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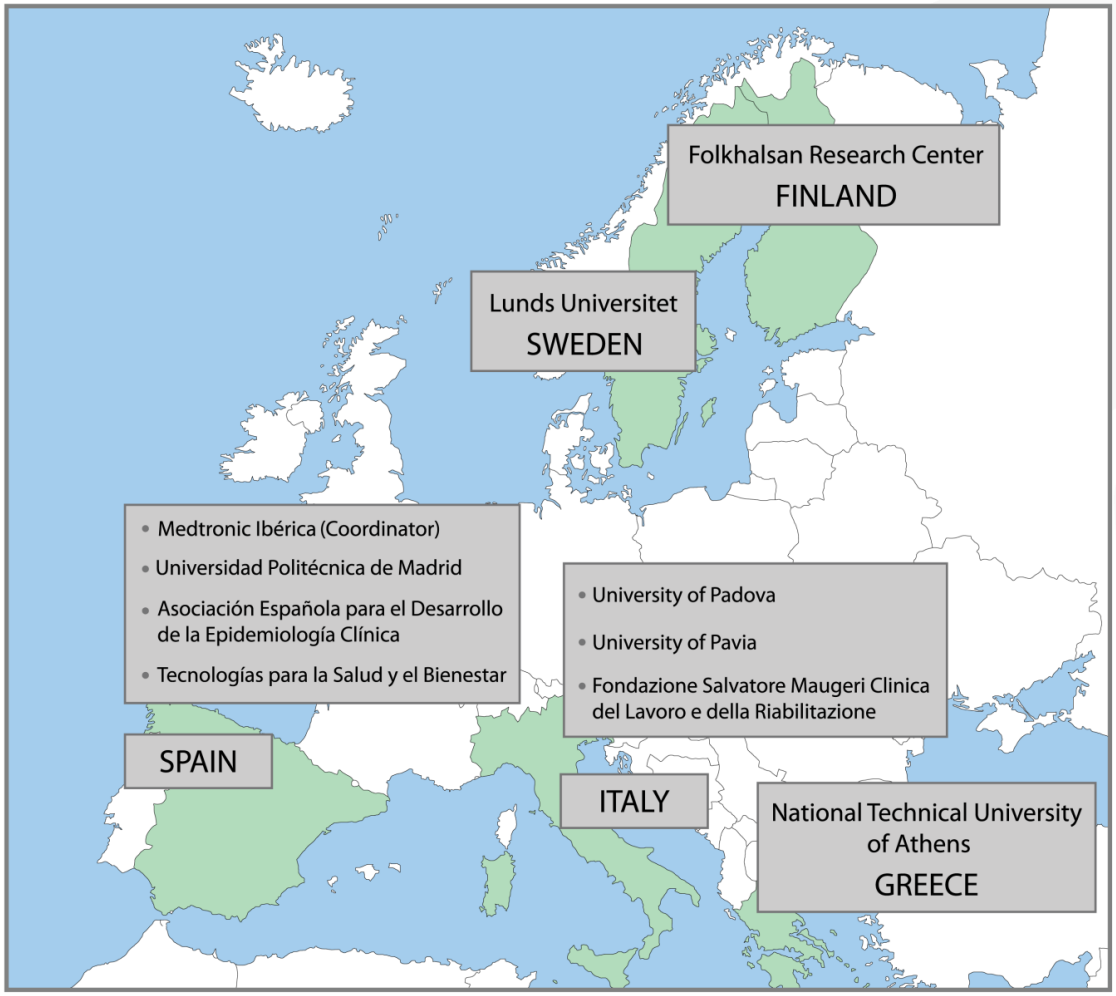
Models and simulation techniques for discovering diabetes influence factors

MOSAIC overview

Consortium presentation

Co-funded by the European Union

EU-funded European ICT project carried out within the 7th Framework Program



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Diabetes Figures

- **382 million** people have diabetes in 2013; by 2035 this will have risen to **592 million**
- The number of people with **type 2 diabetes is increasing** in every country
- **80%** of people with diabetes live in **low- and middle-income countries**
- The **greatest number** of people with diabetes are between **40 to 59** years of age
- **175 million** people (50%) with diabetes are **undiagnosed**
- Diabetes caused **5.1 million deaths** in 2013
- Diabetes caused at least **USD 548 billion dollars** in healthcare expenditures in 2013; **11% of total healthcare expenditures** in adults (20-79 years)
- **79,000 children** develop **type 1 diabetes** every year

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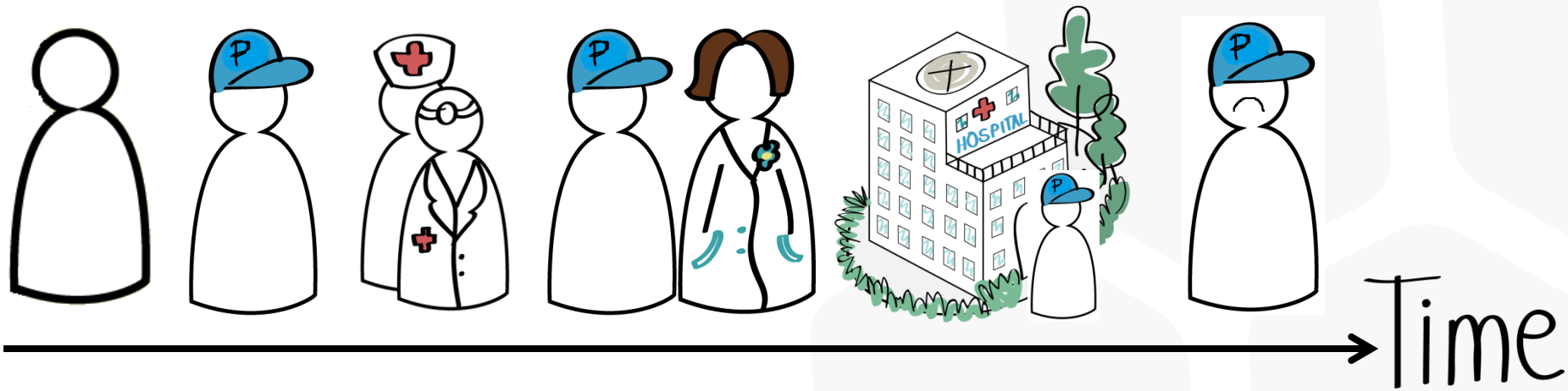
T2DM Diabetes Pathway

MOSAIC (Characterization of the patients and the disease evolution) → Intervention



Healthy… At Risk | Onset | Diagnose | Treatment and follow up | Complications and hospitalizations | Continuous deteroration

MOSAIC (Detection) → Intervention

Sometimes diagnose comes here

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Objectives

1. **Early diagnosis of T2DM and prediabetic states**
2. **Improve characterization of the aforementioned patients**
3. **Evaluate the risk of**
   - **Developing T2DM and prediabetes**
   - **Developing associated complications**

Integrating these into the MOSAIC management tool:

- Stratification of the population at risk
- Personalized treatments and definition of the care pathways
- Enhanced professional decision support systems.

