InAdvance

D7.2 – Functional Dashboard

WP7 – Design of a consolidated standard for appraising PC interventions

Submission Date	28th October 2020
New submission	08th June 2022
Responsible Partner	UPV

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

Project Documentation	
Project Acronym	InAdvance
Project Full Title	Patient-centred pathways of early palliative care, supportive ecosystems and appraisal standard
Grant Agreement	825750
Call Identifier	H2020-SC1-2018-Single-Stage-RTD
Topic	SC1-BHC-23-2018
Funding Scheme	Research and Innovation action (RIA)
Project Duration	48 months
Coordinator	Universitat de Valencia
Website	www.inadvanceproject.eu

Deliverable Documentation	
Number	D7.2
Title	Functional Dashboard
Related WP	WP7
Lead Beneficiary	UPV
Nature of Deliverable	Report
Dissemination Level	Public
Submission Due Date	31/10/2020
Actual Submission Date	31/10/2020
Resubmission date	08/06/2022

Quality Control	
Author(s)	
José Luis Bayo Montón	UPV-SABIEN
María Martínez Piqueras	UPV-SABIEN
Zoe Valero Ramón	UPV-SABIEN
Contributor(s)	
Mª Eugenia Gas	HULAFE
Adriano Fernandes	SCMA
Henrique Silva	SCMA
Editor(s)	
José Luis Bayo	UPV-SABIEN
Zoe Valero Ramón	UPV-SABIEN
Reviewed by	
Ascensión Doñate	UVEG
Approved by	
Project Coordinator	UVEG

Revision History			
Version	**Date**	**Comment**	**Author(s)**
V0.1	01/10/2020	ToC	José Luis Bayo

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

V0.2	05/10/2020	First content	José Luis Bayo
V0.3	16/10/2020	Dashboard description and use cases	José Luis Bayo
V0.4	20/10/2020	Conclusions and summary. Ready for internal revision	José Luis Bayo
V0.4.1	22/10/2020	Revision	Ascensión Doñate
V1.0	22/10/2020	Reviewed version	José Luis Bayo
V1.1	26/10/2020	Revision	Ascensión Doñate
V2.0	26/10/2020	Version ready for submission	José Luis Bayo
V3	06/06/2022	Revision according to the external reviewers' comments	Zoe Valero

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

Table of Contents

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

List of Figures

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

List of Tables

Abbreviations list

Abbreviation	Meaning
AUTH	Aristotle University of Thessaloniki
DSS	Decision Support System
EDC	Electronic Data Capture
EHR	Electronic Health Record
EU	European Union
FHIR	Fast Healthcare Interoperability Resources
HAH	Hospital at Home
HL7	Health Level Seven
HULAFE	Fundación para La Investigación del Hospital Universitario La Fe de la Comunidad Valenciana
ICT	Information and Communication Technologies
IPF	Idiopathic Pulmonary Fibrosis
ISO	International Organization for Standardization
KPIs	Key Performance Indicators
PALIA	Parallel Activity Log Inference Algorithm
PC	Palliative Care
PI	Process Indicator

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

PM	Process Mining
SCMA	Santa Casa da Misericordia da Amadora
UNIVLEEDS	University of Leeds
WP	Work Package

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

1 Executive Summary

This deliverable presents the functional dashboard version for the InAdvance project. The InAdvance Dashboard is a visual and interactive tool based on the use of Process Mining (PM) technologies to assist healthcare professionals in the analysis and early integration and personalised pathways addressed explicitly to older adults in the palliative care (PC) framework. In order to develop the most appropriate dashboard, it was followed an iterative co-creation process, where experts and end-users are consulted in each step of the development.

The first step had, as a result, a mock-up version of the dashboard, which was at the same time the input for the next and current iteration, the development of a completely functional tool. This report describes the InAdvance dashboard, together with its design and implementation. The document also includes a full description of the dashboard's functionalities and two use examples.

This new dashboard version supposes significant progress compared to the previous mock-up version. This version is ready to be used in each trial, however, during the third and last step of the iterative process, a set of customised key performance indicators (KPIs) and views will be designed and implemented. Thus, the result will be five personalised final dashboards, one per pilot site.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

2 Introduction

2.1 InAdvance Project Overview

Due to the increased incidence, prevalence and mortality of chronic diseases and multimorbidity, the need for palliative care (PC) resources is a challenge for health and social care systems. However, currently, access to PC remains inconsistent. Due to the ageing population, it is expected to increase in the rate of people requiring this kind of care over the next 25 years.

The project Patient-centred pathways of early palliative care, supportive ecosystems, and appraisal standard (InAdvance) proposes a novel PC model based on early integration and personalised pathways address explicitly to older people with complex chronic conditions. Thus, the overall aim of InAdvance is to improve the benefit of PC through the design of effective, replicable and cost-effective early PC interventions centred-on and oriented-by the patients. Interventions are defined for/orientated on patients, families, informal caregivers, and front-line care professionals. To achieve this primary goal, InAdvance will produce the following evidence-based outputs to assist care professionals, service managers, and policy and decision-makers in their scalability and replicability:

a) stratification tools to identify potential beneficiaries of early PC actions;
b) optimised interventions co-designed by the needs and preferences of patients and their relatives;
c) eHealth tools addressed to empower palliative patients' ecosystem;
d) policy recommendations and clinical guidelines addressed to service providers and policy and decision-makers;
e) an appraisal standard and dashboard facilitating a critical and comprehensive comparison between actions and interventions derived from the project.

The InAdvance consortium brings together leading interdisciplinary academic, clinical and technological partners from EU organisations actively responding to challenges from health and social care systems and policy-makers in the field.

2.2 Context

This document is framed within the ***WP7 - Design of a consolidated standard for appraising PC interventions***, which main objective is the development of an Appraisal Standard Dashboard to provide a general overview of the users and interventions status based on the work carried out in the previous phases of the project.

The dashboard should offer different views according to the needs of each key user (clinicians, social workers, hospital managers, or policy-makers), covering:

i. Clinical decision support during follow-up consultations, and
ii. Outcome assessment on the population of interest (public health).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

The dashboard design approach planned to consider an iterative co-creation process, where the needs of end-users are taken into account during the whole process. In this context, *Task 7.1 - Creation of a mock-up dashboard* was dedicated to creating a first mock-up of the dashboard. The purpose of this mock-up was to show the possible functionalities of the dashboard to end-users, with two objectives: a) gather their opinion and suggestions for the next iteration, and b) introduce them to the use of such tools.

Task 7.2 - Functional Dashboard corresponds with the second step in the iterative process. Its main objective is to work in developing of a fully functional dashboard with the potential users. Using feedback and results from T7.1 and infrastructure inputs, the aim of T7.2 is to develop the first functional dashboard to be integrated with the rest of the InAdvance project.

This document includes the design and development process implemented within task 7.2 to implement the functional dashboard.

2.3 Structure of the document

The document has the following structure. It starts with the InAdvance dashboard, introducing what a dashboard is, the design process followed for its implementation, and finally, how the dashboard was developed. The report follows with the description of how to use the dashboard, with detailed information about how to download and install it, and the main functionalities, together with two examples of use. Then, a section with the quality check is included. The document ends with the main conclusions and future work.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

3 InAdvance Dashboard

3.1 Introduction

Electronic Health Records (EHR) are widely used to store longitudinal data and record vital signs, medications, laboratory values, diagnostic reports, mental states, patient transfers and other health status parameters. However, EHRs and related software often present data with static views and texts, which do not reveal the underlying evolution, trend, and behaviour in a patient's disease progression nor the similarities among patients' trends. Moreover, health experts usually have to use multiple tools to gather patient status to get a complete health assessment.

On the other side, data-driven medicine relies on visual information about patients' trajectories or disease risk pathways. Visual tools that can track patient variations and physiological status are essential for clinical data visualisation. Integrating such visualisation tools with predictive models and risk estimation tools could support patient stratification for improved care.

In this regard, clinical dashboards are tools that can visually capture the cross-sectional view of a variety of quality metrics, including patient statuses and progress, healthcare delivery measures, performance improvements for care providers and aid in understanding the critical features of the overall patient pathway and improved outcomes.

Clinical dashboards are often developed by hospitals or health systems, emphasising statistical analysis but poor integration of machine learning or predictive modelling (Badgeley, 2016).

In this sense, few works are done in the area of clinical dashboards for clinical decision support during follow-up consultations, and outcome assessment for PC. One work (Tan, 2020) was focused on PC but only on emergency medicine. Other works focused on supportive care interventions in patients with cancer (Adonizio, 2019), or integrating a single palliative outcome (Feathers, 2018).

InAdvance Dashboard supposes a step further, as it integrates machine learning and predictive modelling using Process Mining (PM) techniques, as well as statistical analysis in the same tool. The dashboard will generate novel models as human-understandable graphical representations that could support healthcare stakeholders in comprehending their current awareness of the PC processes, as it considers diseases' variability over time and patient nature. Incorporating the evolution over time and patient's unique behaviour into the analysis, the dashboard will have the potential to present findings from data, as comprehensible insight views, with the ultimate goal of understanding, measurement, and optimisation of the processes associated with PC.

This document proposes the design, development, and implementation of a consolidated standard dashboard for appraising PC interventions in the context of the InAdvance project.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

The InAdvance Dashboard is a visual and interactive tool based on PM technologies to assist healthcare providers in the analysis, early integration, and personalised pathways explicitly addressed to older adults.

3.2 Dashboard design

The InAdvance Dashboard is a tool designed to generate human-understandable graphical representations about PC pathways and interventions that could support healthcare professionals in comprehending current processes, taking into consideration patients' variability and nature, and clinical settings characteristics.

For this purpose, it was followed an iterative co-creation process where end users' needs are taken into the whole design and development process as follows:

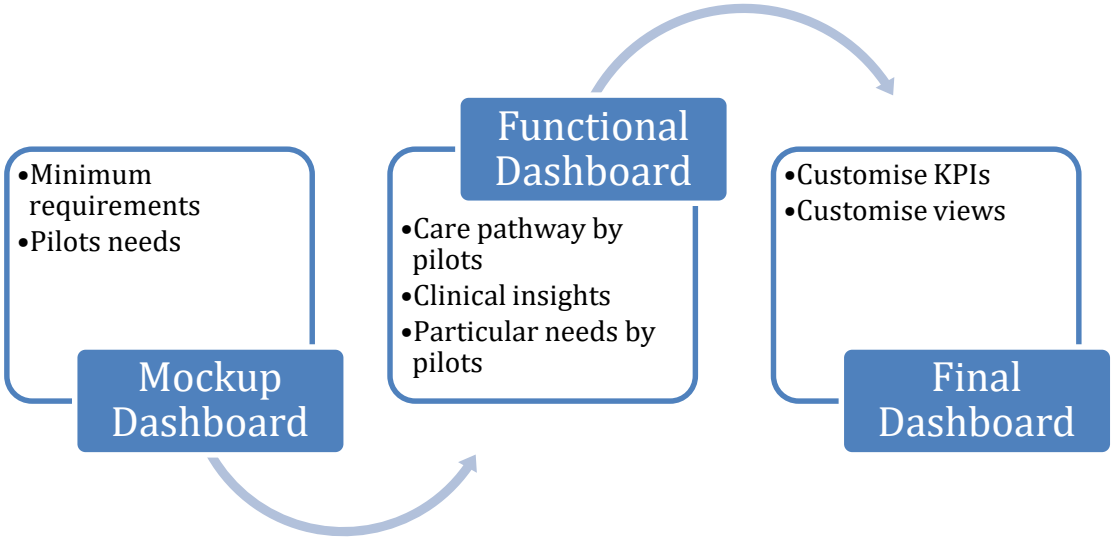


Figure 1 Iterative co-creation design process

Co-creation is not a methodology. It is an iterative process of engaging consumers through various methods to collaborate towards a final result. In this case, customers are the healthcare professionals, and the objective was to engage them in the implementation of the Dashboard with a double purpose. On the one hand, to achieve a useful tool, and on the other hand, to engage them in its use from the very beginning. With this objective, it was implemented a three-step process coinciding with the three main tasks of the WP7 of the project. Within the first step, workshops with clinicians were organised to gather preliminary pilots' needs and minimum dashboard requirements based on these needs.

Considering the current situation, due to the COVID-19 pandemic, two different workshops were organised with SCMA (online workshop) and HULAFE (face-to-face workshop) partners, respectively. Whereas with UNIVLEEDS and AUTH, the information was gathered off-line, through the mail. Within the HULAFE workshop participated three users, of which were two nurses and one data scientist. In the case of SCMA, two experts in the field of PC participated (manager and consultor profiles).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

As a result, the first mock-up version of the dashboard was implemented, which was included in the deliverable D7.1.

