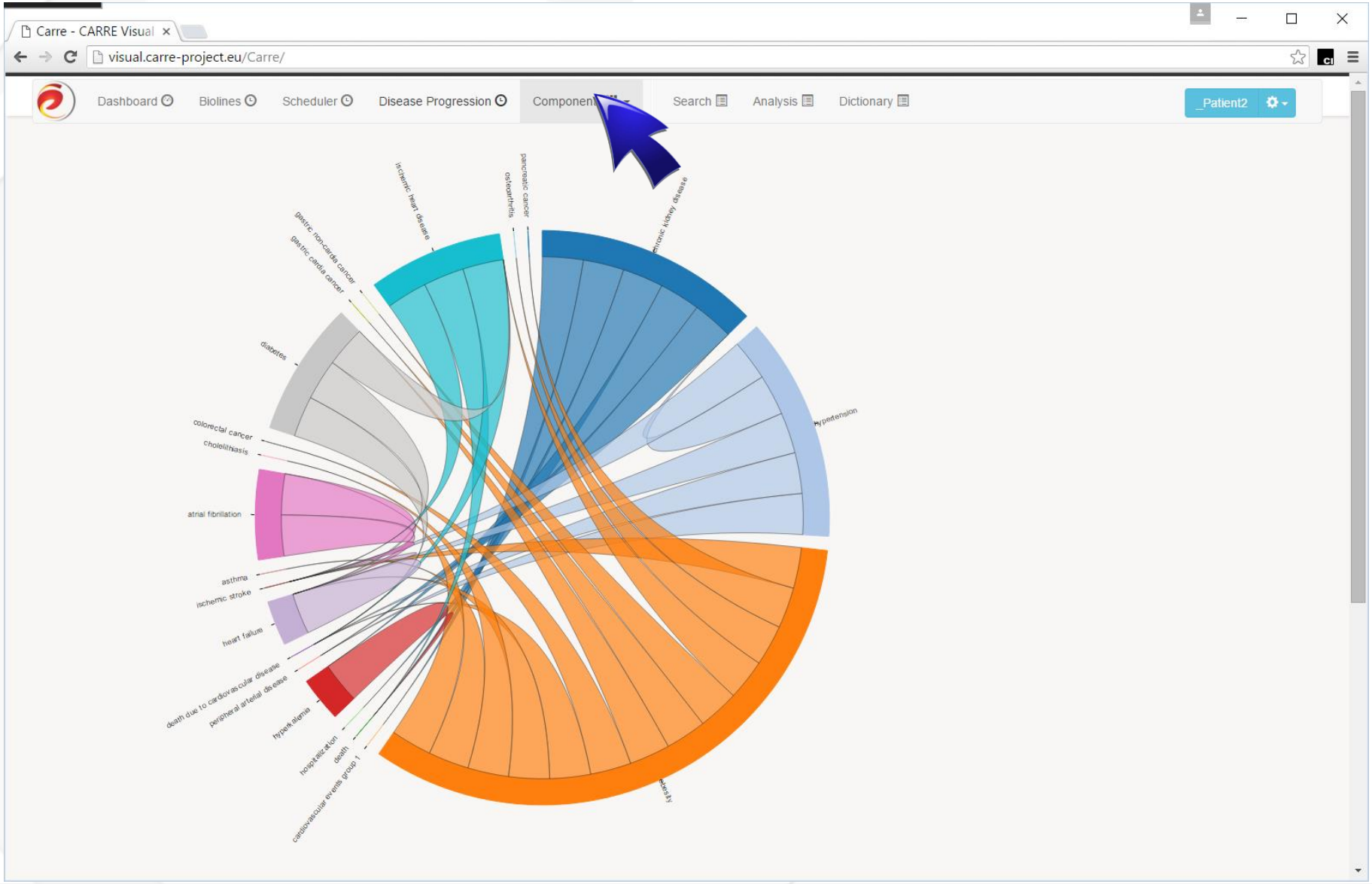
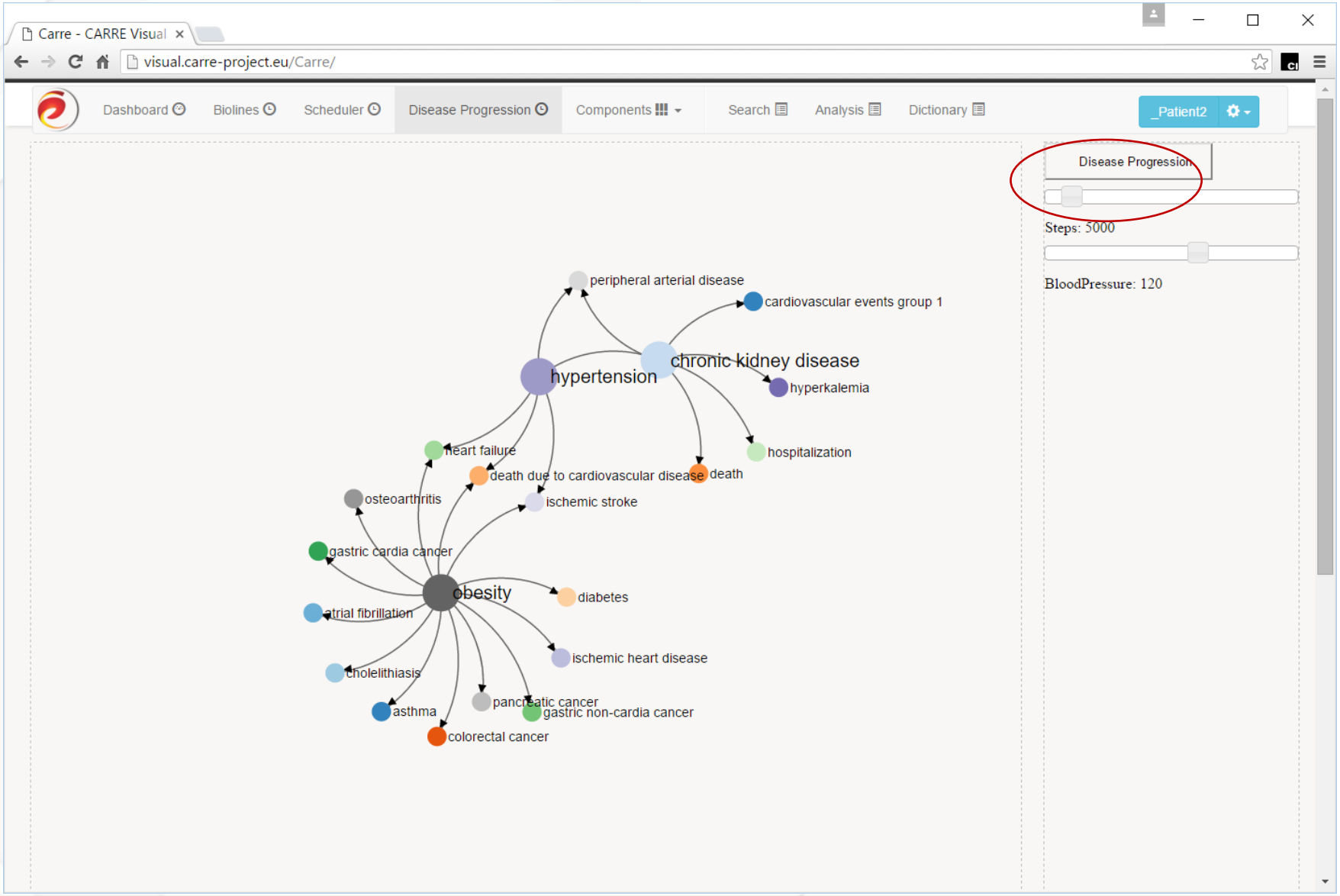
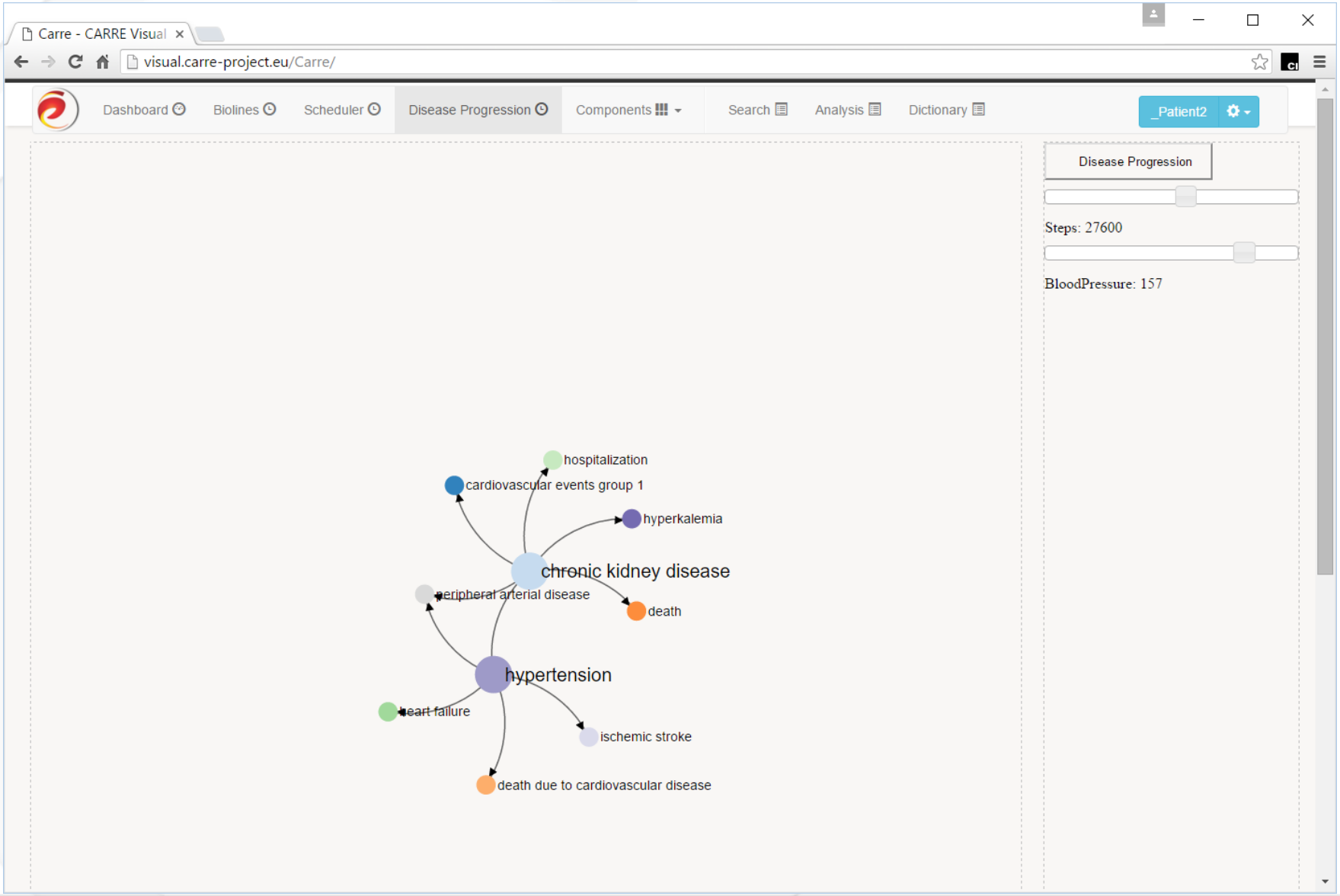
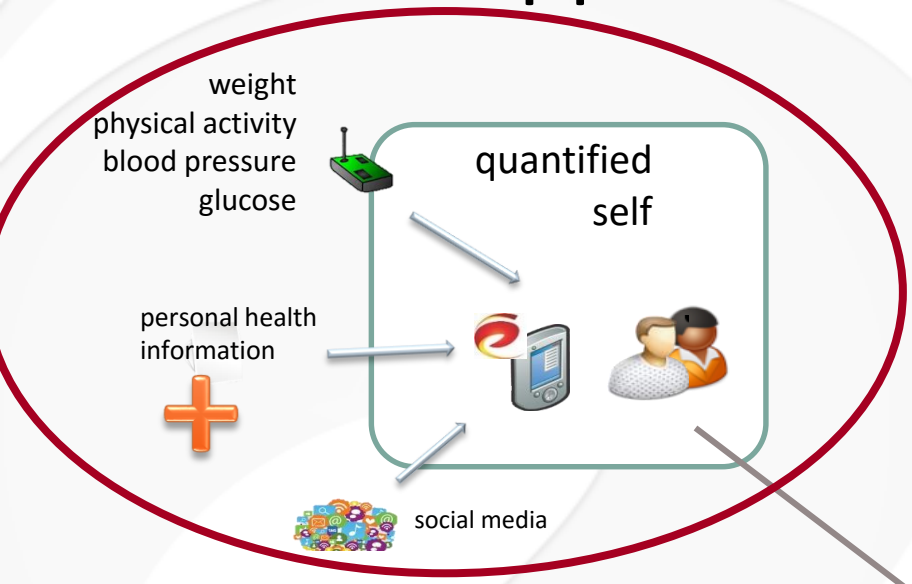
Search
Analysis
Dictionary
_Patient2
Data Correlation
Matrix View
Chord View
Sankey View
Graph View
hospitalization
ischemic heart disease diagnosis
peripheral arterial disease diagnosis
chronic kidney disease diagnosis
chronic kidney disease diagnosis (5 levels)
chronic kidney disease diagnosis (5 levels, sublevels)
estimated glomerular filtration rate
angina pectoris diagnosis
serum potassium (mEq/L)
serum potassium (mmol/L)
heart failure diagnosis
ischemic stroke diagnosis
ankle-branchial index
death diagnosis
diastolic blood pressure
systolic blood pressure
acute myocardial infarction diagnosis
hospitalization
hyperkalemia
hypertension
ischemic heart disease
heart failure
chronic kidney disease
cardiovascular events group 1
death
peripheral arterial disease
ischemic stroke