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Databases

Probabilistic models

Population studies (VIVA, Botnia PPP, Botnia BPS) retrosprective data

- Identification of variables of interest and fusion of the three datasets
- Bootstrapped Bayesian Networks analysis to find relations between known and potential T2DM risk factors

Continuous Glucose Monitoring Dataset (Opt2mize, METABO)

- Identify optimum indices of glucose variability

Temporal data mining model

- From the longitudinal hospital records
- To improve monitoring of diabetic patients and predict its complications

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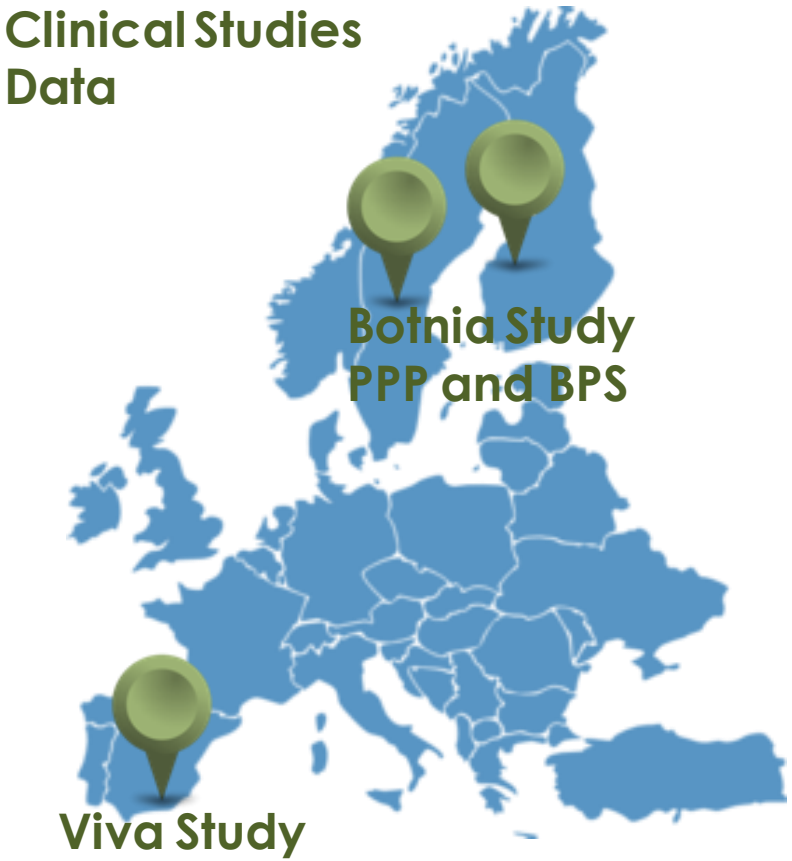
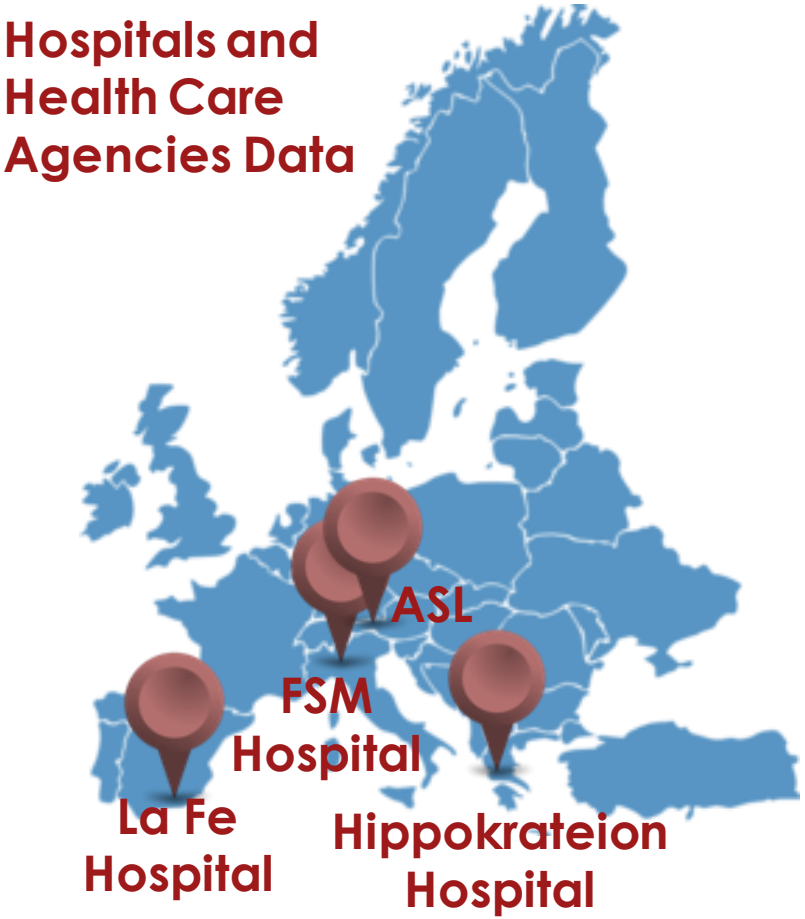
Data Centres





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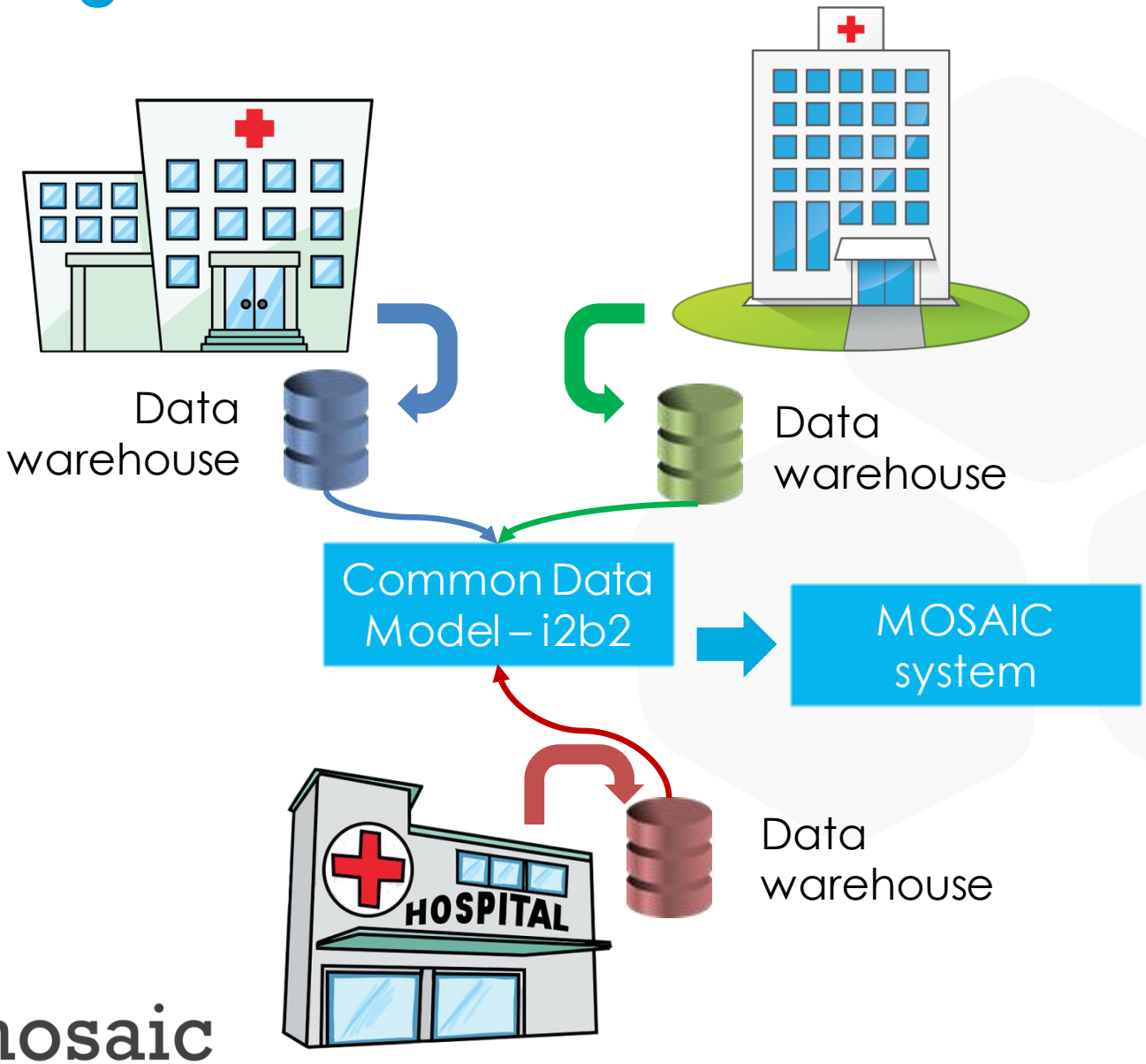
Data integration architecture