The mock-up version of the dashboard was the input for the next iteration. In this case, the work with healthcare professionals was focused on validating preliminary needs and requirements by analysing in-depth care pathways for all pilots, and the particular clinical needs and insights based on each pilot. The result of this second step is the InAdvance Functional Dashboard, which work is included in this document. Finally, the third step will implement the final and pilot customised version of the Dashboard, which input will be the current version and the results from future workshops with healthcare experts to design customised views and KPIs for each pilot site.

3.2.1 Study sites analysis

As said, a detailed analysis of each study site's needs and requirements was done to implement a dashboard that covers all required needs and considers each pilot site's characteristics and objectives. For that, it was established a bilateral work between the dashboard development team and each study site. Project interventions will be implemented within five study sites[1]: HULAFE (Spain), SCMA (Portugal), NHS Inverness (Scotland), Leeds (UK), and Thessaloniki (Greece). The following sections include the analysis performed for all the study sites regarding their legacy systems and care pathways.

3.2.1.1 Valencia: HULAFE

The Clinical Area of Hospital at Home (HAH) and Telemedicine participating in the project depends on the Hospital La Fe level resources in Valencia, and is composed, approximately of by 30 nurses, 11 nurse case managers, 11 physicians, a social worker, a psychologist and a physiotherapist. The Clinical Area is integrated by two units, Hospital at Home Unit, and the Telemedicine Unit where the case management program is coordinated.

Legacy system:

Hospital La Fe is a publicly owned and managed hospital, it is the centre of the Department of Health Valencia La Fe, responsible for the health care of 300,000 inhabitants. It depends on the region's health department and uses proprietary software, Orion Clinic. Orion Clinic is the clinical-care information system for the hospital centres of the Valencian Region.

Due to ethical and legal constraints, there are high restrictions from the regional government to connect to this system. Moreover, any kind of connection should involve the health department of the region, which is not affordable for the project in time and manner.

Care pathway:

The common pathway in older patients with chronic conditions who could benefit from a PC approach is included in Figure 2.

[1] When the original document was finalised (M23) the project still contemplated five study sites.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

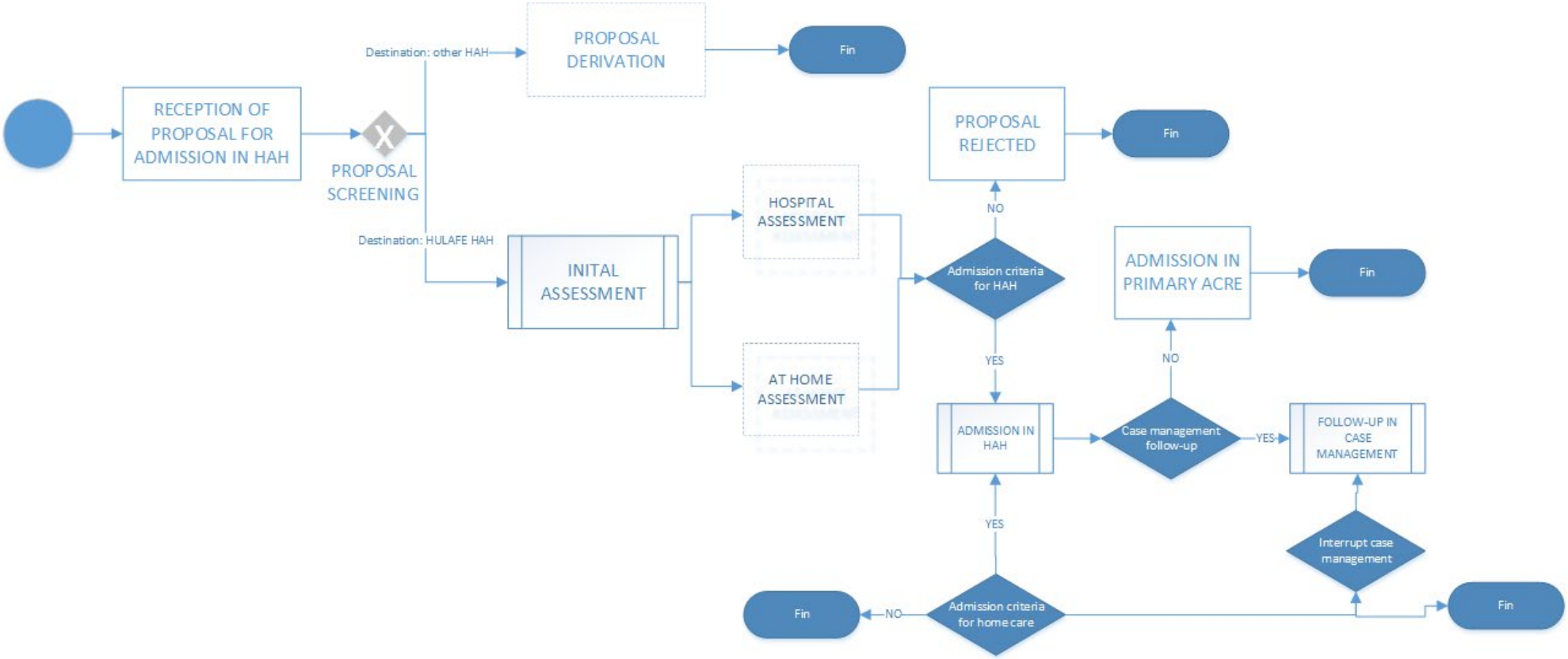


Figure 2 Current PC pathway for HULAFE

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

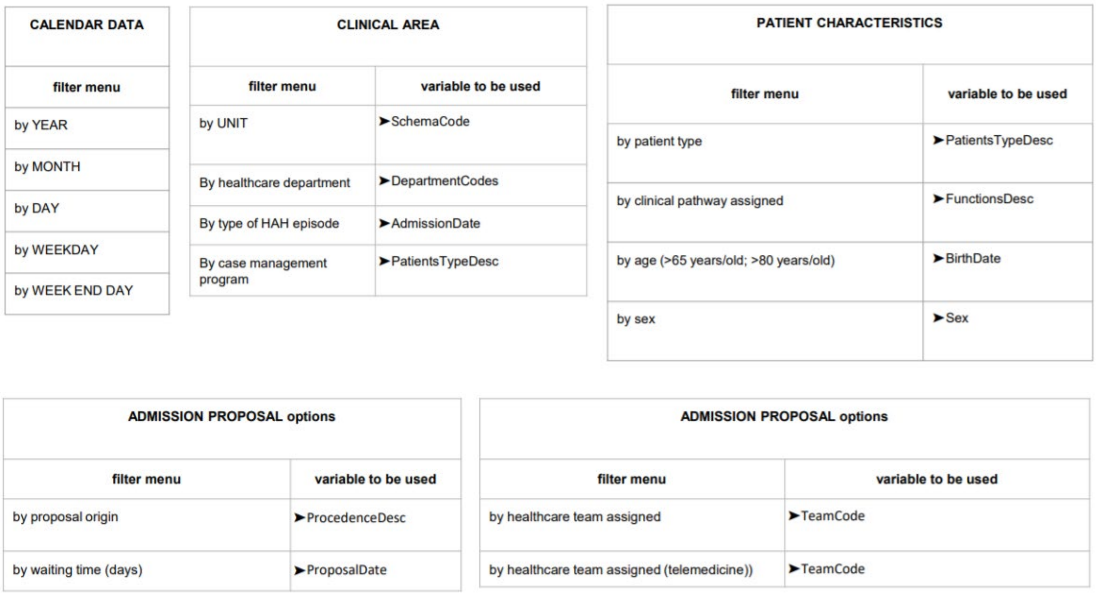
In this context, HULAFE is interested in the following scenarios:

- Scenario 1: management of the admission proposal.
- Scenario 2: admission at the hospital at home unit (HAH).
- Scenario 3: case management program follow-up.
- Scenario 4: last week of life.

Consequently, customised views and KPIs will be based on these four scenarios.

Results from the analysis:

Based on the previous information and the collected feedback during the workshop carried out with HULAFE health professionals, there were obtained the following results. Dashboard end-users will be nurses, managers, social workers, physicians and/or physiotherapists. Based on their pathway and case study needs, they will need to visualise within the dashboard the following information (see Figure 3):



CALENDAR DATA
filter menu
by YEAR
by MONTH
by DAY
by WEEKDAY
by WEEK END DAY

CLINICAL AREA	
filter menu	variable to be used
by UNIT	➤SchemaCode
By healthcare department	➤DepartmentCodes
By type of HAH episode	➤AdmissionDate
By case management program	➤PatientsTypeDesc

PATIENT CHARACTERISTICS	
filter menu	variable to be used
by patient type	➤PatientsTypeDesc
by clinical pathway assigned	➤FunctionsDesc
by age (>65 years/old; >80 years/old)	➤BirthDate
by sex	➤Sex

ADMISSION PROPOSAL options	
filter menu	variable to be used
by proposal origin	➤ProcedenceDesc
by waiting time (days)	➤ProposalDate

ADMISSION PROPOSAL options	
filter menu	variable to be used
by healthcare team assigned	➤TeamCode
by healthcare team assigned (telemedicine))	➤TeamCode

Figure 3 Results from the HULAFE pilot analysis

Previous results will be used during the third step of the iterative co-creation process to extract valuable clinic information and to implement the corresponding views within the dashboard that provide these insights.

3.2.1.2 Amadora: SCMA

This site will take place in Santa Casa da Misericórdia da Amadora (SCMA), an NGO, founded in 1987, oriented to Human dignity in a sustainable and organised way.

Legacy system:

The institution does not allow the "in-live" connection with its legacy system.

Care pathway:

SCMA's current pathway for the assessment of PC is described in the following figure:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

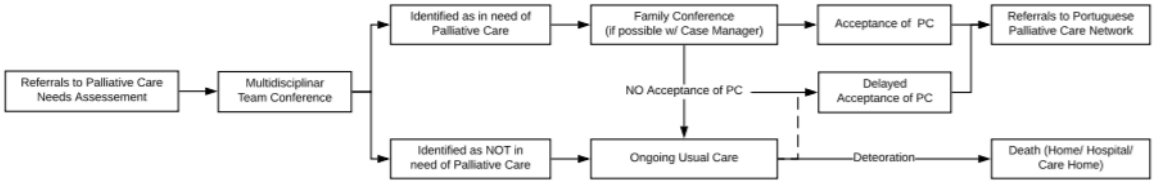


Figure 4 Current PC pathway for SCMA

However, with the implementation of the InAdvance PC approach, the new pathway to be implemented will be as follows:

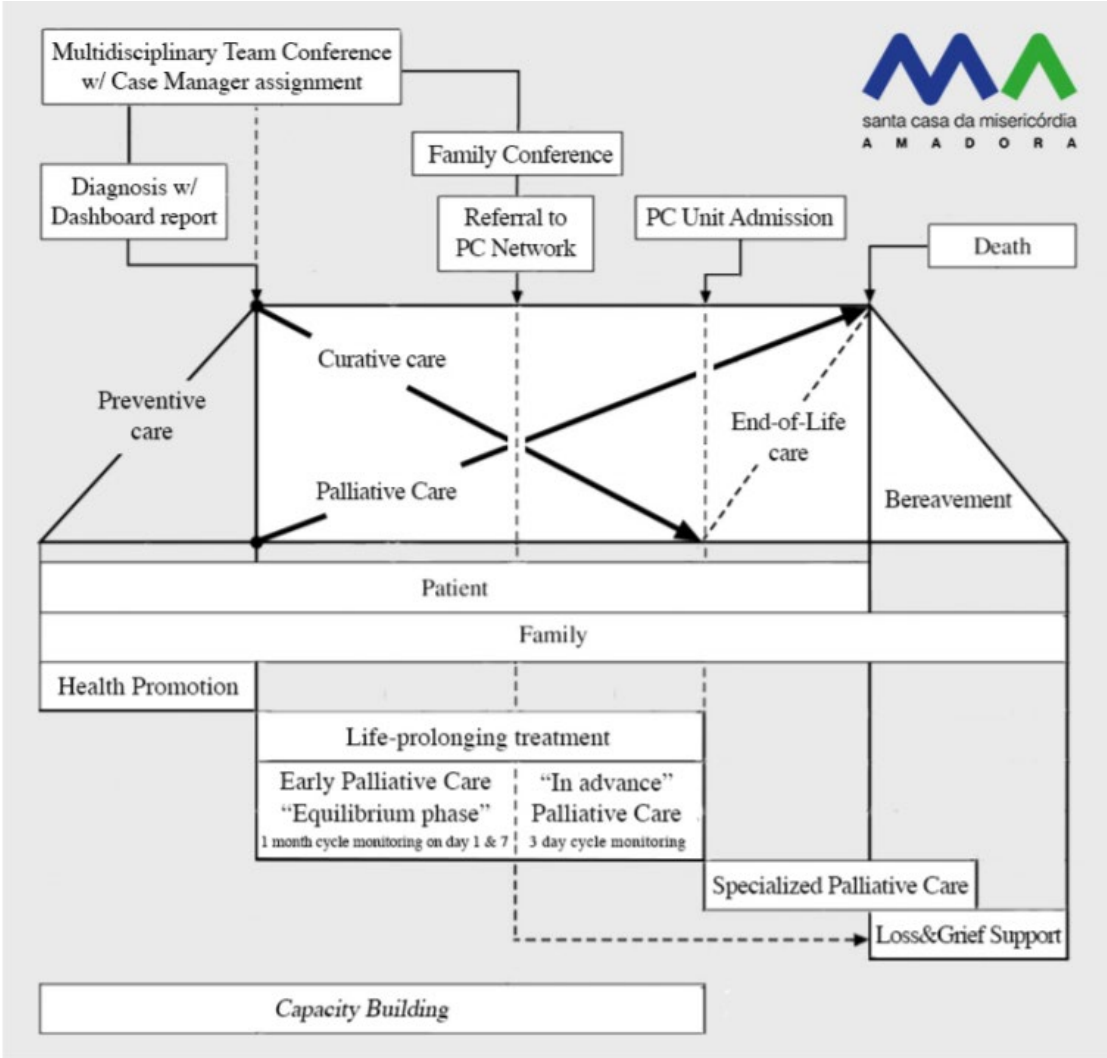


Figure 5 SCMA: InAdvance PC pathway to be implemented

Building upon the Palliative Care Continuum, the pathway to be implemented in SCMA follows a prophylactic integrated and person-centred care approach. It begins with preventive care, delivered to the client/patient as health promotion (healthy and active ageing) with ICT monitoring support; further providing two correlated actions: capacity building and intervention.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

Capacity building will be promoted for formal carers and patients through soft skills enhancing, training on acts of care, and using ICT tools. The intervention will reflect the knowledge acquired on the capacity building with a particular focus on communication to dignify the acts of care and being cared for.

When a special condition is diagnosed/detected, a dashboard profile is created and a multidisciplinary team conference is arranged to access specific needs and outline the strategy to be adopted and to assign a Case manager, that will be the contact person thorough the whole pathway.

So, two complementary drivers need to be addressed, delivering simultaneously a curative care/medicine as a life-prolonging treatment and an early PC intervention to provide an equilibrium of health and wellbeing, continuously monitoring life signals and other relevant parameters.

The collected data should help trace a more accurate prognosis supporting better decisions on when to hold a family conference to decide on the referencing to the Portuguese Palliative Care network (PC network in the workflow included in Figure 6). Since the time between the referral and the admission is considerably long, the second phase of early PC was conceived – this "In advance" PC is a more intensive PC approach focusing on providing wellbeing through psychosocial, emotional, and spiritual support for both the patient and their family.

Results from the analysis:

Based on the information provided by SCMA, the proposed pathway including the InAdvance PC to be analysed within the dashboard is included in Figure 6.

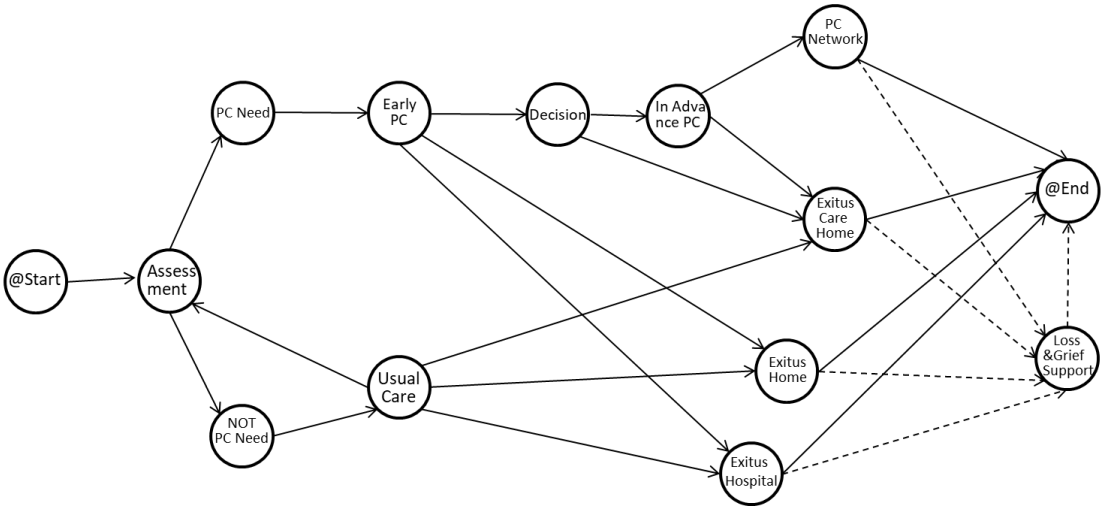


Figure 6 SCMA pathway for InAdvance

As in the previous case, the end-users will be: nurses, managers, social workers, physicians and/or physiotherapists. The preliminary concept for the dashboard, considering different views is included in the following image:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

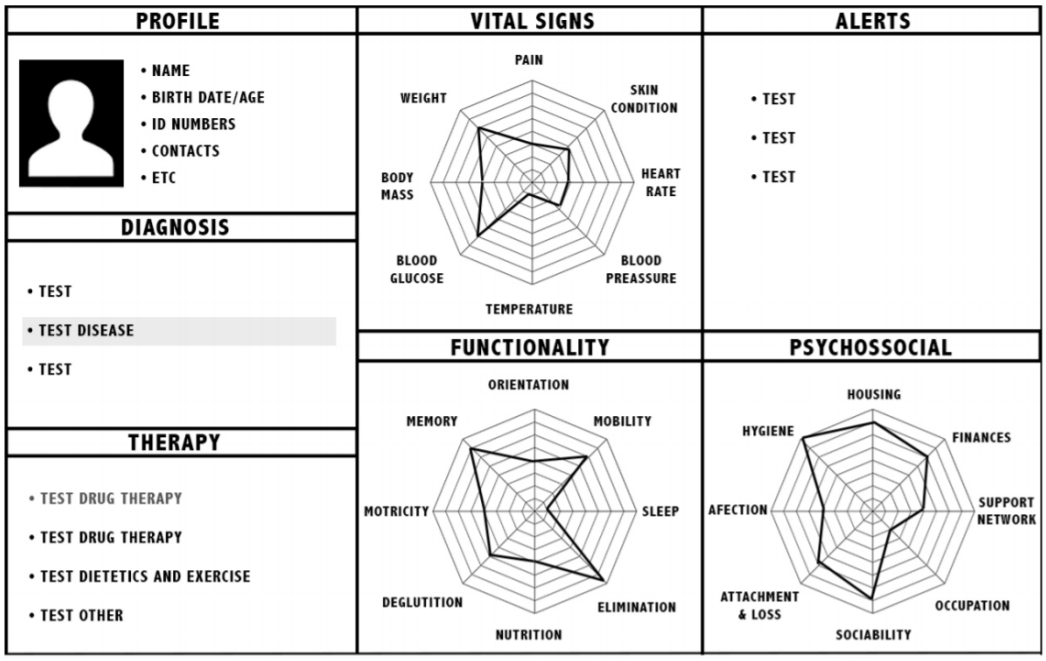


Figure 7 Preliminary dashboard concept for SCMA

During the workshop conducted with SCMA health professionals, their needs were considered in two main areas: statistical information and temporal perspective of the processes at patient and population levels. At the patient level, they need that the dashboard includes patient's information about:

- Profile, diagnosis, tests, and therapies.
- Vital signs, such as weight, height, heart rate, blood pressure, etc.
- Information about the functional ability, such as memory, mobility, sleep, nutrition, etc.
- Report about psychosocial status, as occupation, sociability, affection, etc.

During the third step of the iterative process, the work with SCMA should be focused on developing a set of KPIs to cover the temporal perspective of the processes of SCMA, considering previous information and new one coming from the study site.

3.2.1.3 Thessaloniki: AUTH

The Aristotle University of Thessaloniki will collaborate with the Hippokration General Hospital in Thessaloniki and the AUTH Pulmonary Department of G. Papanikolaou General Hospital on this site.

Legacy system:

Thessaloniki's site does not have any digital in place, this includes a legacy system, or EHR to connect.

Care pathway:

Thessaloniki site's current pathway for frail older with comorbidities to be considered is presented in Figure 9.

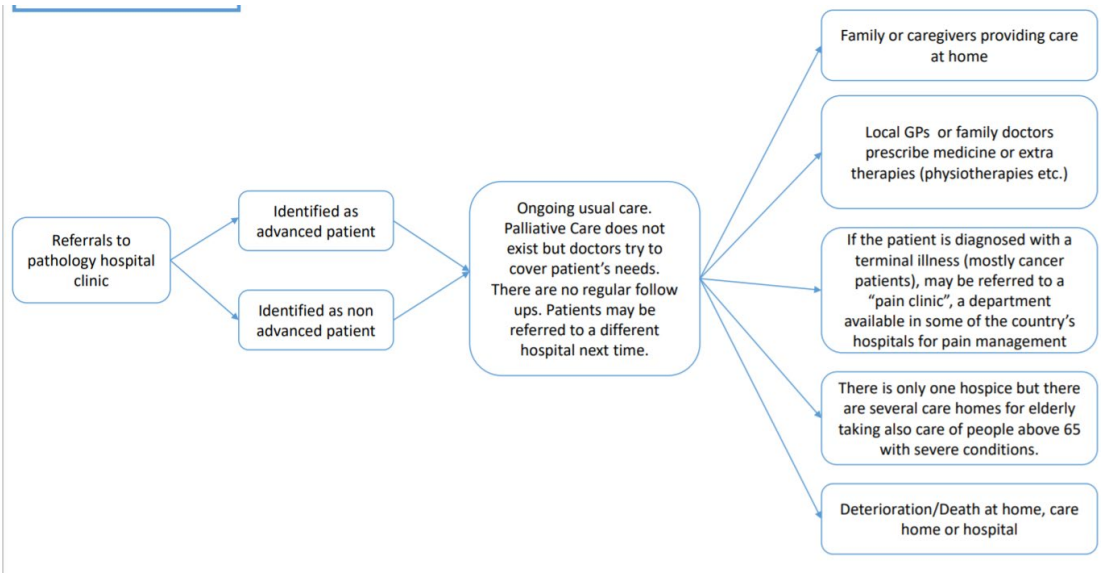


Figure 8 Frail older adults with comorbidities pathway: Thessaloniki

3.2.1.4 NHS Highland

NHS Highland is a public body, a legal entity in its own right but also part of the National Health Service in the United Kingdom. NHS Highland will work in close cooperation with the Highland Hospice. The clinical trial will take place at the Highland Hospice.

Highland Hospice is an independent local charity covering the Highland region (a population of over 230,000 in a scattered area). The Hospice delivers some of its services on behalf of NHS Highland. They participate in data collection, analysis and evaluation of historical and actual clinical data.

Legacy system:

The nationwide implementation of electronic health records, known as the NHS Care Records Service. The NHS Care Records Service will enable NHS organisations in England to store patient health care records on computers that will link together, providing information where it is needed.

Due to ethical and legal constraints, there are high restrictions on connecting to the NHS Care Records Service in time and manner.