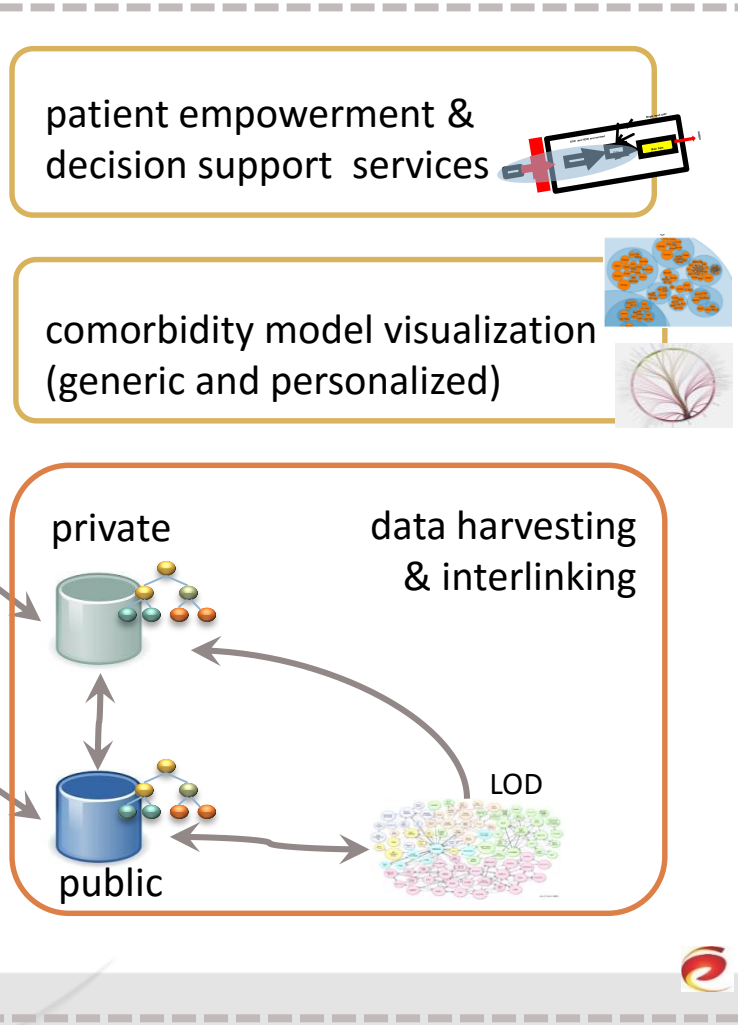

Carre - CARRE Visual
visual.carre-project.eu/Carre/
Dashboard
Biolines
Scheduler
Disease Progression
Search
Analysis
Dictionary
_Patient2
ischemic heart disease
pancreatic cancer
osteoarthritis
chronic kidney disease
gastric non-cardia cancer
gastric cardia cancer
diabetes
hypertension
colorectal cancer
cholelithiasis
atrial fibrillation
asthma
ischemic stroke
heart failure
death due to cardiovascular disease
peripheral arterial disease
hyperkalemia
hospitalization
death
cardiovascular events group 1