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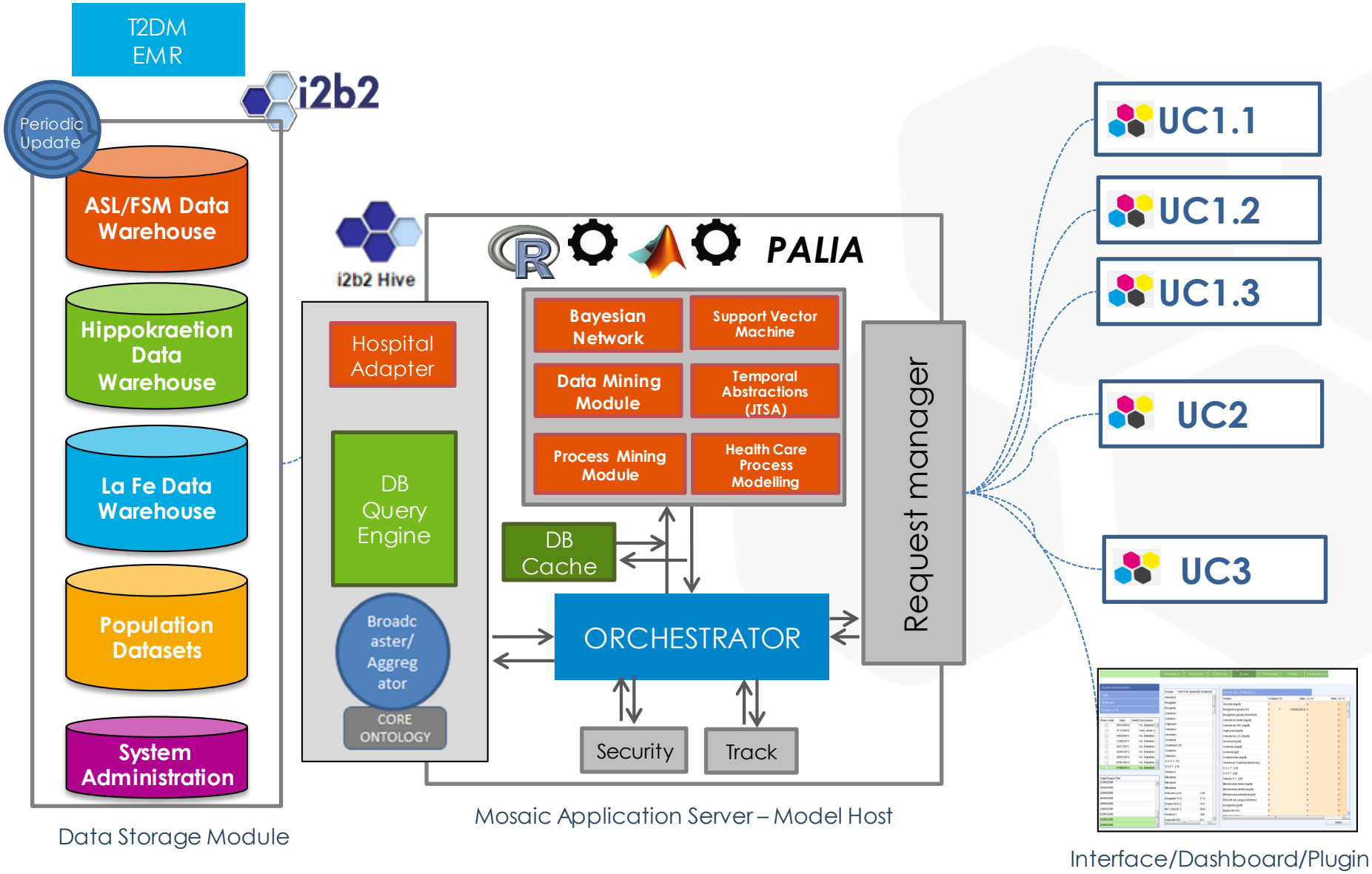
Architecture Schema



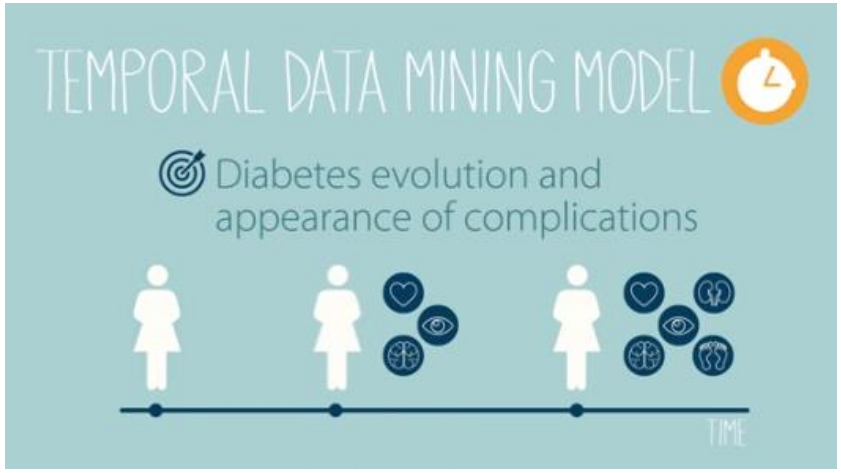
Predictive models developed

Cox Regression Model

It reveals the **risk** of a patient or a population of **developing Type 2 diabetes** in the next 2-12 years.

Bayesian Network

It reveals if an individual patient is **diabetic** and is **currently undiagnosed**.



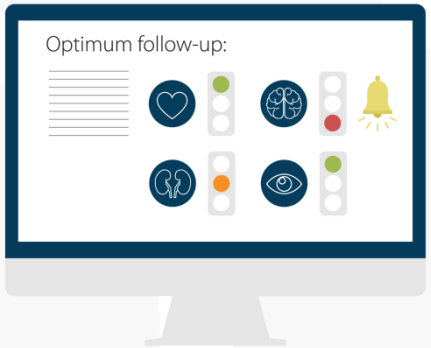
Logistics and Naïve Bayes regressions

- **Retinopathy, neuropathy and kidney disease** in the next **3, 5 and 7 years** from the **first visit in the hospital.**
- **Temporary data mining** to find relevant patterns for the **prevention of complications.**

MOSAIC results: TOOLS

TOOL 1 - PREVENTION AND RISK DETECTION OF TYPE 2 DIABETES MELLITUS

TOOL 2 - PREVENTION AND ANALYSIS OF COMPLICATIONS IN TYPE 2 DIABETIC PATIENTS



TOOL 3 – DECISSION SUPPORT SYSTEM IN FOLLOW-UP VISITS

TOOL 4 – DIAGNOSIS OF TYPE 2 DIABETES

TOOL 5 - MOSAIC PATIENT TOOL

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TOOL 1 - PREVENTION AND RISK DETECTION OF TYPE 2 DIABETES MELLITUS

1st STEP

User: Prevention / Health Care Coordination / Ministry of Health

- In a given geographic area (eg, Madrid), users can select by hospital and see the population they have. They can also apply filters to select the type of population to analyze.
- After this, the system provides percentages of the population assigned to selected hospitals at risk of developing TD2M (Cox regression model).
- The tool, as currently conceived, is enable to send a report to healthcare managers, informing the population at risk belongs to their hospitals.