Care pathway:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

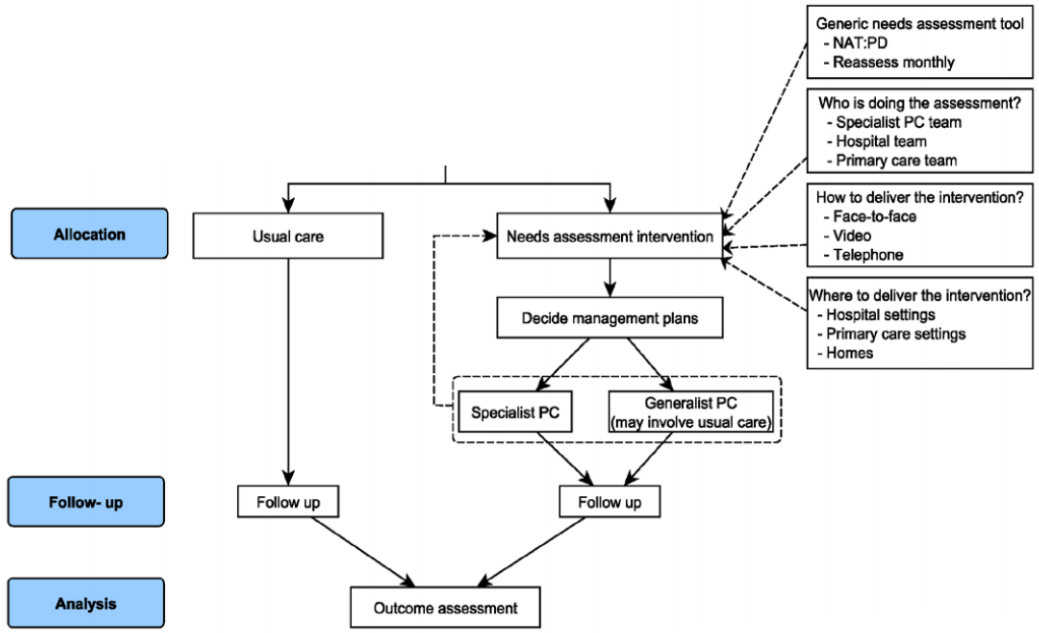


Figure 9 NHS Highland pathway

3.2.1.5 Leeds: UNIVLEEDS

The St Gemma's Hospice is where the clinical trial will take place in Leeds.[2]

Legacy system:

As in the previous case, NHS Highland there are high restrictions on connecting to the NHS Care Records Service in time and manner, due to ethical and legal constraints.

Care pathway:

Regarding the Leeds use case, they are currently implementing the below pathway (Figure 10) for patients needing PC.

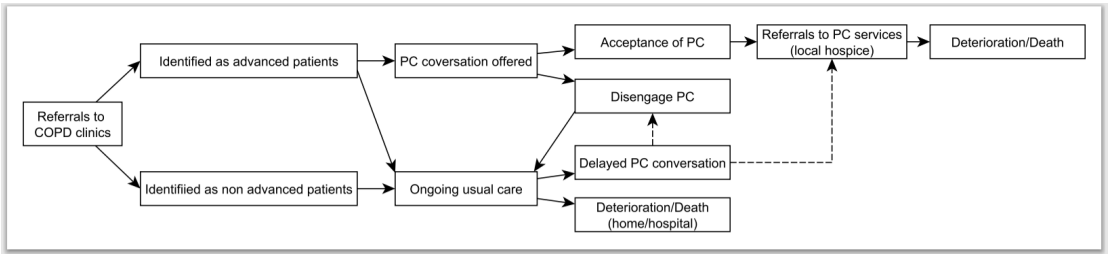


Figure 10 Leeds pathway

[2] When the first version of this deliverable was finished (M23), the project still considered five pilots, Leeds was one of them. Although it is not a pilot at this moment, we maintain this information.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

Based on this information, an analysis of their needs regarding the KPIs to understand their processes should be done in the next step of the iterative co-creation strategy.

3.2.2 Integration strategy

The analysis performed in the previous section (Study sites analysis) concluded that none of the pilot sites has formally defined Electronic Health Records, using some standards such as HL7[3], FHIR[4], or ISO EN 13606[5].

Moreover, it is not only a problem of the use of standards to connect with, it is also an ethical and legal issue. Regarding the interoperability of the project data in a syntactic manner, high restrictions were found in all pilots in this concern and ethical and legal constraints. This is because the use of standards should be integrated by both parts of the connection, the dashboard and the EHR or legacy system at pilot premises.

This implies the impossibility of integrating the dashboard with the existing legacy systems at the piloting premises in time and manner. Below it is explained each site's constraints:

- In the case of HULAFE, it was discharged because of the impossibility of obtaining permissions for connecting to its legacy systems.
- SCMA does not allow the connection with its legacy system.
- As explained Thessaloniki site has no EHR implemented to connect with.
- Lastly, in the case of Leeds and Highland, both part of the NHS in the United Kingdom, the procedures and their timeframe make it impossible to connect with the system.

Moreover, none of the responsible structures for the EHR at the different pilot sites was at the disposal of implementing any kind of changes in their legacy systems to comply with any standard in the framework of the InAdvance project.

For such reasons, at the project level it was decided to incorporate a widely used tool for the data trial gathering (CASTOR). CASTOR[6] is an Electronic Data Capture (EDC) System for Clinical Research Trials. It solved all the ethical and legal constraints and made the development of an interoperability connector unnecessary. More details about CASTOR and the implemented data model are provided in section 3.3.1.

3.2.3 Preliminary analysis of views and KPIs

The iterative process carried out has been adapted to the particularities of each use case scenario, in consequence different actions and results have been obtained, and even different speeds are currently working among them. Because of the characteristics of the HULAFE work and pathway definition, they have been

[3] https://www.hl7.org/
[4] https://www.hl7.org/fhir/modules.html
[5] http://www.en13606.org/information.html
[6] https://www.castoredc.com/electronic-data-capture-system/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

able to elaborate a preliminary analysis about the clinical queries that could be used as KPIs for the dashboard. The result of this analysis is included in the following seven tables.

For the first scenario that HULAFE manages, management of the admission proposal to HAH unit, there were gathered the following questions:

CLINICAL QUERIES Scenario 1: MANAGEMENT OF THE ADMISSION PROPOSAL to HAH UNIT	
# of query	**Clinical query**
1	From which services do the proposals come?
2	How much time, on average, does elapse between the issuance of the proposal and the initial assessment?
3	How much time elapses between the issuance of the proposal and the admission into HAH?
4	What percentage of proposals have been evaluated in the first 48 hours after receipt?
7	Of the accepted proposals (admission to HAH), what percentage corresponds to the level of care to avoid hospital admissions?
8	Of the accepted proposals (admission to HAH), what percentage corresponds to the level of early discharge care?
9	How long the average time between the proposal registration and the first registered HAH contact is?
10	Sociodemographic profile of the patients who are proposed for admission to HAH.
11	Percentage of patients aged > 65 years; > 80 years; > 90 years (calculated at the time of the consultation).

Table 1 Clinical queries for the management of the admission proposal to HAH unit scenario

Table 2 and Table 3 include interesting questions for the second scenario, admission at the hospital at home unit regarding the health status, and the indicators related with the clinical pathway.

CLINICAL QUERIES Scenario 2.1: HAH ADMISSION- Patient health status

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

# of query	Clinical query
1	Distribution of patients according to the general clinical profile in the first episode in the area.
2	Percentage of patients in whom an assessment of their functional status has been carried out in the first episode in the area.
3	Percentage of patients whose cognitive status has been assessed in the first episode in the area.
4	Percentage of patients in whom a pressure ulcer risk assessment has been performed in the first episode in the area.
7	Percentage of patients in whom an assessment of the risk of falls in the first episode has been carried out in the area.
8	Distribution of patients according to their functional status (Score ranges: <20 Total dependency; 21 – 60 Severe dependency; 61 – 90 Moderate dependency; 91 – 99 Mild dependency; 100 Independence) in the first episode in the area.
9	Patients according to their cognitive state (Scores ranges: 0-3 errors: Normal intellectual functioning. * 4-7 errors: Deficient intellectual functioning. Suspicion of deterioration. * 8-10 errors: Severe intellectual deficit) in the first episode in the area.
10	Percentage of patients according to the risk of pressure ulcers (Score ranges: 5 to 9 very high; 10 to 12 high; 13 to 14 medium; More than 14 minimal or no risk) in the first episode in the area.
11	Percentage of patients according to the risk of falls (High risk: Greater than 2 points) in the first episode in the area.
12	Polypharmacy: Total / mean / median of drugs prescribed in the first episode in the area.
13	Percentage of patients according to the following distribution in the prescription of drugs: > 3 drugs; > 5 drugs; > 7 drugs; > 12 drugs.
14	Percentage of patients with continence problems (Bladder AND / OR Bowels).
15	Percentage of patients with mobility problems (Stairs AND / OR Mobility AND / OR Transfer).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

16	Percentage of patients who need to be fed (Feeding).

Table 2 Clinical queries for the HAH admission -Patient health status- scenario

CLINICAL QUERIES Scenario 2.2: HAH ADMISSION- Indicators related with the clinical pathway	
# of query	**Clinical query**
1	Distribution of the care schemes in which patients are treated in the first episode in the area.
2	Average of stays in the first episode in the area.
3	Distribution of patients according to destination / discharge circumstance and patient profile.
4	Distribution of patients according to cause of hospital readmission.
5	Percentage of patients who die during admission to HAH.
6	Percentage of patients assigned to a case management program after the first admission to HAH.
7	Average number of stays according to each healthcare function.
8	Time deviation between the planned discharge date and the final discharge date.

Table 3 Clinical queries for the HAH admission –Indicators related with the clinical pathway- scenario

Table 4 introduces the preliminary clinical queries for the third scenario proposed by HULAFE, case management program, concretely for patient health status.

CLINICAL QUERIES Scenario 3.1: CASE MANAGEMENT PROGRAM – Patient health status	
# of query	**Clinical query**
1	Distribution of patients according to the general clinical profile in the first episode in the area.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

2	Percentage of patients whose functional status has been assessed during the first scheduled follow-up episode in the Area.
3	Percentage of patients in whom an assessment of their cognitive status has been carried out during the first scheduled follow-up episode in the area.
4	Percentage of patients in whom an assessment of the risk of pressure ulcers has been carried out during the first scheduled follow-up episode in the area.
5	Percentage of patients in whom an assessment of the risk of falls has been carried out during the first scheduled follow-up episode in the area.
6	Distribution of patients according to their functional status (Score ranges: <20 Total dependency; 21 – 60 Severe dependency; 61 – 90 Moderate dependency; 91 – 99 Mild dependency; 100 Independence) in the first episode in the area.
7	Patients according to their cognitive state (Scores ranges: 0-3 errors: Normal intellectual functioning. * 4-7 errors: Deficient intellectual functioning. Suspicion of deterioration. * 8-10 errors: Severe intellectual deficit) in the first episode in the area.
8	Percentage of patients according to the risk of pressure ulcers (Score ranges: 5 to 9 very high; 10 to 12 high; 13 to 14 medium; More than 14 minimal or no risk) in the first episode in the area.
9	Percentage of patients according to the risk of falls throughout the first scheduled follow-up episode in the Area (High risk: Greater than 2 points) in the first episode in the area.
10	Polypharmacy: No. / Mean / median drugs in the first episode in the area.
11	Percentage of patients according to the following distribution in the prescription of drugs: > 3 drugs; > 5 drugs; > 7 drugs; > 12 drugs.
12	Sociodemographic profile of patients with a scheduled follow-up episode.
13	Percentage of patients aged> 65 years; > 80 years; > 90 years (calculated at the time of consultation).
14	Percentage of patients with continence problems (Bladder AND / OR Bowels).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

15	Percentage of patients with mobility problems (Stairs AND / OR Mobility AND / OR Transfer).
16	Percentage of patients who need to be fed (Feeding).

Table 4 Clinical queries for the case management program -Patient health status- scenario

Table 5 includes the preliminary clinical queries for the third scenario for the indicators related with the clinical pathway.

CLINICAL QUERIES Scenario 3.2: CASE MANAGEMENT PROGRAM – Indicators related with the clinical pathway	
# of query	**Clinical query**
1	Average stays in a follow-up episode in the case management.
2	Time (DAYS) elapsed since entering the Case Management program and the first registration.
3	Number of HHU episodes during the follow-up episode in Case Management.
4	Distribution of patients according to destination / discharge circumstance and patient profile.

Table 5 Clinical queries for the case management (indicators of the clinical pathway) scenario

In the same way, Table 6 incorporates the clinical queries for the third scenario, case management program, with the indicators specifically related with the episodes whose origin setting is self-referral.

CLINICAL QUERIES Scenario 3.3: CASE MANAGEMENT PROGRAM – Indicators related specifically with the episodes which origin setting is SELF-REFERRAL	
# of query	**Clinical query**
1	Average stays.
2	Rate of episodes originating from SELF-REFERRAL by patient profile.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

3	Rate of episodes originating from SELF-REFERRAL by team and patient profile.
4	Most frequent care scheme in HAH in each episode originating from SELF-REFERRAL.

Table 6 Clinical queries for the case management (indicators of self-referral) scenario

Finally, Table 7 describes the clinical questions for the fourth scenario; it is the indicators related to the last week of life.

CLINICAL QUERIES Scenario 4: Indicators related to last week of life	
# of query	**Clinical query**
1	For patients who have never been to the Case Management program: Rate of referral to hospital from HAH (episode prior to death: discharge circumstance – any which involves referral to hospital).
2	For patients in the Case Management program: Referral to the hospital from the area – includes from HAH or from Case Management – (episode prior to death: discharge circumstance – any which involves referral to the hospital).
3	Place of death in the hospital environment.
4	Percentage of patients under follow-up for HAH at the time of death.
5	For patients who have never been to the Case Management program: Rate of referral to hospital or emergency room from HAH or from Case Management voluntarily.