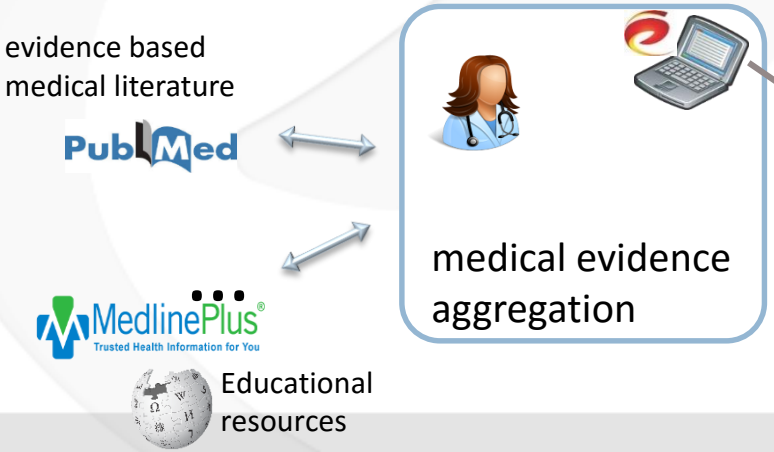

Carre - CARRE Visual
visual.carre-project.eu/Carre/
Dashboard
Biolines
Scheduler
Disease Progression
Components
Search
Analysis
Dictionary
_Patient2
Disease Progression
Steps: 5000
BloodPressure: 120
peripheral arterial disease
cardiovascular events group 1
chronic kidney disease
hypertension
hyperkalemia
hospitalization
heart failure
death due to cardiovascular disease
death
osteoarthritis
ischemic stroke
gastric cardia cancer
obesity
diabetes
atrial fibrillation
ischemic heart disease
cholelithiasis
pancreatic cancer
asthma
gastric non-cardia cancer
colorectal cancer


Carre - CARRE Visual
visual.carre-project.eu/Carre/
Dashboard
Biolines
Scheduler
Disease Progression
Components
Search
Analysis
Dictionary
_Patient2
Disease Progression
Steps: 27600
BloodPressure: 157
hospitalization
cardiovascular events group 1
hyperkalemia
chronic kidney disease
peripheral arterial disease
death
hypertension
heart failure
ischemic stroke
death due to cardiovascular disease

CARRE approach







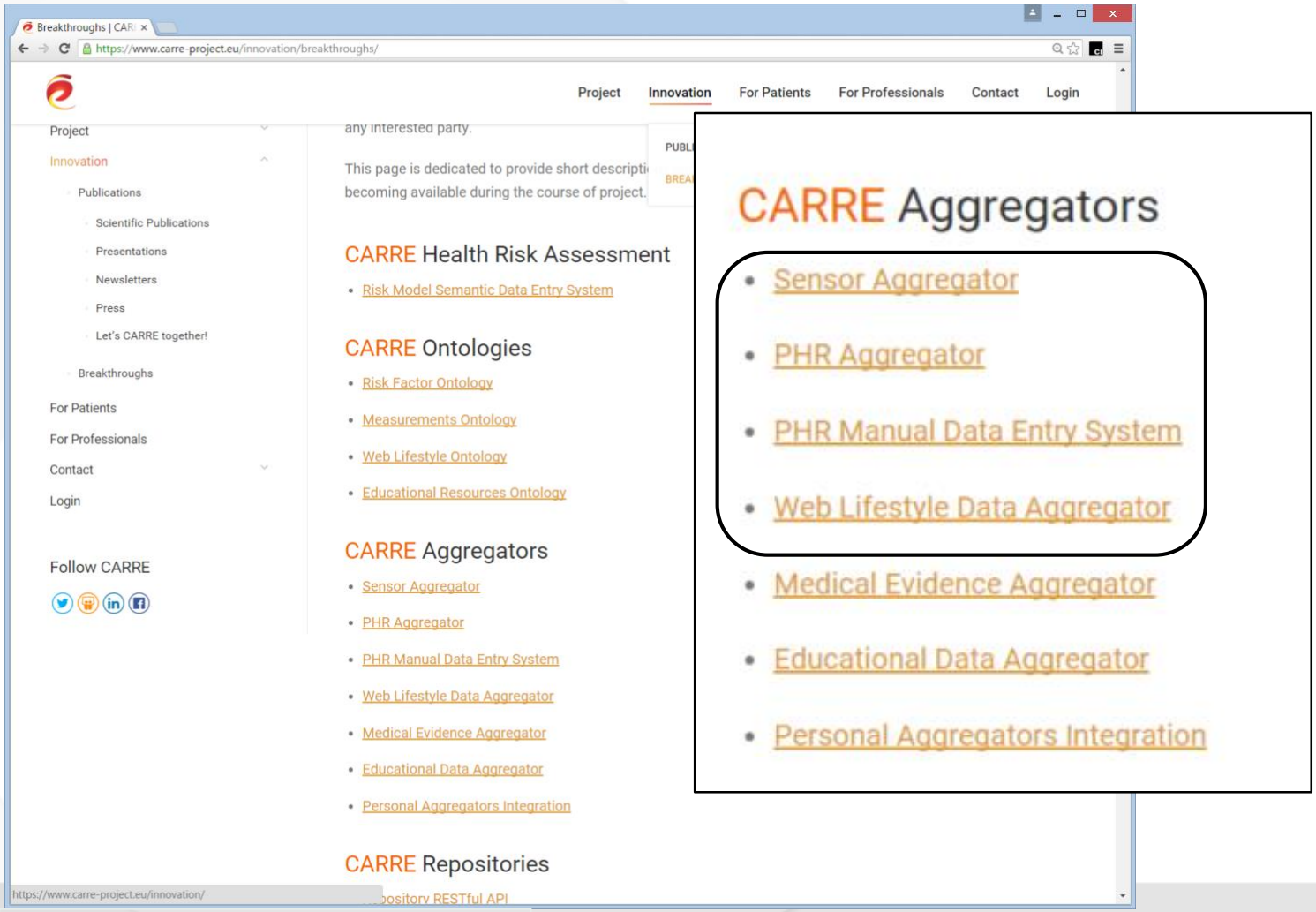
personal data aggregators (WP3)