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TOOL 1 - PREVENTION AND RISK DETECTION OF TYPE 2 DIABETES MELLITUS

Users: Prevention/Health Care Coordinators/Insurers/Private hospitals

Regions

- Valencia
  - [x] Hospital la Fe
  - [ ] Hospital General
- Pavia
  - [ ] ASL
  - [ ] FSM
- Athens
  - [ ] Hippocrateon

Centers

Name	Patients	Doctors	Nurses	Services	Region
Hospital la Fe	10750	65	20	6	Valencia
Total:	**10750**	**65**	**20**	**6**	

Filters

None

Gender
- (•) Both
- ( ) Male
- ( ) Female

Age
- (•) All
- ( ) 0-20
- ( ) 20-40
- ( ) 40-60
- ( ) 60-80
- ( ) +80

Education Level
- (•) All

BMI
- (•) All
- ( ) <20 - Underweight
- ( ) 20-25 - Normal Weight
- ( ) 26-29 - Slightly Overweight
- ( ) >30 - Overweight
- ( ) >40 - Extremely Overweight

Comorbidities
- (•) All
- ( ) CVD (Hypertension, Angina, AMI, Stroke)
- ( ) Neuropathy
- ( ) Nephropathy
- ( ) Retinopathy
- ( ) Dyslipidemia

Family History of Diabetes
- (•) All
- ( ) Yes
- ( ) No

Gestational Diabetes History
- (•) All
- ( ) Yes
- ( ) No

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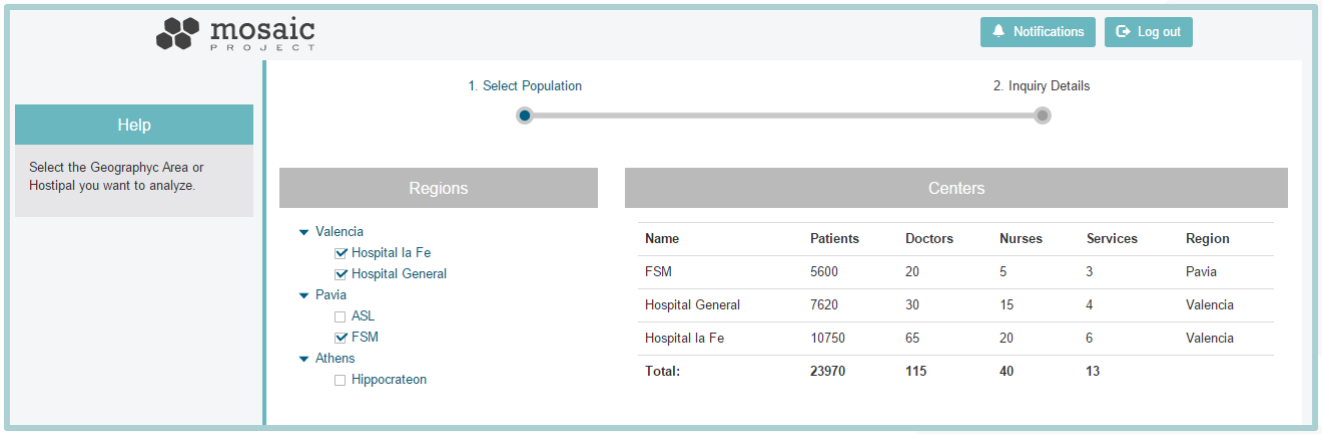
TOOL 1 - PREVENTION AND RISK DETECTION OF TYPE 2 DIABETES MELLITUS



- Selected population for risk assessment of T2DM

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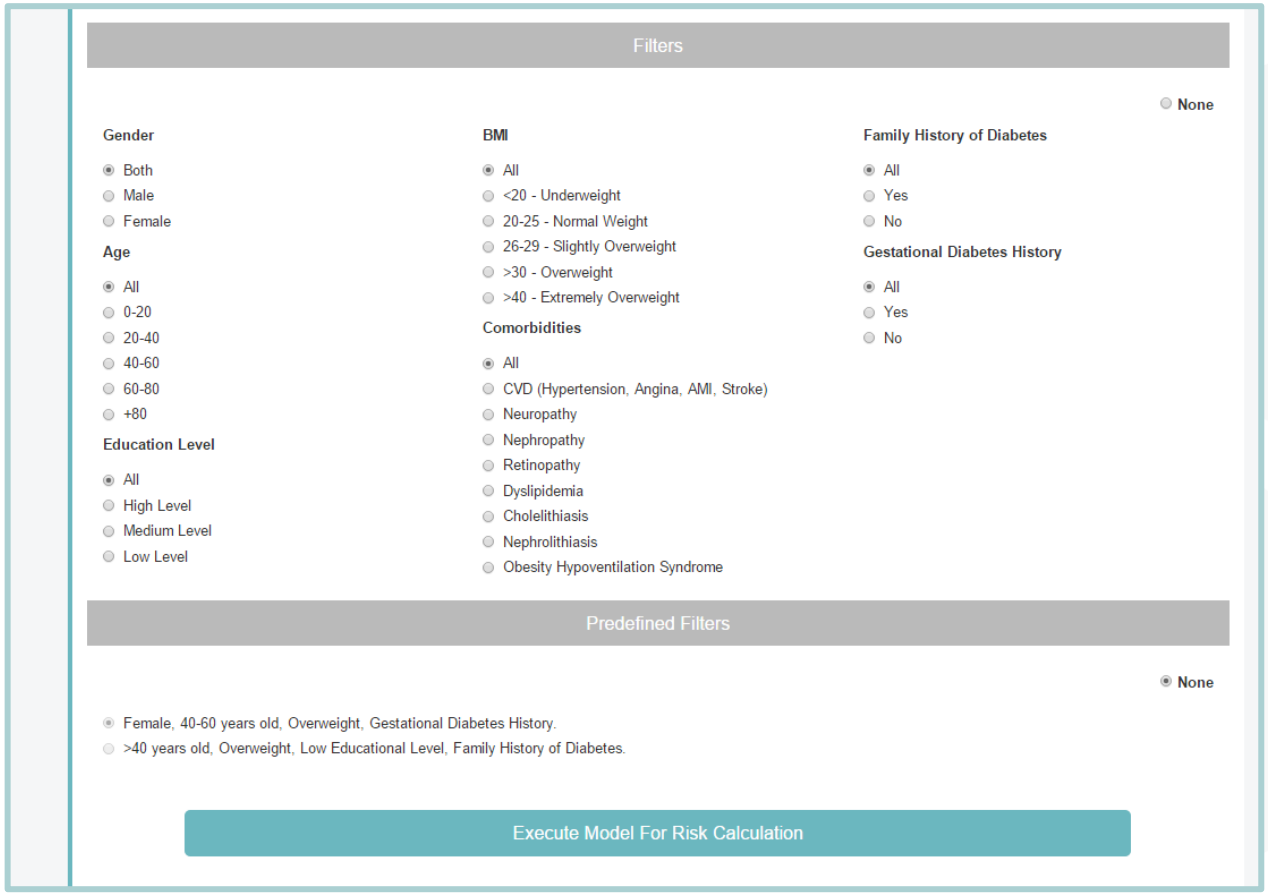
TOOL 1 - PREVENTION AND RISK DETECTION OF TYPE 2 DIABETES MELLITUS