Table 7 Clinical queries for the fourth scenario, indicators related to last week of life

3.3 Dashboard development

With the InAdvance Dashboard, we aim to leverage the longitudinal nature of clinical data, designing a tool able to present events over time, and the patient's evolving clinical state, through visual analytics (Caban, 2015), implemented through a dashboard. Dashboards implement a specific user interface approach, and they are defined as Decision Support Systems (DSS) that are capable of querying multiple databases to merge information and provide a visual summary of KPIs (Wilbanks, 2014), (Hartzler, 2016). In this line, the InAdvance tool performs a system-level dashboard, summarising data from multiple sources, and

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

a set of different-level dashboards. These different views allow healthcare professionals to monitor the data and navigate through coordinated displays in various formats to quickly zoom in on specific variables of interest. The architecture of the tool, shown in Figure 11, is based on three main modules: data integration and storage, data querying and mining, and graphical user interface and data visualisation through the InAdvance Dashboard.

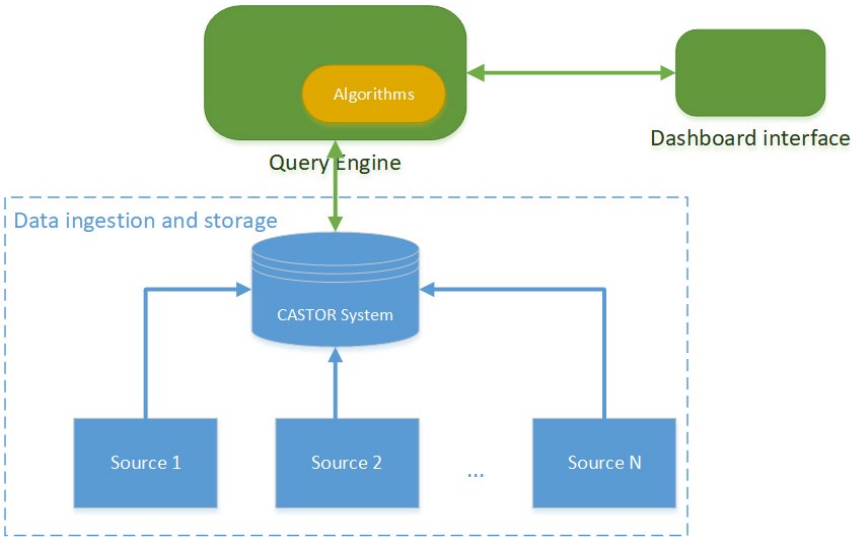


Figure 11 Architecture of the InAdvance dashboard tool

3.3.1 Data ingestion and storage

The data integration and repository module is devoted to gather, integrate, and store data from heterogeneous sources, among of data coming from the different study sites sources. As explained in section 3.2.2, it is implemented by CASTOR, a loud-based clinical data management platform to incorporate data from the clinical trials.

CASTOR is an Electronic Data Capture (EDC) system, a software that stores patient data collected in clinical trials. Data is typically first recorded on paper and is then transcribed into the system and saved in an electronic case report form (eCRF). It enables researchers to easily capture and integrate data from any source in real-time.

Below are included main CASTOR characteristics:

- Decentralise your trials with Castor eConsent, ePRO, and video.
- Build a study within hours using an intuitive form builder.
- 90% of studies in Castor are built and pass UAT in less than four weeks.
- Capture patient, clinician, EMR/EHR, and device data on a central platform.
- Monitor study progress through real-time reporting.
- Compliant with 21 CFR Part 11, GCP, GDPR and HIPAA.
- ISO27001 and ISO9001 certified.
- Top-rated EDC and ePRO systems.
- World-class support.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

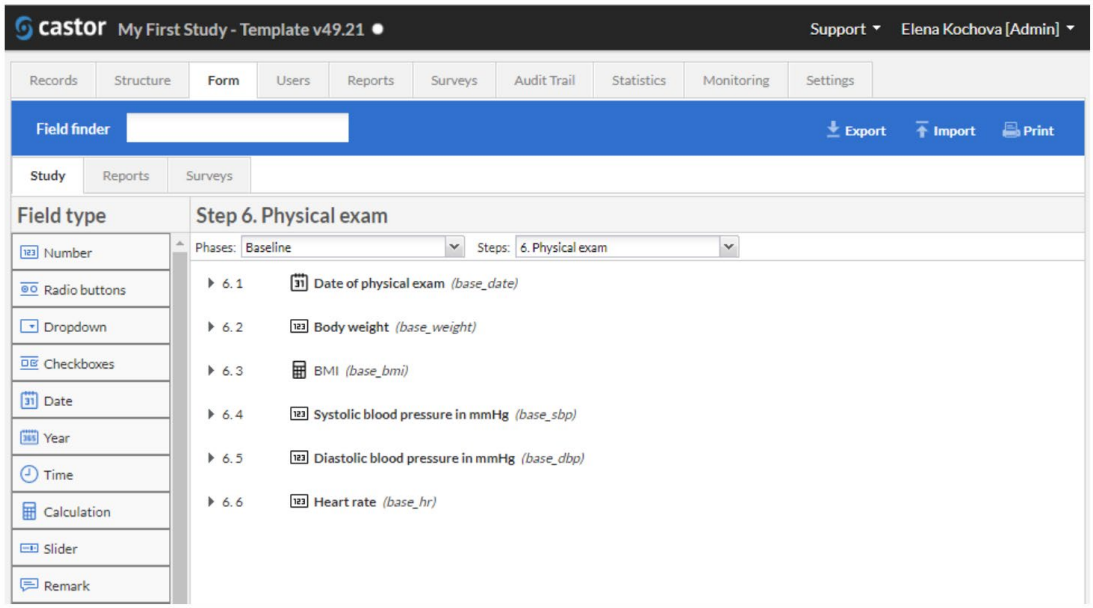


Figure 12 CASTOR screenshot

CASTOR incorporates an export functionality which enables to export of trial data into a .csv format. This data will feed the InAdvance Dashboard each evaluation time-point. The Dashboard includes a dedicated modulo to ingest data coming from CASTOR in the agreed format. Below, Table 8 shows the data points included in CASTOR that the Dashboard will consume.

Data Point	Response Options (from Participants)	Source / Site	Type of Participant
Patient characteristics			
Study ID number	Number	NHSH / Thessaloniki / HULAFE / SCMA	Patient / Carer / HCP
Age	Actual	NHSH / Thessaloniki / HULAFE / SCMA	Patient / Carer / HCP
Gender	M / F / Other	NHSH / Thessaloniki / HULAFE / SCMA	Patient / Carer / HCP
Marital Status	Single / Married / Widowed / Cohabiting / Other	NHSH / Thessaloniki / HULAFE / SCMA	Patient
Level of Education	School / Undergraduate / Masters / PhD / Other	NHSH / Thessaloniki / HULAFE / SCMA	Patient / Carer / HCP
Ethnicity	White / Black (Site Country) / Asian (Site Country) / Chinese (Site Country) / Other	NHSH / Thessaloniki / HULAFE / SCMA	Patient / Carer

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

Data Point	Response Options (from Participants)	Source / Site	Type of Participant
Socio-Economic Background	Higher managerial & professional; Lower managerial & professional; Intermediate occupations; Small employers & own account workers; Lower supervisory & technical; Semi-routine occupations; Routine occupations	NHSH / Thessaloniki / HULAFE / SCMA	Patient / Carer
Active Clinical Diagnosis	COPD / Multi-morbidity	NHSH / Thessaloniki / HULAFE / SCMA	Patient
Time since diagnosis (years/ months)	Number	NHSH / Thessaloniki / HULAFE / SCMA	Patient /
Medications	Number (separate drugs)	NHSH / Thessaloniki / HULAFE / SCMA	Patient
Type of drugs	Type names (e.g., opioid)	NHSH / Thessaloniki / HULAFE / SCMA	Patient
Preferences for location of care and EoL care	Home; Hospice; Care Home; Nursing Home: Hospital; Other	NHSH / Thessaloniki / HULAFE / SCMA	Patient / Carer / HCP
CARER characteristics			
Relationship with Patient	Spouse; Child; Sibling; Friend; Professional Caregiver; Other	NHSH / Thessaloniki / HULAFE / SCMA	Carer
Cohabiting with Patient	Yes / No	NHSH / Thessaloniki / HULAFE / SCMA	Carer
Caregiving Profile	Experience (years) in caregiving	NHSH / Thessaloniki / HULAFE / SCMA	Carer
Caregiving Profile	Skills in caregiving; Medication management; Wound dressing; Activities of daily living (ADL)(bathing, dressing, transferring, continence/incontinence care, toileting, locomotion, feeding); Catheter care; Nebuliser; Suctioning Insulin or other injections; Other	NHSH / Thessaloniki / HULAFE / SCMA	Carer
HCP characteristics			

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

Data Point	Response Options (from Participants)	Source / Site	Type of Participant
Years of experience in general healthcare practice	Number	NHSH / Thessaloniki / HULAFE / SCMA	HCP
Years of experience in Palliative Care	Number	NHSH / Thessaloniki / HULAFE / SCMA	HCP
Previous training in Palliative Care (what training)	Written details	NHSH / Thessaloniki / HULAFE / SCMA	HCP
Visit Information			
Consent Date	Date	NHSH / Thessaloniki / HULAFE / SCMA	
Visit Number	Number	NHSH / Thessaloniki / HULAFE / SCMA	
Visit Date	Date	NHSH / Thessaloniki / HULAFE / SCMA	
Visit Location	Home; Hospice; Care or Nursing Home; Hospital; Telephone; Zoom; Other	NHSH / Thessaloniki / HULAFE / SCMA	
EQ-5D-5L	Questionnaires responses	NHSH / Thessaloniki / HULAFE / SCMA	Patient / Carer
HADS	Questionnaires responses	NHSH / Thessaloniki / HULAFE / SCMA	Patient / Carer
POS2	Questionnaires responses	NHSH / Thessaloniki / HULAFE / SCMA	Patient
PPSv2	Questionnaires responses	NHSH / Thessaloniki / HULAFE / SCMA	HCP (about the patient's status)
BRIEF ZBI	Questionnaires responses	NHSH / Thessaloniki / HULAFE / SCMA	Carer
MOS	Questionnaires responses	NHSH / Thessaloniki / HULAFE / SCMA	Patient
MCQ	Questionnaires responses	NHSH / Thessaloniki / HULAFE / SCMA	Patient
VICQ	Questionnaires responses	NHSH / Thessaloniki / HULAFE / SCMA	Carer
CFIR	Questionnaires responses	NHSH / Thessaloniki / HULAFE / SCMA	HCP
Perceived quality of care	Questionnaires responses	NHSH / Thessaloniki / HULAFE / SCMA	Patient / Carer
Fidelity	Questionnaires responses	NHSH / Thessaloniki / HULAFE / SCMA	HCP

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

Data Point	Response Options (from Participants)	Source / Site	Type of Participant
Intervention costs	Questionnaires responses	NHSH / Thessaloniki / HULAFE / SCMA	HCP

Table 8 CASTOR data end-points

3.3.2 Query Engine and Mining module

The data querying and mining modules implement the longitudinal analytics algorithms to retrieve meaningful patterns in patients' follow-up and determine patients' distributions in specific groups. The analytics included in the dashboard are two:

i. Statistical Business Intelligence: the dashboard includes analytics for a quick assessment of the control level of specific parameters.
ii. Process Mining: the dashboard also incorporates the temporal perspective of the processes thanks to PM techniques, ranging from simple mapping of variables into meaningful intervals to more complex behaviours including trends and multivariable episodes.

These analyses could be performed for an individual patient or a group of patients, which may be the complete patient cohort evaluated or maybe a selection of patients filtering by different variables, as already mentioned. Finally, the dashboard shows all these insights and analytics through the dashboard interface, which is also the entry point for the users.

3.3.3 Process Mining

Process Mining (PM) (Van Der Aalst, 2016)(Van, 2016) solutions can offer a better understanding of a care process than other techniques. PM techniques are based on a syntactical data mining framework thought to support experts in the sense of complex processes, in comprehensive, objective and exploratory ways (Van Der Aalst, 2016). Health processes are structured multidisciplinary care protocols and plans, that detail essential steps in the care of patients within a specific clinical problem (Campbell, 1998). In this line, care pathways are complex processes including each stage of the management of a patient with a particular condition over a given period, and include progress and outcome details. In that way, care pathways should be understood as a patient's overall journey instead of isolated functions independently. The application of PM technologies can support health professionals in the discovery of health processes and patients' behaviours.