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

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

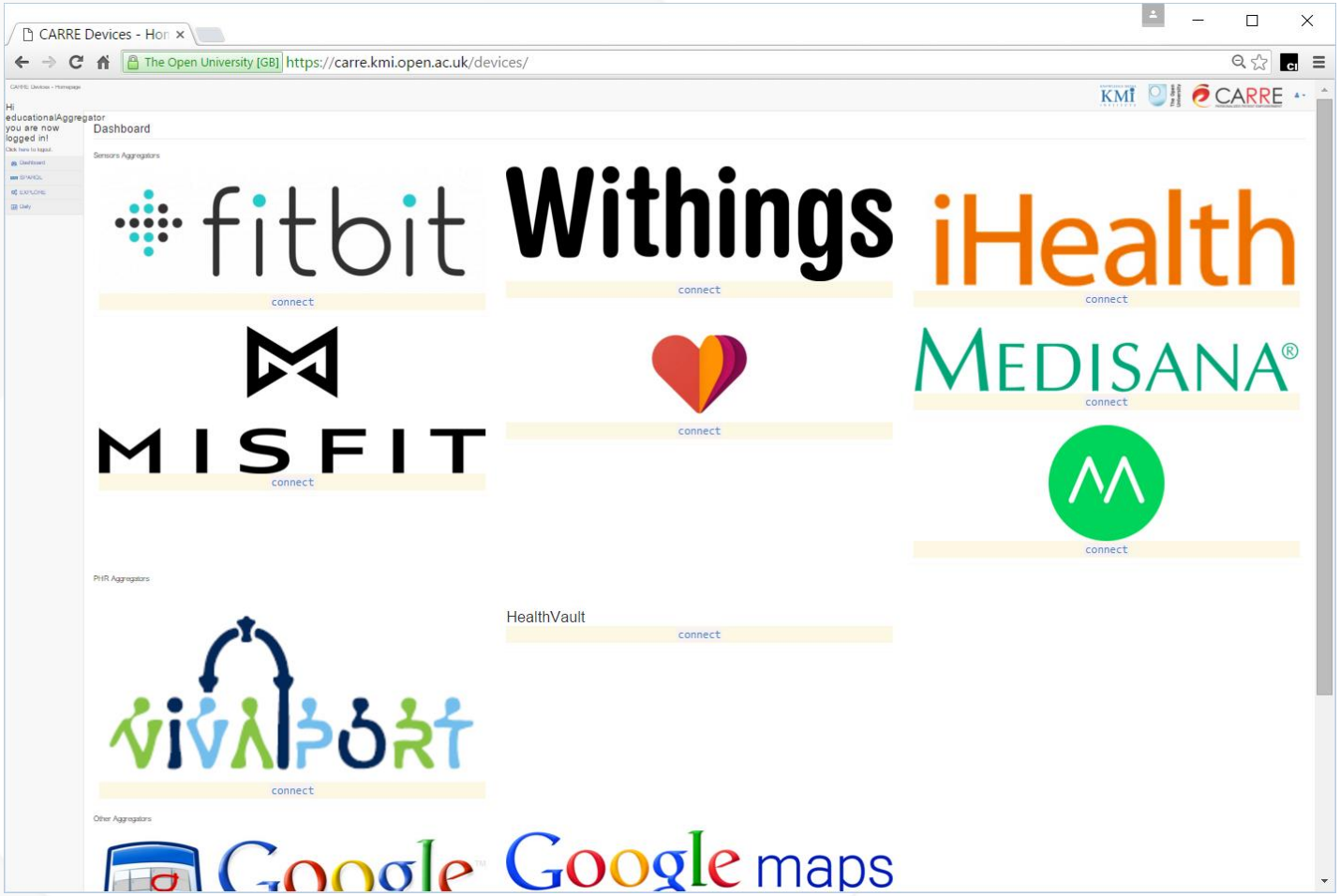
project site → innovation → breakthroughs

https://www.carre-project.eu/innovation/breakthroughs/



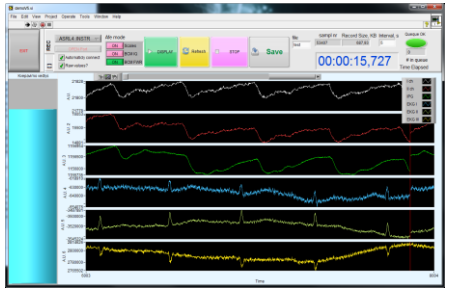
CARRE D.3..2 & D.3.3, 2015

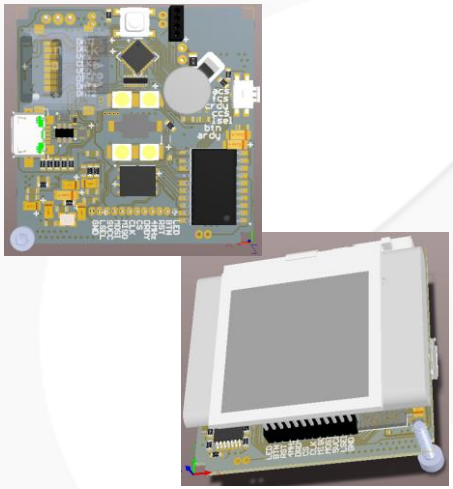
aggregator integration
https://carre.kmi.open.ac.uk/devices/

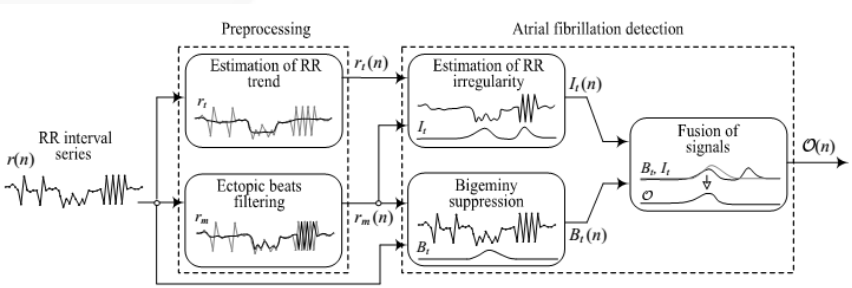


CARRE sensor innovation

- multiparametric CARRE Weight Scale - body fluid balance monitoring, other parameters
- ECG aggregator – atrial fibrillation detection
- CARRE Wristwatch – heart arrhytmia detection, …







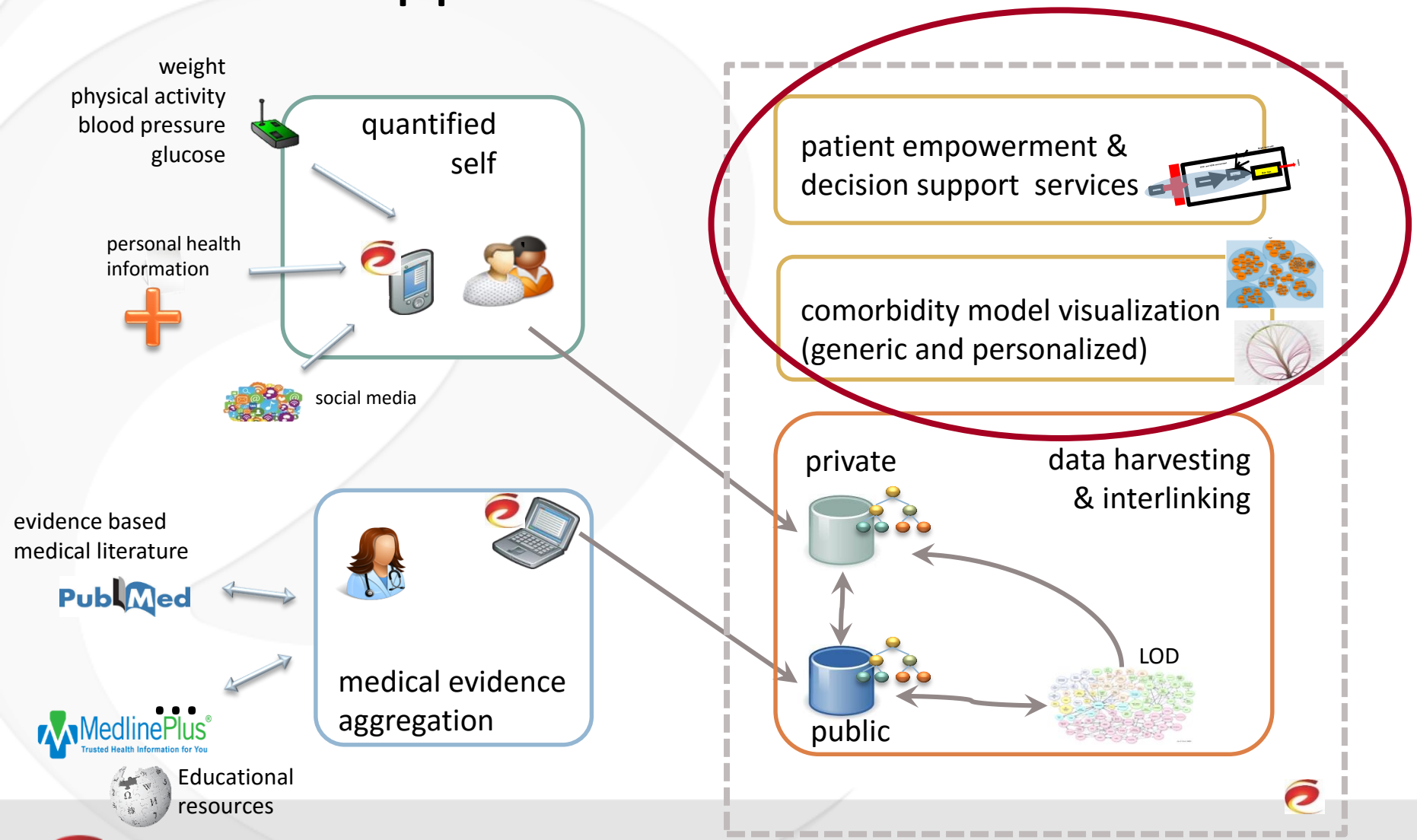
Paliakaite B., Daukantas S., Sakalauskas A., Marozas V., "Estimation of pulse arrival time using impedance plethysmogram from body composition scales," in *Sensors Applications Symposium (SAS), 2015 IEEE*, pp.1-4, 13-15 April 2015