- Possibility of filtering

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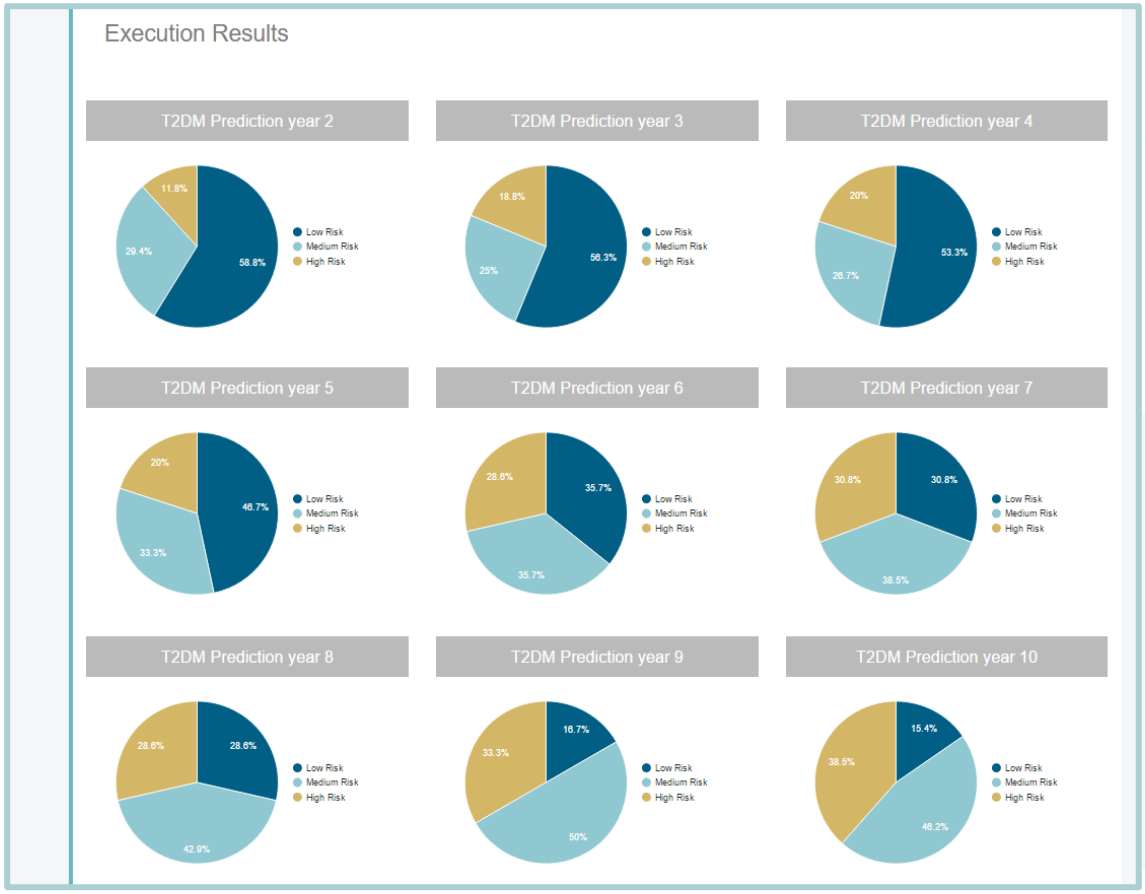
TOOL 1 - PREVENTION AND RISK DETECTION OF TYPE 2 DIABETES MELLITUS



- Results obtained: Probability of developing T2DM in the future.

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TOOL 1 - PREVENTION AND RISK DETECTION OF TYPE 2 DIABETES MELLITUS

User: Hospital Endocrinology/General practotioners

- The head access to the system and finds a list of patients. They can select a patient and see their clinical and demographical variables, etc. which has been self-filling.

- At this point, the second predictive model (Bayesian Network) is applied.

- This predictive model will indicate the current risk of each patient to be **already diabetic**, based on the **automatic estimation performed on the results that would give us an oral glucose tolerance and HDL-C** (cholesterol high density lipoprotein).

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TOOL 1 - PREVENTION AND RISK DETECTION OF TYPE 2 DIABETES MELLITUS

System impact

- This process allows to identify **patients at risk** from a general population to the individual and **focus** the **diagnostic tests** for T2DM detection to those patients that indeed are in **high risk of developing the disease, increasing the success rates in tests like Oral Glucose Tolerance Test.**

- A **better detection and diagnosis** of T2DM in **early stages** will enable to start **activities of secundary prevention and healthy lifestyle** before the patient starts to develop the associated **complications** of this chronic disease. (Micro and macro vascular complications).

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TOOL 2 - PREVENTION AND ANALYSIS OF COMPLICATIONS IN TYPE 2 DIABETIC PATIENTS

- **MOSAIC** use **large databases** available on **long-term monitoring** of diabetic patients with the goal of providing health services with **innovative methods and tools** to monitor the **evolution** of patients, facilitating the **control and management of the disease .**

- Any center collecting information from patients about lifestyle, physical parameters, clinical values, hospitalizations, etc. take advantage from a tool such as MOSAIC, which exploits the integration of different sources of information, to provide several useful features from a clinical, strategic and organizational perspective, of each healthcare organization based on the needs of their patients.

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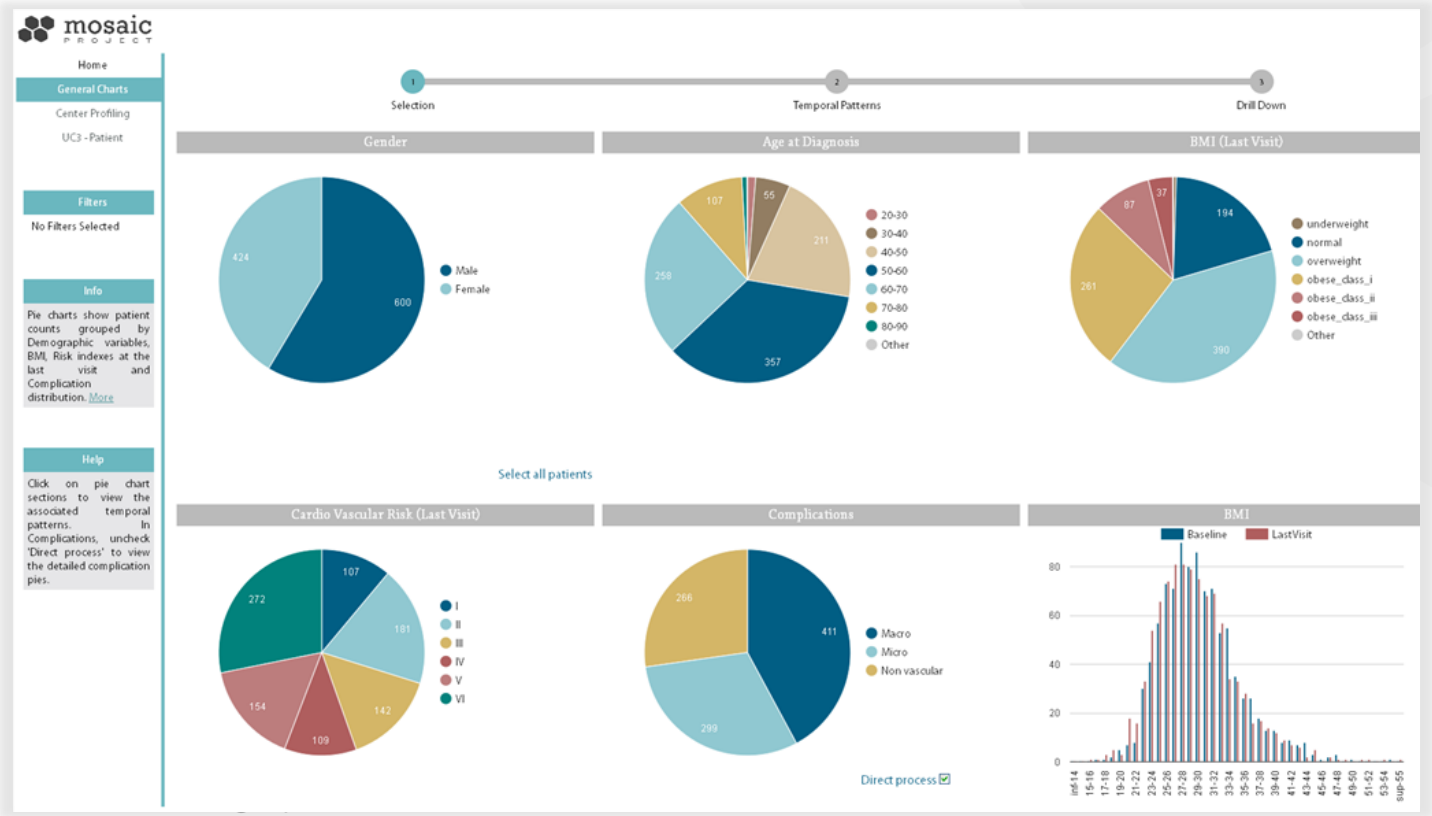
TOOL 2 - PREVENTION AND ANALYSIS OF COMPLICATIONS IN TYPE 2 DIABETIC PATIENTS