The Query engine, the algorithms and the dashboard interface implemented are based on the solutions provided by the PMApp tool. PMApp is a PM toolkit based on the PALIA (Parallel Activity Log Inference Algorithm) Suite tool (Ibanez-Sanchez, 2019). Both PALIA and PMApp have been developed at the Universitat Politècnica de València. PALIA has been widely tested in real healthcare scenarios.

The flow of data through the PM methodology implemented within the dashboard is represented in Figure 12. The process starts with the data ingestion from the

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

corresponding data source (csv file exported from CASTOR). During the second step, data are processed to compute the needed variables for the PM analysis. After applying the filtering and processing step, the data is ready for obtaining the model behind the data using PALIA algorithm. After this, it is performed the computation of the metadata associated with the model. The final step is the representation of the graphical models, and the statistics associated with the dashboard.

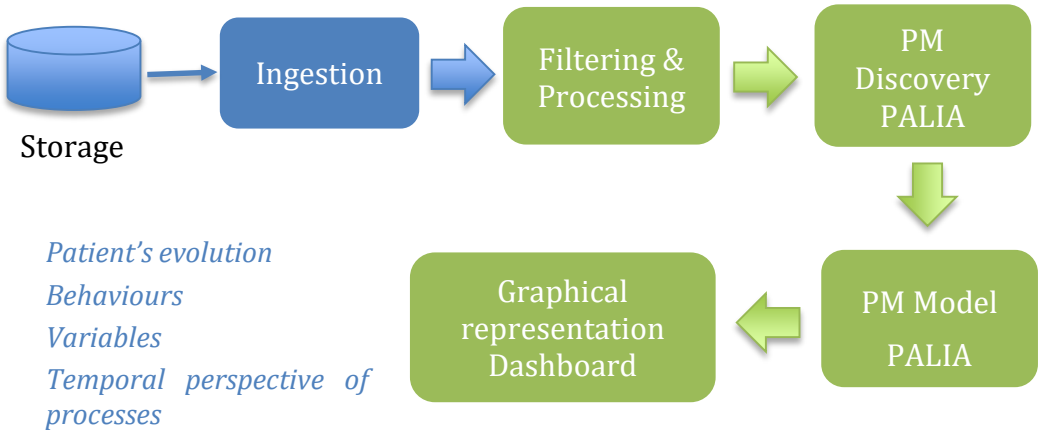


Figure 13 Dashboard implementation: Data flow

All previous steps could be configured and executed "in live". Healthcare experts using the dashboard could decide what data to ingest, what filters and processing to apply, what metadata to be used, and what statistics to be represented with the model, in order to obtain the most valuable model for each moment. However, the flow can also be configured as a "close" experiment, so health experts will directly go to the graphical representation and the analysis of the results and statistics.

3.4 Appraising PC interventions

One of the main WP7 goals is the development of an appraisal dashboard to provide a general overview of the users and interventions' status. With this objective in mind and within the InAdvnace context, the dashboard will provide awareness of the PC processes and will support the assessment of the PC intervention implemented during the project lifetime.

Typical Data Science solutions include inductive methods based on statistical frameworks that produce accurate results only when the number of cases is adequate. However, the dashboard represents the flow behind the data as it is currently happening, it is not a matter of tendencies or predictions, where a significant amount of data is needed to present valuable results. The graphical representation of the current flow in a human-understandable manner allows discovering what is actually happening within the care process thanks to the data.

In this context, a Process Indicator (PI) is a human-understandable graphical representation based on the available information about the care process (clinical

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

events, variables, measures…). PIs are visual and navigable models that handle actual processes.

For that, an initial set of PI has been designed focusing on the site care process and patients' outcomes for appraising the PC interventions. These PIs will allow the analysis from a temporal perspective to focus on the outcome's evolution to appraisal of the intervention from two different aspects:

- Care process: analysis of the pare process during the intervention lifecycle.
- Patient's outcomes: Quality of Life, intensity of symptoms, functional status, emotional distress, perceived quality of care, and adherence to treatment.

Based on the information included in WP5, during the intervention, data will be collected on the following basis:

- T0: baseline data from patients (PROMs, cost-effectiveness, interviews) (M0)
- T1: PROMs (effectiveness) (w6)
- T2: PROMs (effectiveness), cost-effectiveness, interviews (M6)
- T3: PROMs (effectiveness), cost-effectiveness, interviews (M12)
- T4: PROMs (effectiveness, cost-effectiveness, and final interviews, and questionnaires (M18)

The analysis and models could be performed in three different moments, after the second and third intermediate evaluations, and coinciding with the final assessment (see Figure 13 Evaluation flow).

1. Socio-demographic data at the beginning of the evaluation (T0)
2. Data regarding the effectiveness of the intervention through PROMs in five moments (T0, T1, T2, T3, T4)
3. Data regarding the cost-effectiveness in four moments (T0, T2, T3, T4)
4. And other data gathered was through interviews and questionnaires in four moments (T0, T2, T3, T4)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

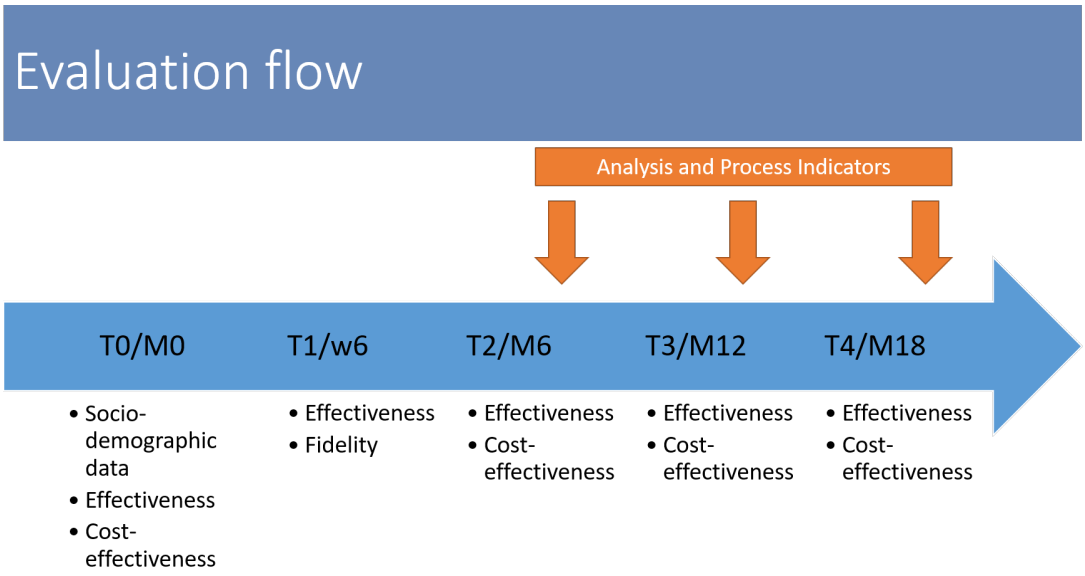


Figure 14 Evaluation flow

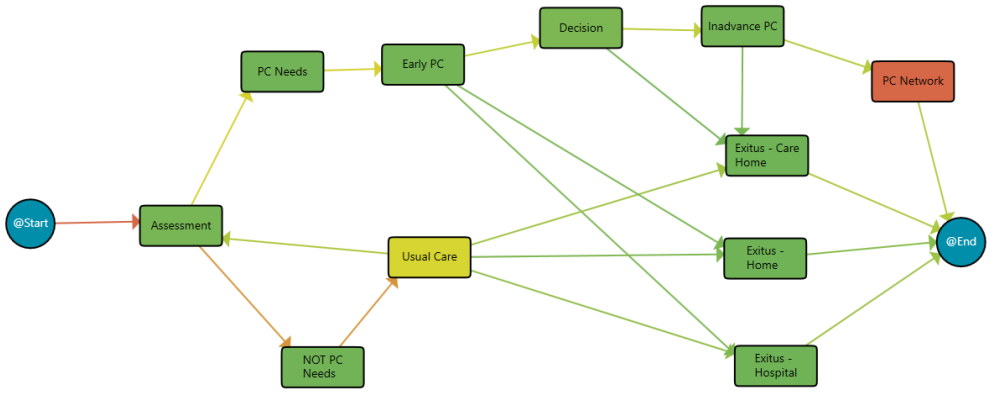
3.4.1 Care process

To infer the process behind the intervention, we will collect information about the different steps of the process. Based on the information included in the deliverable D3.4 Report describing the initial version of InAdvance interventions for the procedures in Leeds, Highlands, Spain, Greece and Portugal, the different events that describe these processes are:

- Needs Assessment
- Usual Care
- Decided Plan
- Specialist PC (might be not needed)
- Generalist PC
- Follow-up
- Outcome assessment

Therefore, these clinical events will have associated timestamp (the date on which the event happened). Using the InAdvance dashboard and Process Mining techniques, we will obtain the care process for each intervention. The care process will look like the following image.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750



.

Figure 15 Care process example

Process Mining techniques infer knowledge from data, understanding data as recorded event logs, where each event refers to timestamp information about a patient's healthcare episode, a set of events corresponding to the same patient is a case, and the log is a set of cases. By using colour gradients to provide information about the duration of the actions or the number of transitions between actions, it becomes possible to visually represent deadlocks and bottlenecks in the process, and detect the most common paths and activities performed by patients. By comparing the process of the intervened and control groups, it will be possible to discover differences.

3.4.2 Patients' outcomes

As said, patients' outcomes will be used for appraising the intervention focusing on the outcome's evolution. For this to end, six PIs have been designed and will be implemented, based on the outcome measures collected during the trials and listed below.

1. Quality of Life

Quality of Life will be measured by the EQ-5D-5L questionnaire. The following table includes the analysis and assessment performed for this PI during the trial's lifecycle.

The overall idea is to use all available information to understand how the outcome is related to it and see the possible evolution or progress of the outcome during the trial duration. For this, the PI will model how the outcome, in this case the quality of life, is related to the socio-demographic variables and health effects. The PI will also include the available information from the carer, as well as the interrelationship with the secondary outcomes or the intervention costs.

Quality of Life (EQ-5D-5L)	Model	Assessment
	Patient's Socio-demographic/health effects: age, sex, marital status, level of education, ethnicity, socio-economic level, active diagnoses, time since diagnoses, #prescribed drugs.	Different perspectives based on different information: population level, patient level

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

	Socio-demographic data from carer: relation with patient, cohabiting with patient, caregiving profile, skills in caregiving.	Cohort: comparison of patients by different variables Patient stratification: groups of patients with similar characteristics regarding a concrete variable Statistical information
	Interrelationship with secondary outcomes: emotional distress, perceived quality of care, and adherence to treatment.	
	Interrelationship with caregiver outcomes: Quality of life, Emotional distress, Caregiving burden, Quality of care, Informal care costs.	
	MCQ results: interventions costs.	

Table 9 Quality of Life PI assessment

2. Intensity of symptoms

Intensity of symptoms will be assessed with POS1 and POS2 questionnaires. The following table includes the analysis and assessment that will be performed for this PI during the trial's lifecycle.

Intensity of symptoms (POS1, POS2)	Model	Assessment
	Socio-demographic/health effects: age, sex, marital status, level of education, ethnicity, socio-economic level, active diagnoses, time since diagnoses, #prescribed drugs	Different perspectives based on different information: population level, patient level Cohort: comparison of patients by different variables Patient stratification: groups of patients with similar characteristics regarding a concrete variable Statistical information
	Socio-demographic data from carer: relation with patient, cohabiting with patient, caregiving profile, skills in caregiving.	
	Interrelationship with secondary outcomes: emotional distress, perceived quality of care, and adherence to treatment.	
	Interrelationship with caregiver outcomes: Quality of life, Emotional distress, Caregiving burden, Quality of care, Informal care costs.	
	MCQ results: interventions costs.	

Table 10 Intensity of symptoms PI assessment

3. Functional status

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

The functional status will be estimated using the PPS2 questionnaire. The following table includes the analysis and assessment that will be performed for this PI during the trial's lifecycle.

Functional status (PPS2)	Model	Assessment
	Socio-demographic/health effects: age, sex, marital status, level of education, ethnicity, socio-economic level, active diagnoses, time since diagnoses, #prescribed drugs	Different perspectives based on different information: population level, patient level Cohort: comparison of patients by different variables Patient stratification: groups of patients with similar characteristics regarding a concrete variable Statistical information
	Socio-demographic data from carer: relation with patient, cohabiting with patient, caregiving profile, skills in caregiving.	
	Interrelationship with secondary outcomes: emotional distress, perceived quality of care, and adherence to treatment.	
	Interrelationship with caregiver outcomes: Quality of life, Emotional distress, Caregiving burden, Quality of care, Informal care costs.	
	MCQ results: interventions costs.	