Paliakaitė B., Daukantas S., Marozas V., Assessment of Pulse Arrival Time for Arterial Stiffness Monitoring on Body Composition Scales, Computers in Biology and Medicine, submitted to special issue: Self-monitoring systems for personalized health-care and lifestyle surveillance, 05/10/2015.

Petrenas, V. Marozas, L. Sörnmo, Low-complexity detection of atrial fibrillation in continuous long-term monitoring, Computers in Biology and Medicine, vol. 35, iss. 47, pp. 3365-3376, 2015.

Stankevicius et al. „Photoplethysmography based system for atrial fibrillation detection during hemodialysis“, submited to Medicon 2016

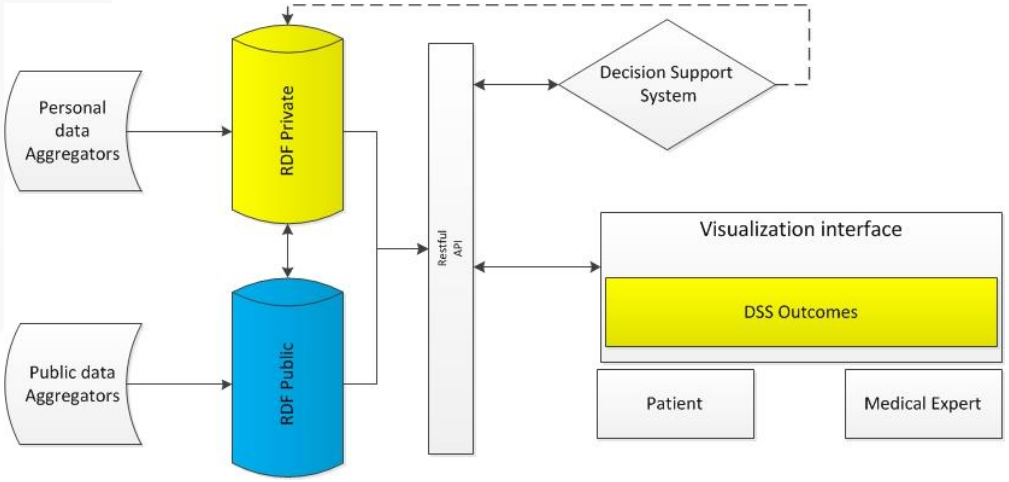
CARRE approach

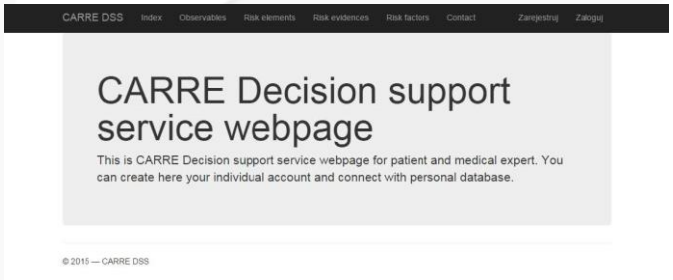


decision support services

interlace personal data and medical evidence for personalized services to

- plan
- monitor
- alert
- educate

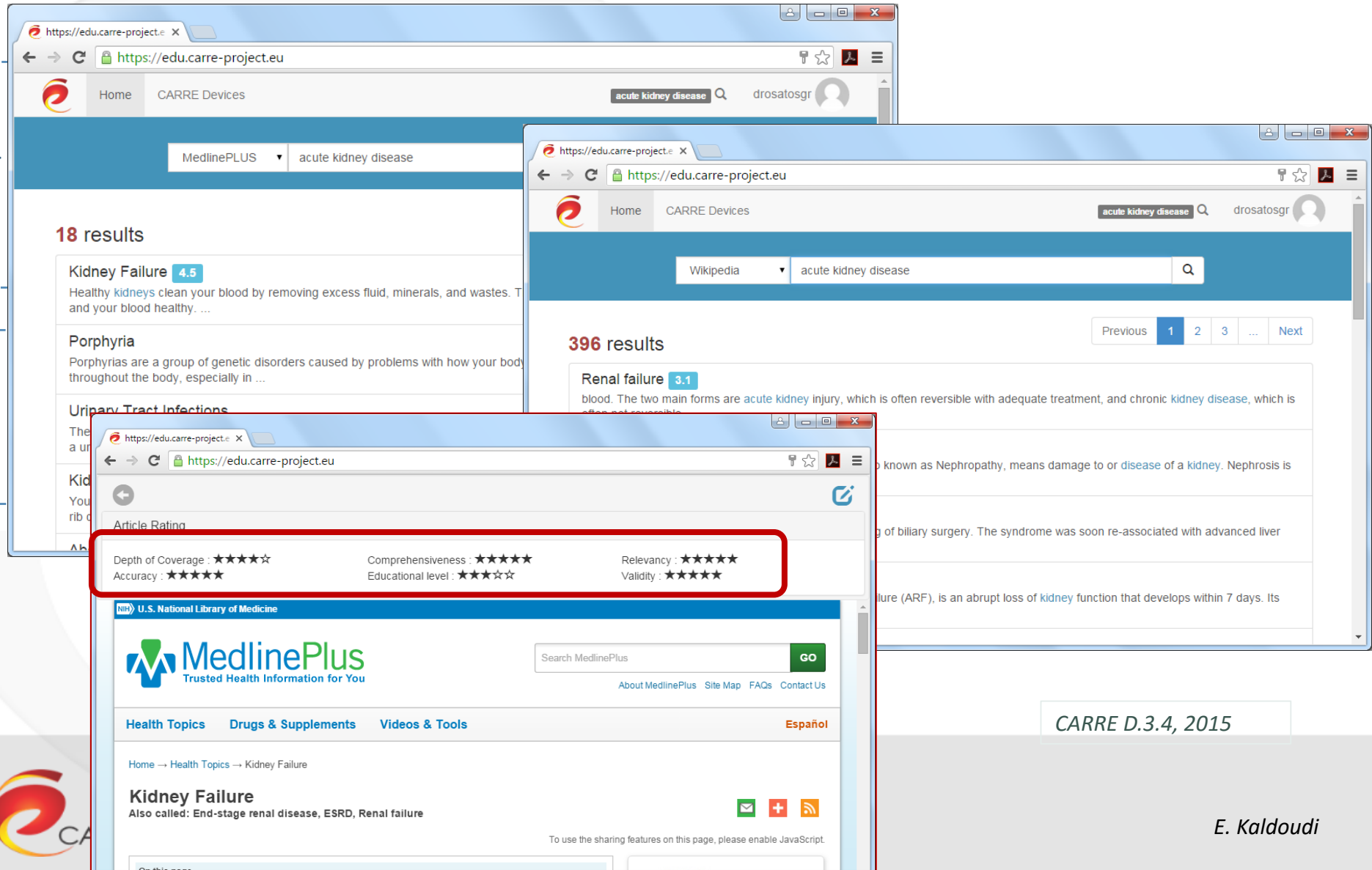




CARRE D.6.2 & D.6.3, 2016 (in progress)