MOSAIC users will open the tool and they will find information about their diabetic patients clasiffied by:

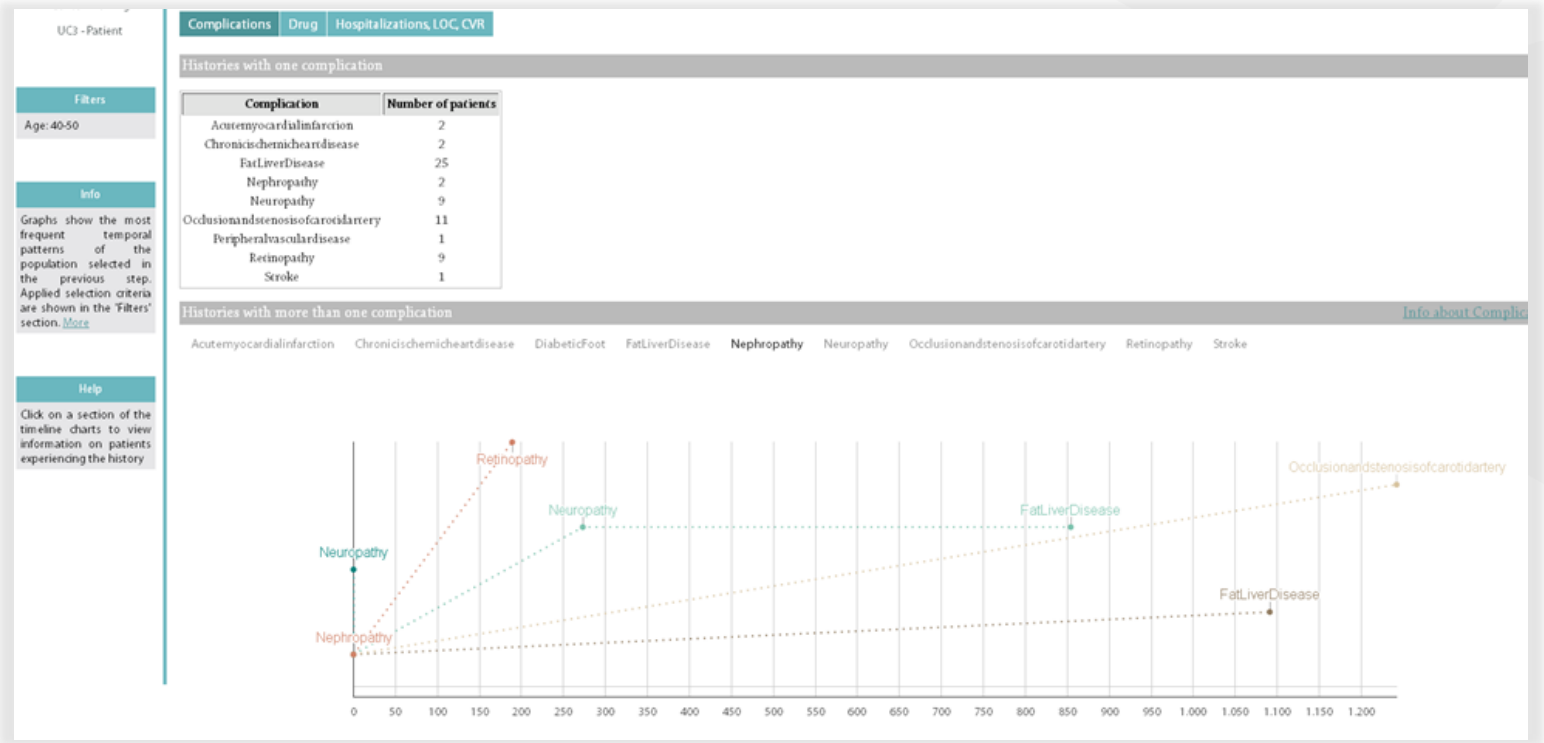
- Gender
- Age at diagnosis
- Body Mass Index (BMI)
- Cardiovascular risk(last visit)
- Complications



TOOL 2 - PREVENTION AND ANALYSIS OF COMPLICATIONS IN TYPE 2 DIABETIC PATIENTS

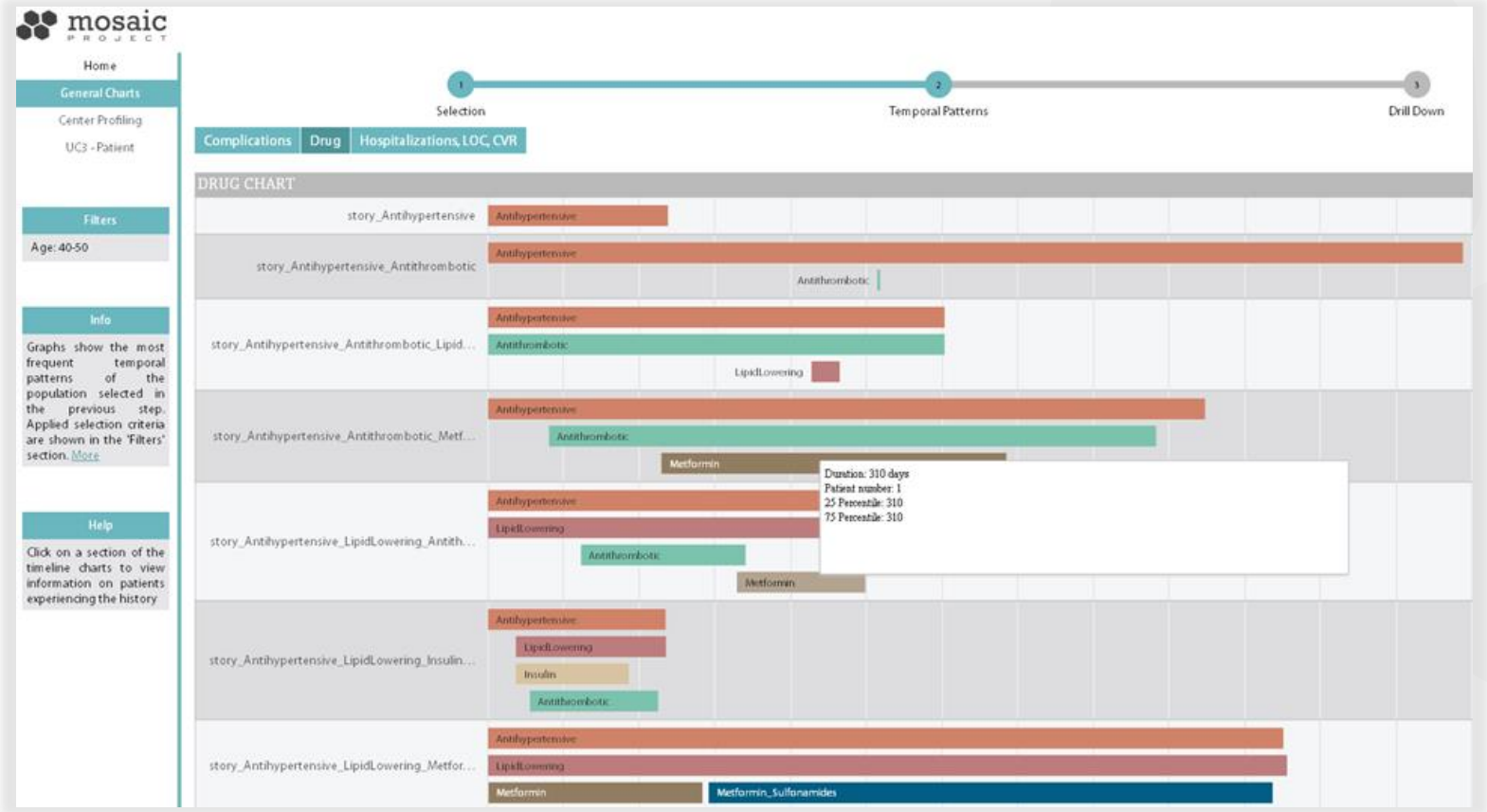
Once the users have select in the first screen the group on which they want to have more information, they will access to the 2nd screen where they will find information from the patients group selected regarding:

- **Complications**: History of the complications suffered by the patients group selected, as well as the order in which they have appeared, temporarily placing taking into account the days of disease progression.



TOOL 2 - PREVENTION AND ANALYSIS OF COMPLICATIONS IN TYPE 2 DIABETIC PATIENTS

- The medication received for their patients during their illness



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TOOL 3 – DECISICION SUPPORT SYSTEM IN FOLLOW-UP VISITIS

- **Users**: General Practitioners or diabetologists – Professional coordinator of the disease.

- With this tool the users will be able to insert the **patient ID** and the system provides **clinical information about the patient** in a friendly and intuitive way, organized by:

  - Clinical data
  - Traffic lights
  - Therapies

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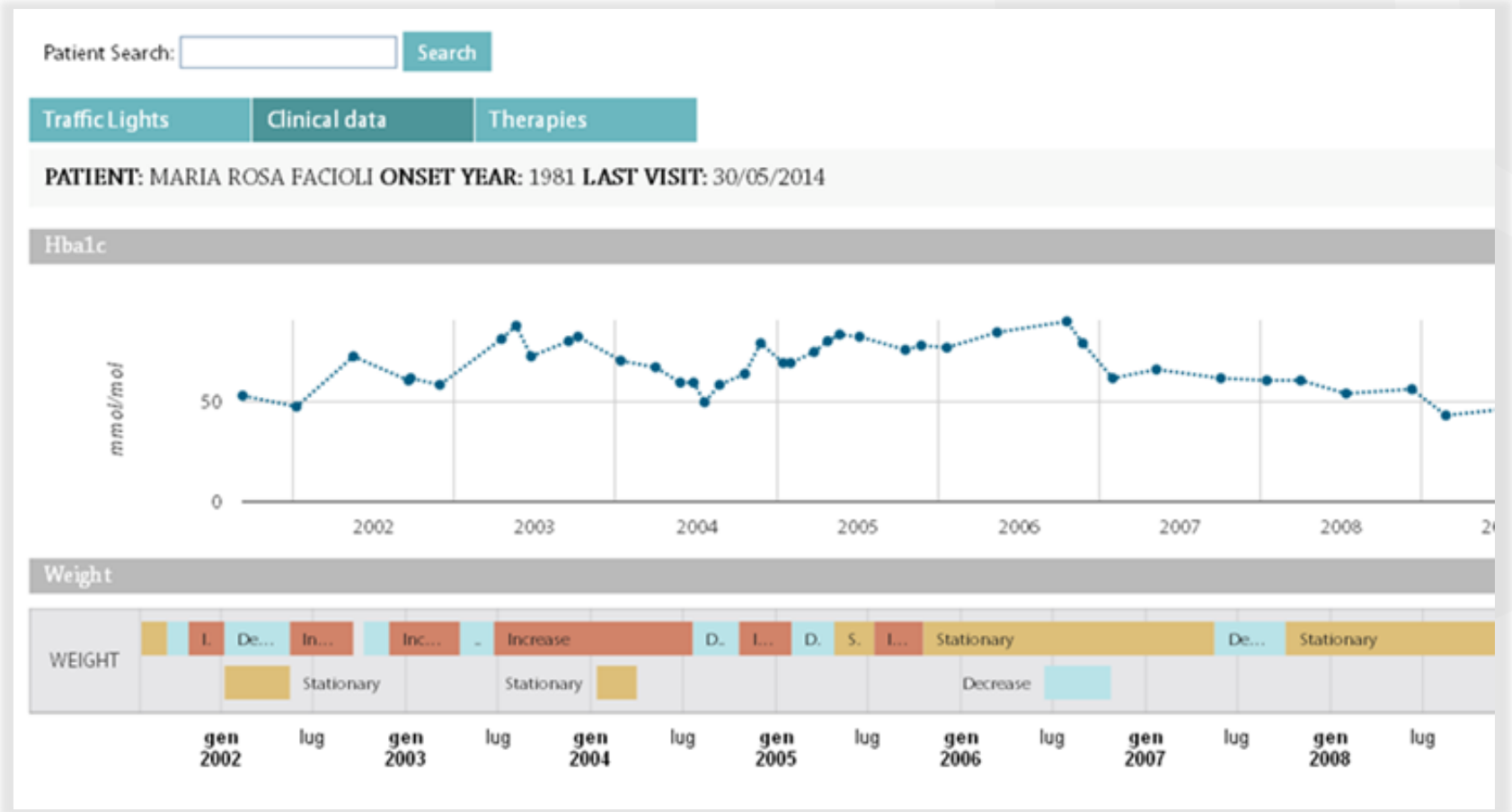
TOOL 3 – DECISICION SUPPORT SYSTEM IN FOLLOW-UP VISITIS