Table 11 Functional status PI assessment

4. Emotional distress

HADS questionnaire will assess emotional distress. Table 12 includes the analysis and assessment that will be performed for this PI during the trial's lifecycle.

Emotional distress (HADS)	Model	Assessment
	Socio-demographic/health effects: age, sex, marital status, level of education, ethnicity, socio-economic level, active diagnoses, time since diagnoses, #prescribed drugs	Different perspectives based on different information: population level, patient level Cohort: comparison of patients by different variables Patient stratification: groups of patients with similar characteristics regarding a concrete variable Statistical information
	Socio-demographic data from carer: relation with patient, cohabiting with patient, caregiving profile, skills in caregiving.	
	Interrelationship with primary outcomes: quality of life, intensity of symptoms, and functional status.	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

	Interrelationship with caregiver outcomes: Quality of life, Emotional distress, Caregiving burden, Quality of care, Informal care costs.	
	MCQ results: interventions costs.	

Table 12 Emotional distress PI assessment

5. Perceived quality of care

The perceived quality of care will be analysed by a customised set of items. Table 13 presents the analysis and assessment that will be performed for this PI during the trial's lifecycle.

Quality of care (Short set of items)	Model	Assessment
	Socio-demographic/health effects: age, sex, marital status, level of education, ethnicity, socio-economic level, active diagnoses, time since diagnoses, #prescribed drugs	Different perspectives based on different information: population level, patient level Cohort: comparison of patients by different variables Patient stratification: groups of patients with similar characteristics regarding a concrete variable Statistical informationValidation of clinical/assessment questions
	Socio-demographic data from carer: relation with patient, cohabiting with patient, caregiving profile, skills in caregiving.	
	Interrelationship with primary outcomes: quality of life, intensity of symptoms, and functional status.	
	Interrelationship with caregiver outcomes: Quality of life, Emotional distress, Caregiving burden, Quality of care, Informal care costs.	
	MCQ results: interventions costs.	

Table 13 Perceived quality of care PI assessment

6. Adherence to treatment

Finally, TAAS and MOS questionnaires will assess the adherence to treatment, as in previous PI, Table 14 includes the analysis and assessment that will be performed for this PI during the trial's lifecycle.

Adherence to treatment (TAAS, MOS)	Model	Assessment
	Socio-demographic/health effects: age, sex, marital status, level of education, ethnicity, socio-economic level, active	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

	diagnoses, time since diagnoses, #prescribed drugs	Different perspectives based on different information: population level, patient level Cohort: comparison of patients by different variables Patient stratification: groups of patients with similar characteristics regarding a concrete variable Statistical information
	Socio-demographic data from carer: relation with patient, cohabiting with patient, caregiving profile, skills in caregiving.	
	Interrelationship with primary outcomes: quality of life, intensity of symptoms, and functional status.	
	Interrelationship with caregiver outcomes: Quality of life, Emotional distress, Caregiving burden, Quality of care, Informal care costs.	
	MCQ results: interventions costs.	

Table 14 Adherence to treatment PI assessment

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

4 How to use it

The Functional Dashboard could be downloaded from the following URL:

https://gofile.me/3YTY9/ghHep3c6B

The .zip file includes the following files:

- PMAppInAdvanceF 0.0.1.msi: the dashboard installer.
- AMADORA sim: folder with the files for the SCMA use case example.
- HULAFE sim: folder with the files for the HULAFE use case example.

4.1 Installation

After extracting files for the FunctionalDashboard.zip file, double click to **PMAppInAdvanceF 0.0.1.msi** to start the installation process.

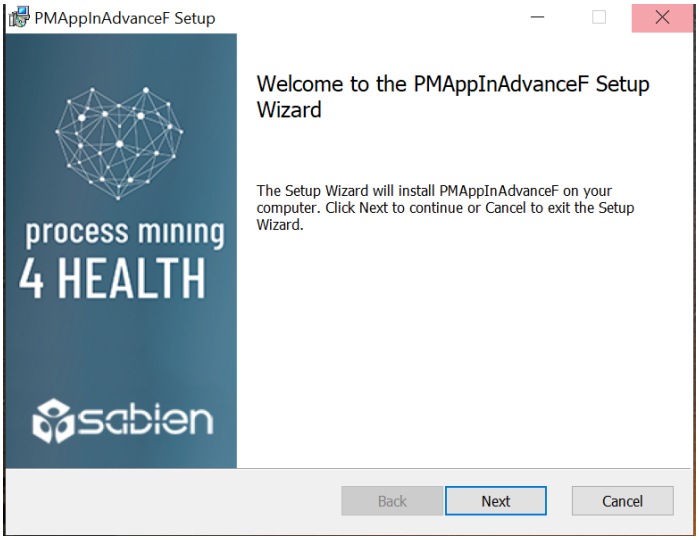


Figure 16 Dashboard setup wizard

Accept the terms in the License Agreement, and click next. Then, it can be installed into the default folder or change to choose another folder. Now click install to begin the installation or back to review or change any of the setting, or cancel to exit the wizard.

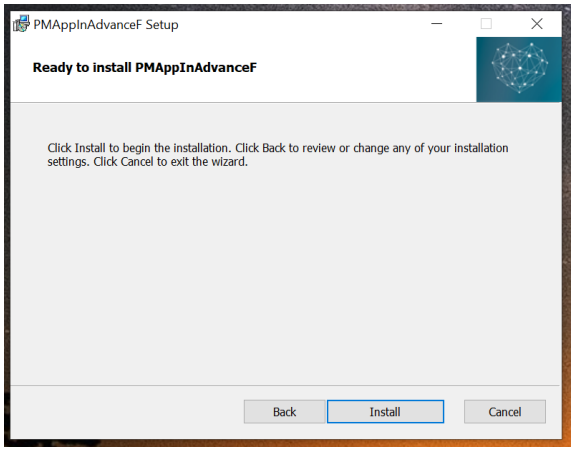


Figure 17 Dashboard setup process

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

The setup process will inform about the installation status:

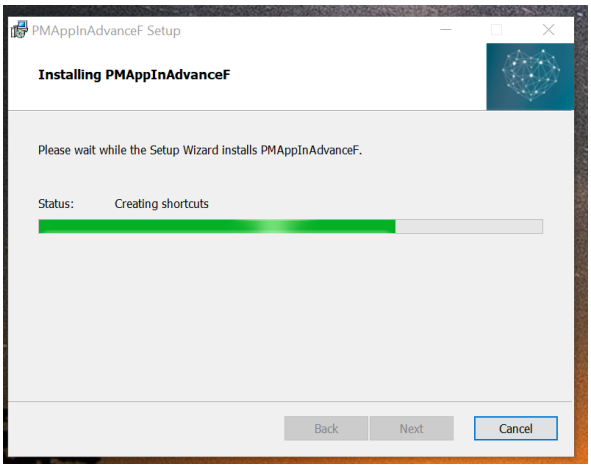


Figure 18 Dashboard installation process

Now the setup PMAppInadvance wizard is completed:

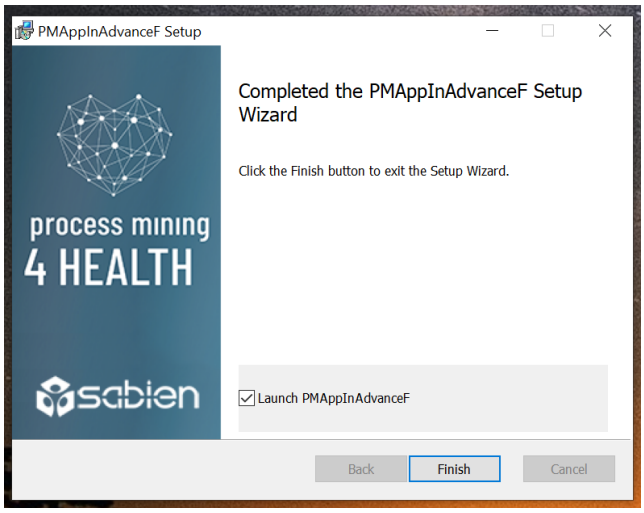


Figure 19 Dashboard installation competed

By clicking finish and with the launch option selected, the Dashboard will be automatically launched and a shortcut on the desktop will be created. Now the InAdvance Dashboard is ready for use.

4.2 InAdvance Functional Dashboard use

Figure 17 shows the InAdvance Functional Dashboard main window. The “Open” button permits to open a stored experiment (PM analysis) to review the results or to continue with the analysis.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 825750

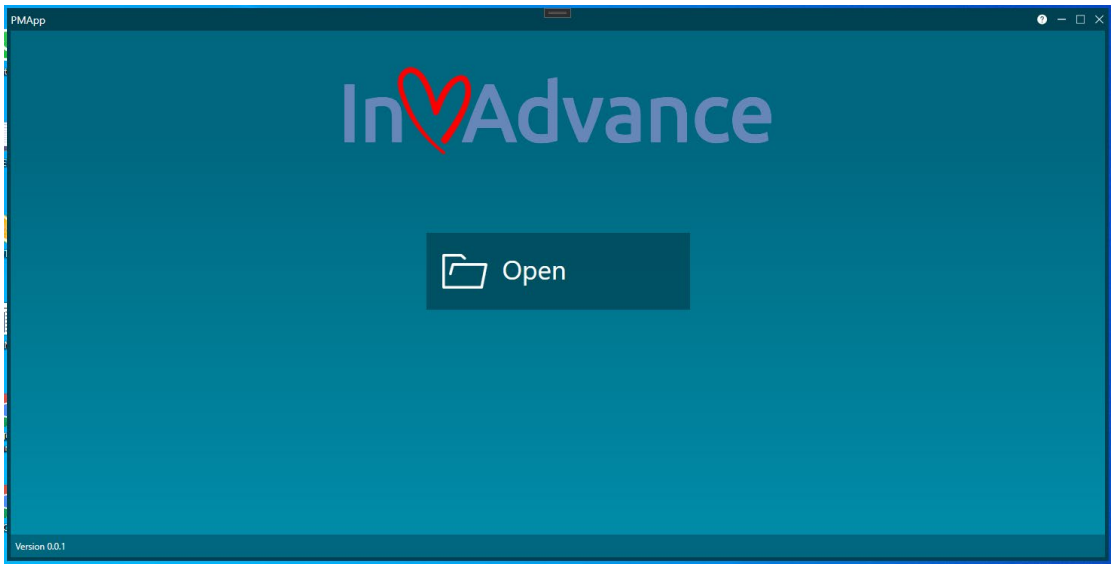


Figure 20 InAdvance Functional Dashboard main window

The Dashboard includes a complete "Help" online section that will be opened by clicking in the top right question mark.

Figure 21 Dashboard Help section

Figure 22 InAdvance Functional Dashboard main screen

The main screen is launched once a file (data, runner or experiment) is opened. This window is divided into three main areas (Figure 19):

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

- **Top bar** (red rectangle). It allows minimizing, maximizing and closing the dashboard screen. Thus, it provides access to the help of the app that by clicking in the icon will open an internet navigator.
- **Bottom tabs** (perspectives) (purple rectangle). The first time the dashboard is run, and after performing the mining, it is shown a tab named MAIN. This tab (also known as perspective) will contain as much (top) tabs as mining are performed, representing workflow diagrams. There are different perspectives and each one manages each own (top) tabs.
- **Left menu** (green rectangle). Once mining is performed, it allows working with the obtained inference by applying different types of visualization or filtering.

4.2.1 Top bar

As it is said, it allows minimizing, maximizing and closing the current dashboard screen with the results of current experimentation, as well as, to open the help of the dashboard in an internet navigator.

4.2.2 Bottom tabs (perspectives)

There are different perspectives:

- **MAIN**: to represent workflows.