educational aggregator

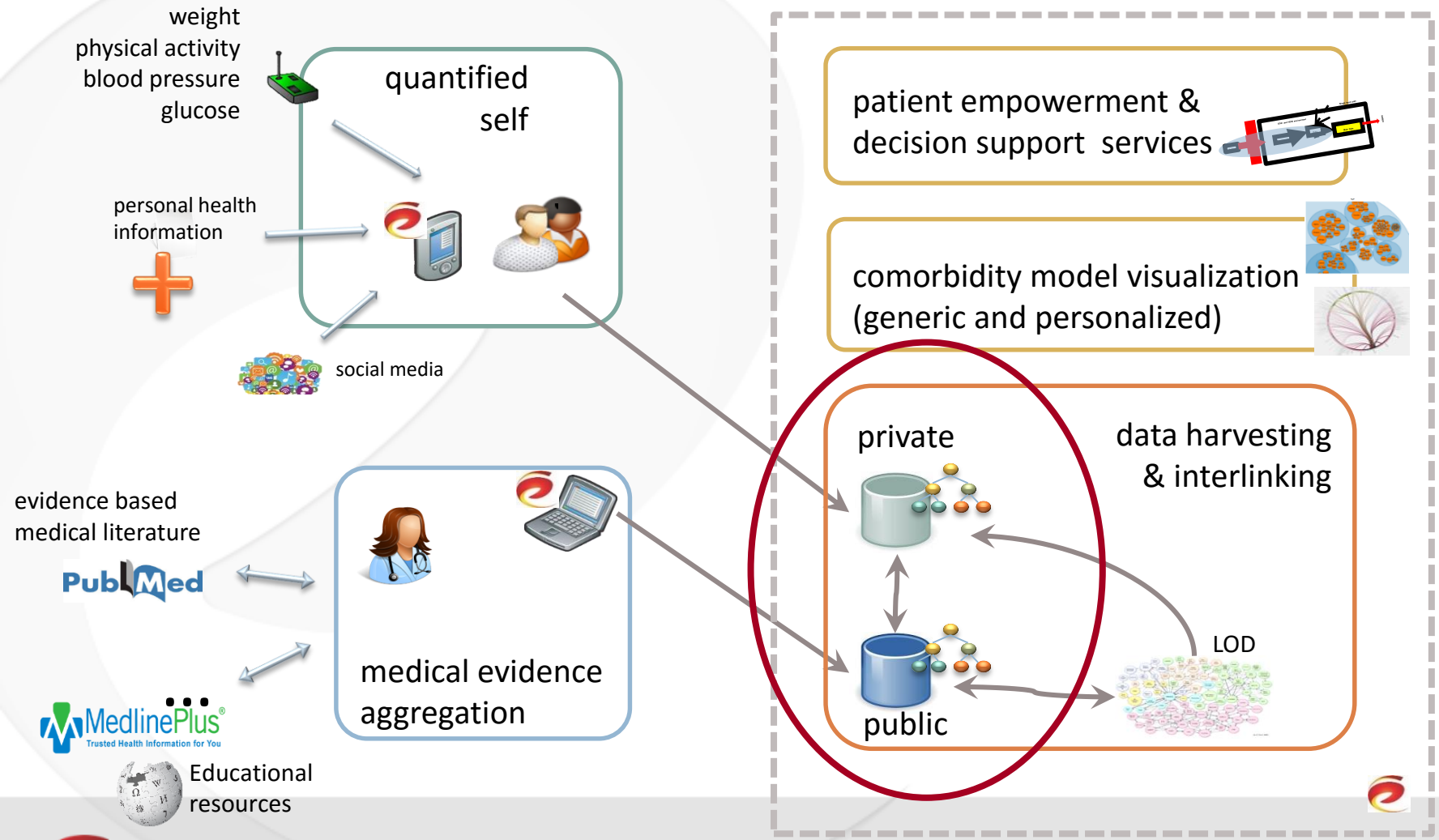
https://edu.carre-project.eu/



CARRE D.3.4, 2015

E. Kaldoudi

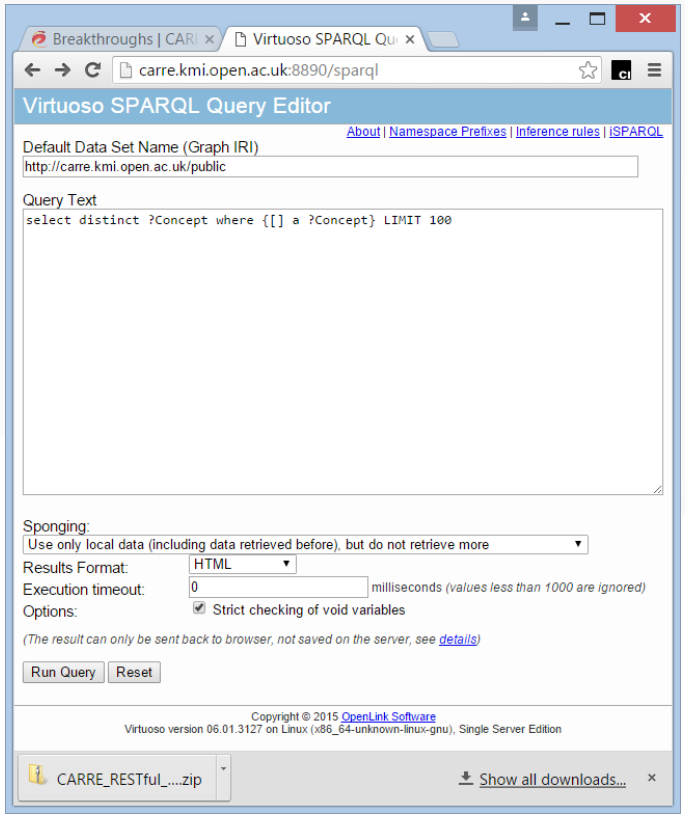
CARRE approach

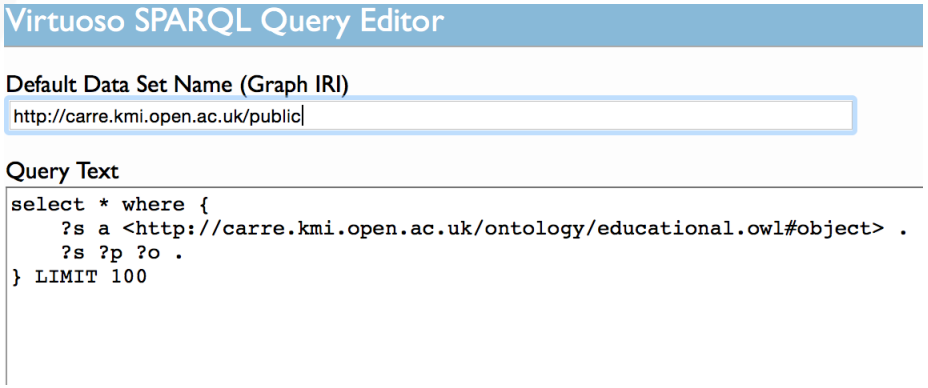


project site → innovation → breakthroughs

https://www.carre-project.eu/innovation/breakthroughs/

public RDF SPARQL endpoint





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#websource	"wikipedia"^^<http://www.w3.org/2001/XMLSchema#string>
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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
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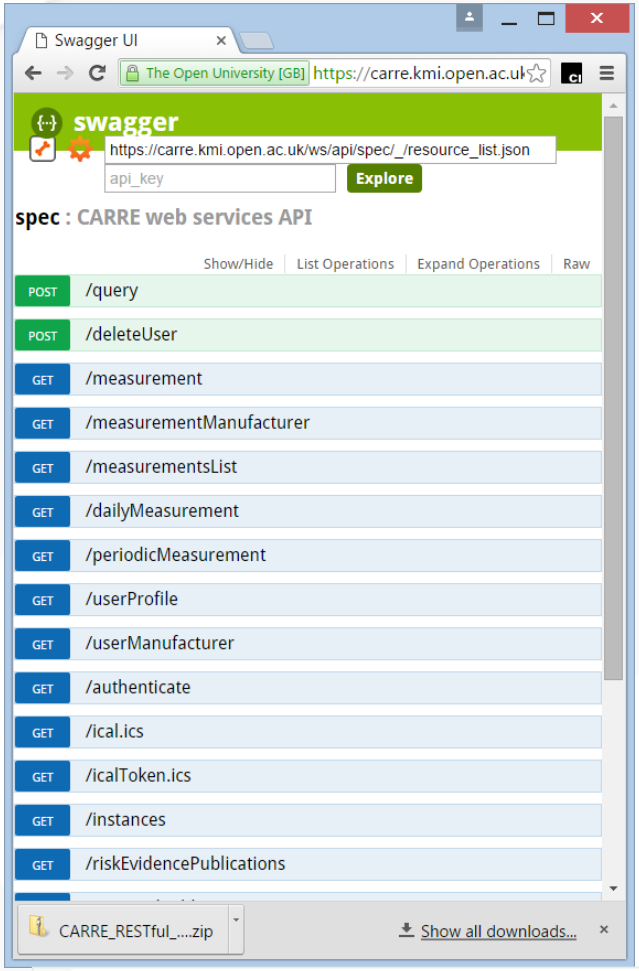
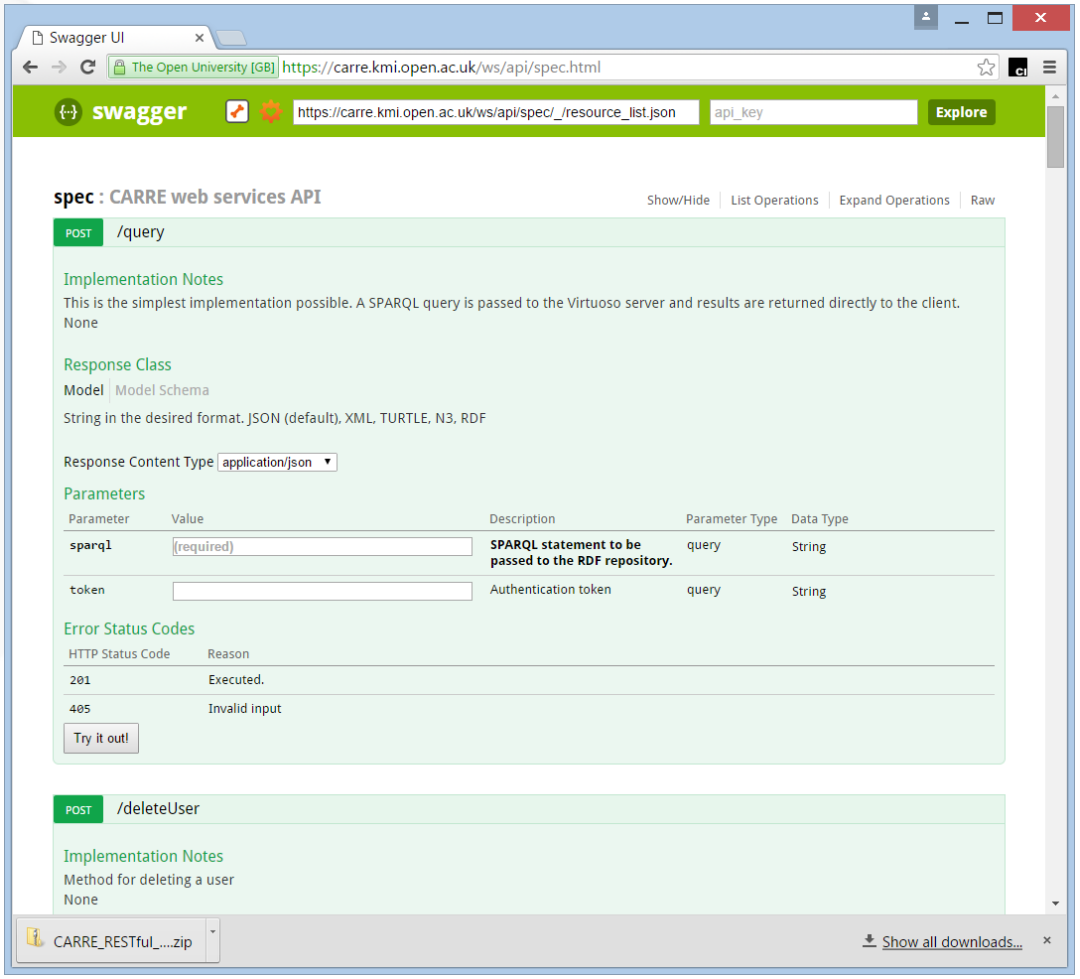
http://carre.kmi.open.ac.uk/beta/educational/bedc4c16-ad7e-4052-bf69-156dfd60e136	http://carre.kmi.open.ac.uk/ontology/educational.owl#views	5