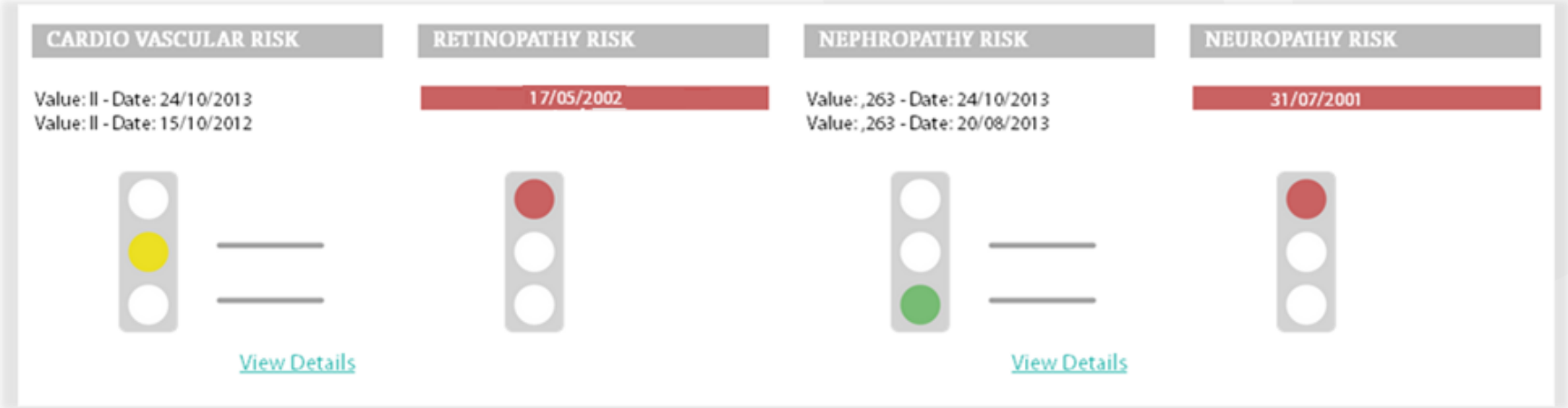
- **Clinical data:** provides information about the chronological evolution of the patient regarding HbA1c, weight, etc. in a graphical way



TOOL 3 – DECISICION SUPPORT SYSTEM IN FOLLOW-UP VISITIS

Traffic lights: using traffic lights graphs the users can see the evolution of their patients from the previous follow-up visit so far, taking into account key parameters for an adequate control of diabetes, as well as the risk of develop certain complications.

Therefore, the tool identifies patients at risk, enabling HC providers to recommend some kind of intervention, either lifestyle changes, medication or a consultation with the specialist.



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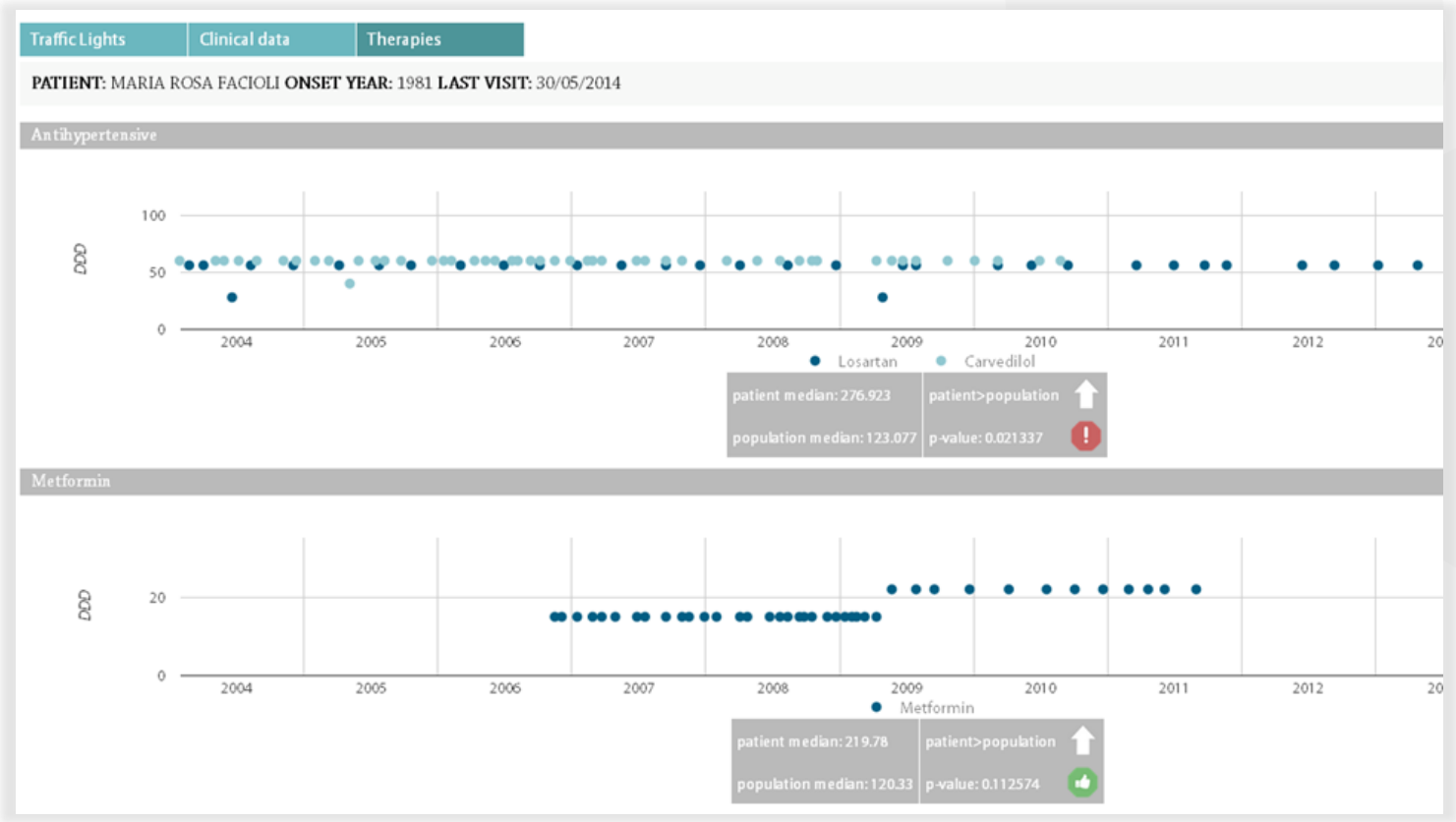
TOOL 3 – DECISICION SUPPORT SYSTEM IN FOLLOW-UP VISITIS

- **Therapies:** in those systems where information about purchasing drugs prescribed by physicians is collected, the tool is enable to track the treatment adherence of their patients.



TOOL 4 – DIAGNOSIS OF TYPE 2 DIABETES

- This tool allows to identify undiagnosed T2DM patients at individual level
- The process is very simple, and would require:
  1. **Enter the ID number of the patient.**
  2. **Check that clinical, demographic and lifestyle data are correct and if not correct them**
  3. **Activate the system.**

- **System Response:** the most likely value resulting from a Oral Glucose Tolerance Test (OGTT) in this patient in particular based on a predictive model (Bayesian Network) which takes into account all the other clinical variables of the patient.
- One of the most powerful features of the system is that estimates those variables (clinical, demographic and lifestyle) not available. (While it is true that the more variables available the system have, the more accurate diagnostic response will be given)

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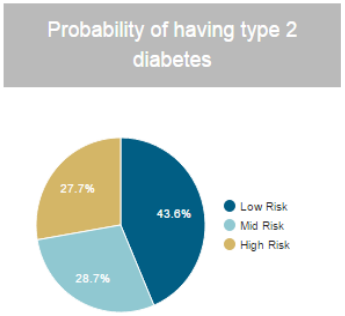
TOOL 5 - MOSAIC PATIENT TOOL



- **Concept:**
  A web tool to calculate the risk of developing diabetes within 2 and 12 years (best results at 6 years).

- **Path (Ongoing):**
  - The user opens the Mosaic web page and press on an icon (link to the MOSAIC tool).
  - In a new web page users inserts information used by the models. (The user will be able to fill just the known required information and can leave some fields empty).
  - The Mosaic tool calculates the risk of having diabetes and prompts a short feedback / advise.

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Currently under validation

Continuous concept validation during the life of the project

- Interviews, focus groups + workshops with clinicians

Scientific value + impact

- Assessment of the MOSAIC models
- Evaluation of the methods in two hospitals:
  - La Fe in Spain
  - FSM in Italy
- MOSAIC Prospective Study based in CGM data to feed and improve the models

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