http://carre.kmi.open.ac.uk/beta/educational/bedc4c16-ad7e-4052-bf69-156dfd60e136	http://carre.kmi.open.ac.uk/ontology/educational.owl#date_accepted	2015-03-03
http://carre.kmi.open.ac.uk/beta/educational/bedc4c16-		"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 sho 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 happe

restful API





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

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

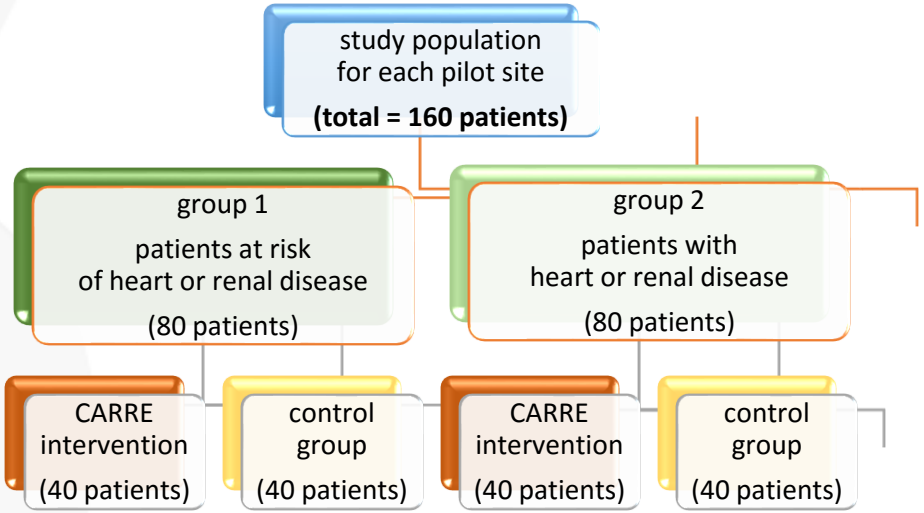
***** *based on the model proposed by Cornford, T., Doukidis, G.I., and Forster, D., Int. J. Manag. Science, 22(5), 491-504, 1994*

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

CARRE D.7.4, 2016 (in progress)

what?

CARRE

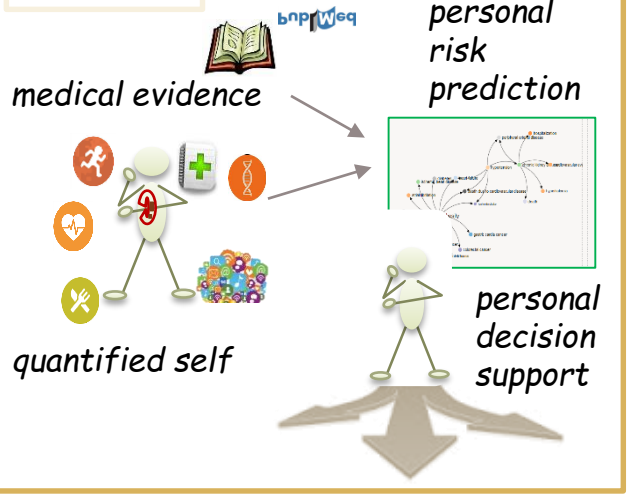
EU FP7-ICT-2013-611140
3.2M, 2013-2016
DUTH, OU, BED, VULSK, KTU, PIAP

why?

cardiorenal disease

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

how?

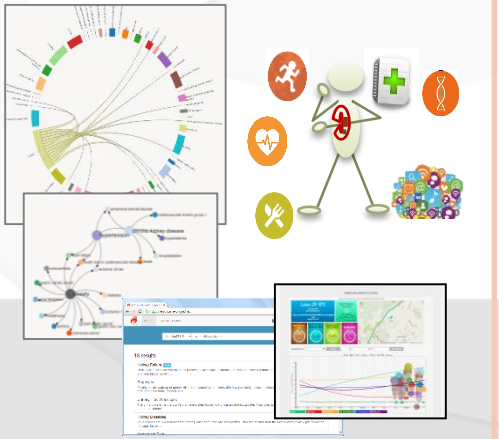


http://carre-project.eu

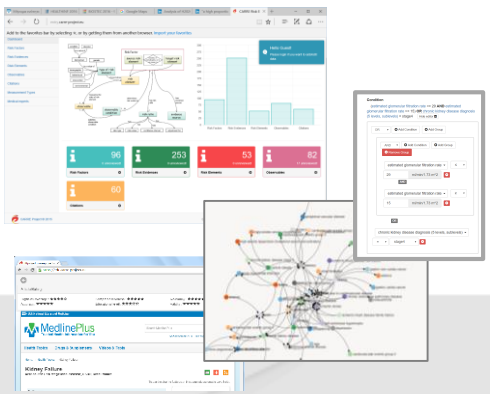
CARRE

Personalized patient empowerment and shared decision support for cardiorenal disease and co\morbidities

for the patient

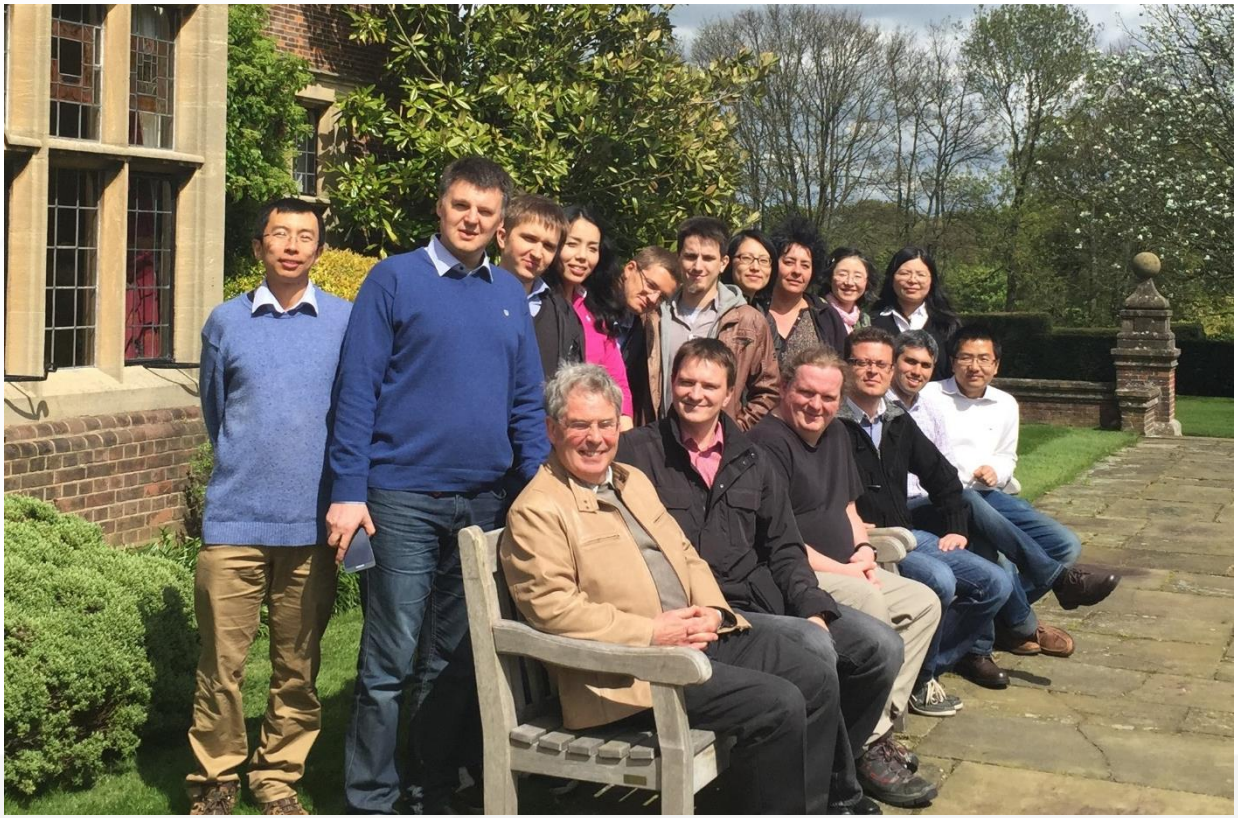


for the medical expert



for the ICT expert

thank you !!!



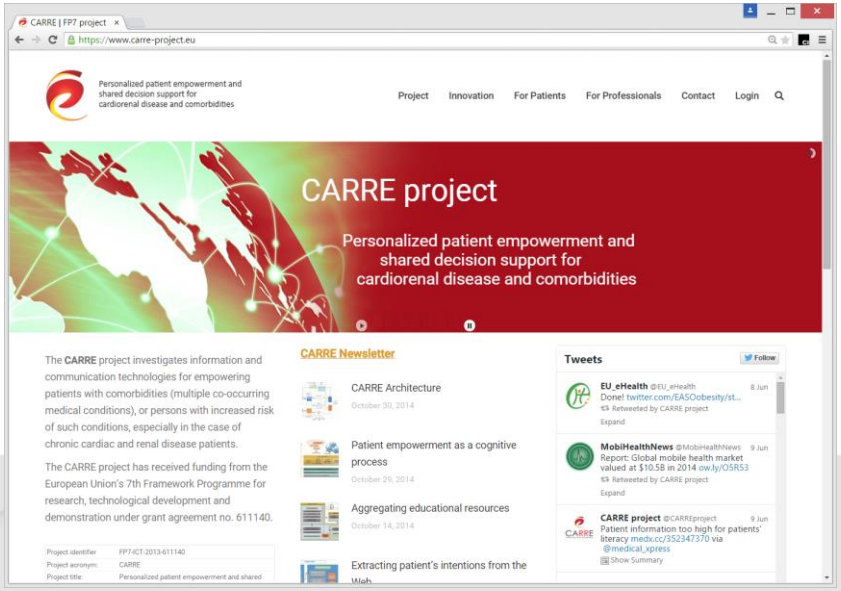
acknowledgment

work funded under project CARRE

co-funded by the
European Commission under the
Information and Communication Technologies (ICT)
7th Framework Programme
Contract No. FP7-ICT-2013-611140

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

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



Cite as

Eleni Kaldoudi

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

Presentation & Demo

HealthInf 2016: 9th International Conference on Health Informatics, part of BIOSTEC, Rome, Italy, 21-23 February, 2016

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