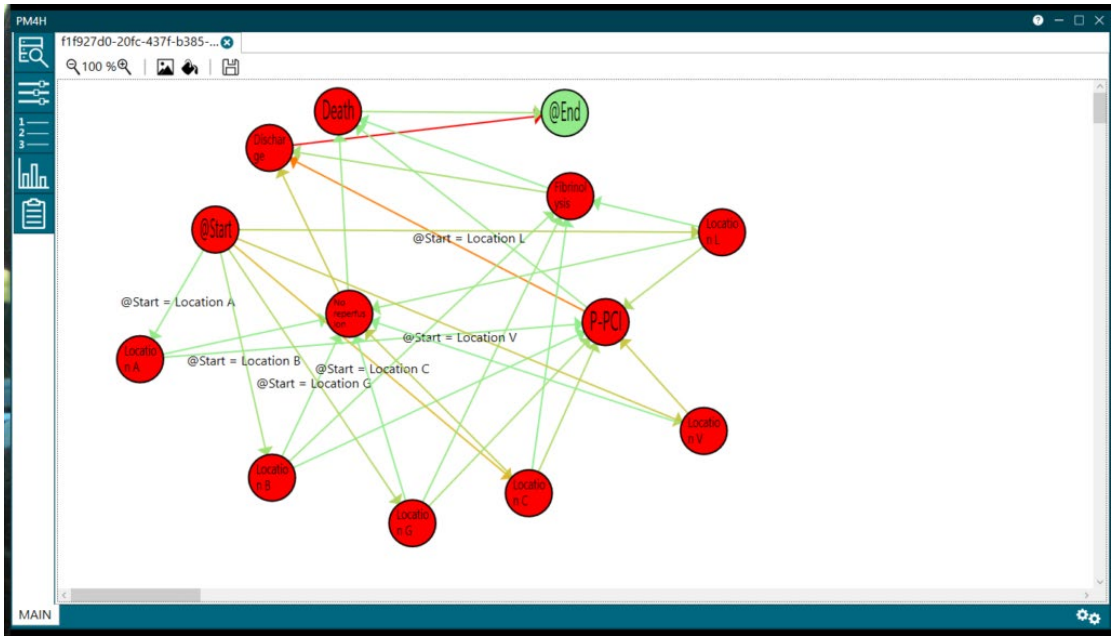


Figure 23 Main perspective

- **PROGRESS**: it is available the resulting logs of the processing carried out in the application. It is accessible in the bottom right side of the bar by clicking in the gears icon.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

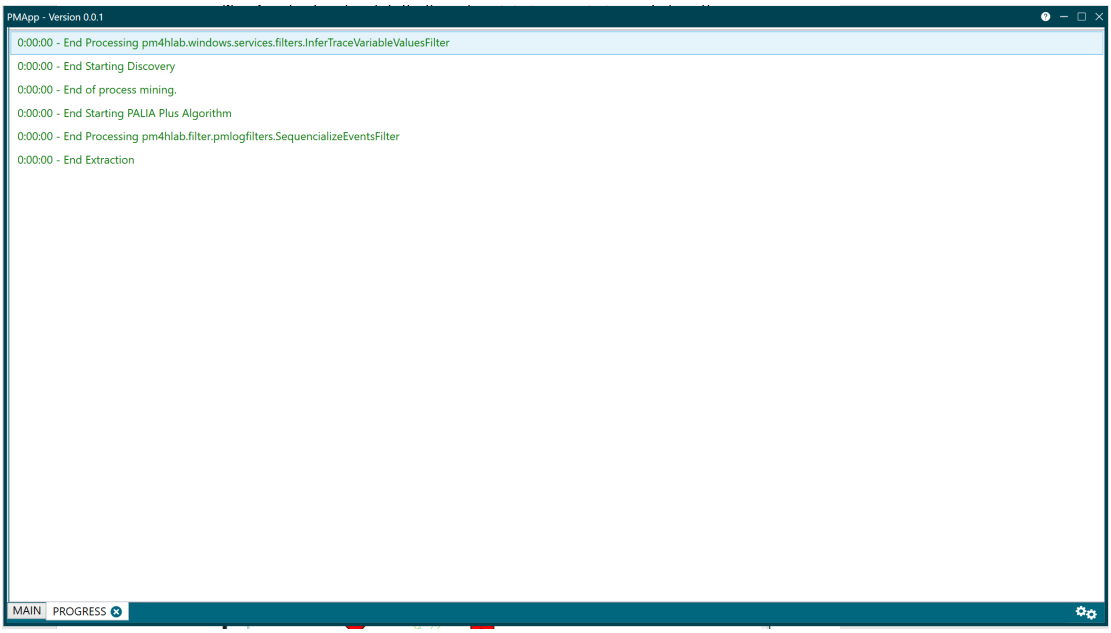


Figure 24 Progress perspective

- **TRACE INFORMATION**: it shows the detail of a patient (episode) trace.

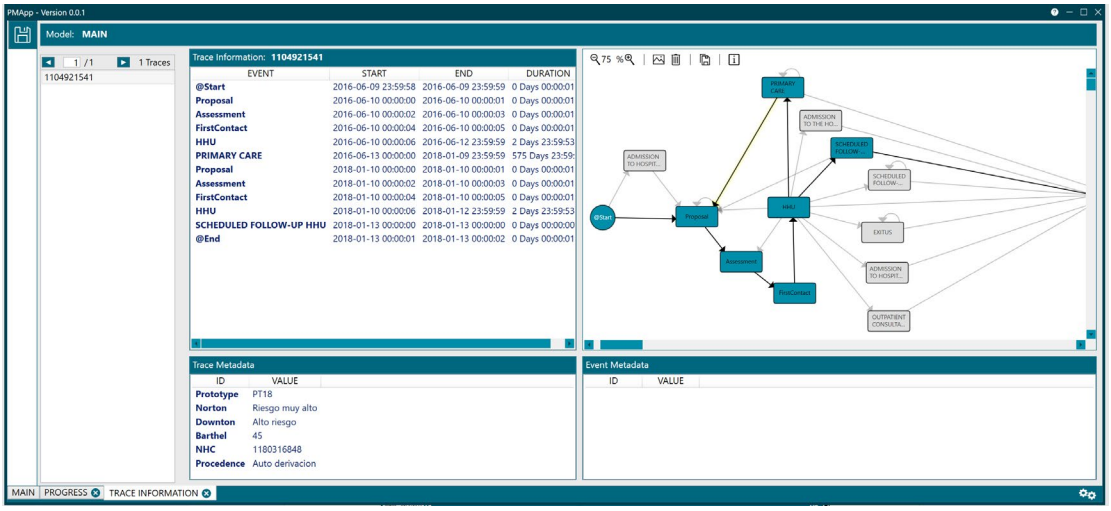


Figure 25 Trace perspective

4.2.3 Top tabs

The mining results represented in these tabs will depend on the type of perspective they belong to.

Main perspective

Each tab is for visualizing the inference or inferences obtained because of applying the mining algorithm. Actions that can be performed over each workflow are:

- Zoom. In and out.
- Add a background picture
- Remove the background picture
- Save the workflow, where the most interesting options are:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

- JPEG file. Save the workflow as an image
- The followings save the workflow as a CSV file, which allows to open it in an excel file to do further calculations
  - TPA node Stats (*.csv)
  - TPA node Duration (*.csv)
  - TPA trace stats (*.csv)

Progress perspective

This perspective presents the progress of the mining execution, errors or any output coming from the app.

4.2.4 Left menu

This menu will change depending on the perspective it is associated with.

Main perspective

This menu contains five sections in which can be found:

- **Selections**. It allows applying the mining in a subset of data of the available CSV. It will result in additional workflows' representations.
- **Enhancements**. This menu allows adding a colour map to the workflows that are already drawn.
- **Traces**. This menu lists the traces (episodes) available and details they contain.
- **Statistics & Charts**. This menu allows visualizing statistical information, charts and graphs related to the selected workflows.
- **Report.** It is a summary related to the data quality of the CSV and the errors found during the mining execution.

Trace information perspective

It is only possible to save the information as CSV file for further analysis outside the application.

4.2.5 Selections Menu

This menu allows performing a new mining, resulting in a new (top) tab.

1. If it is indicated a new name, this will be used as naming the new tab. If not, an automatic name is created based on the selection.
2. At least one option per set is selected. In the example of the following figure, there are three sets (gender, dead, age), and each one contains different options.
3. To apply the selection, it is needed to click on Run Discovery button.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

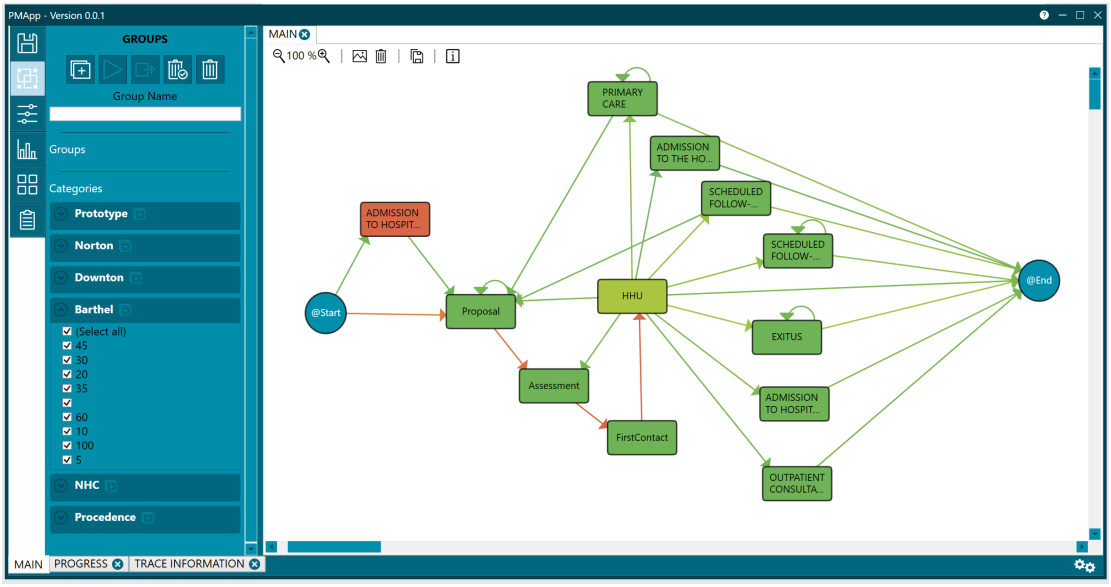


Figure 26 Selections menu

4.2.6 Enhancements Menu

This menu allows for adding a colour map to the workflows that are represented.

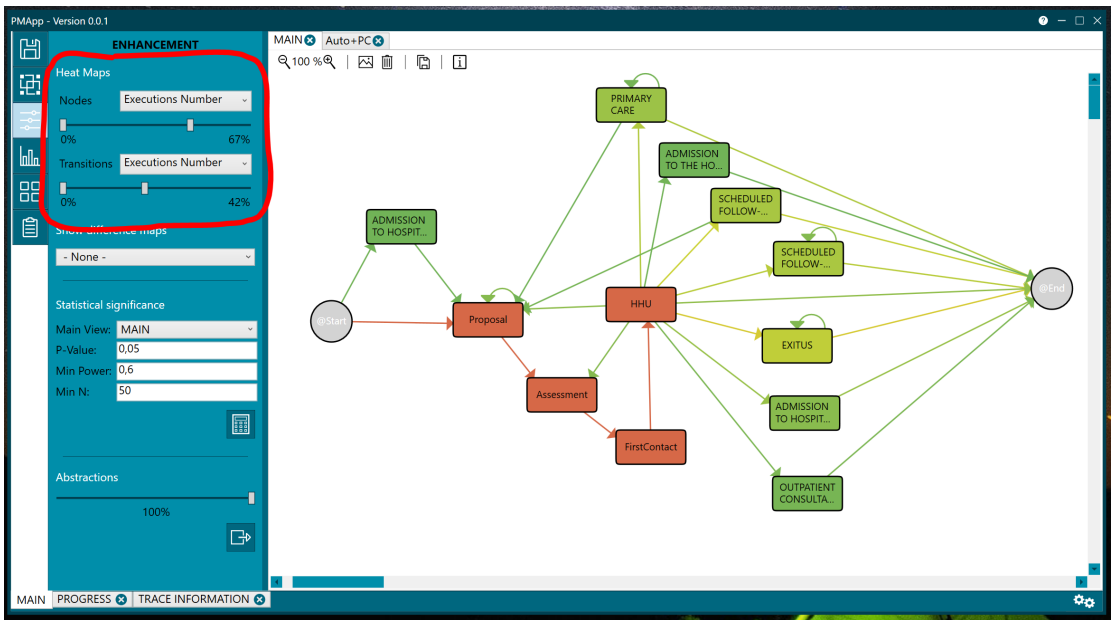


Figure 27 Enhancements menu

1. Heat Maps. Colours can be applied to represent the time spent in each node or the number of patients that have gone through the transition. The colours range goes from green to red with a colour scale. In the case of the nodes, green means that people have spent little time on the node while a red represents that time has been high. In the case of transitions, green means that few people have gone through this transition, while red indicates the highest number of people have gone through the transition. The specific way the heat maps are calculated can be chosen through the drop-down that appears of the Node and Transition options. This colour

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

representation makes it easier to understand things such as where the bottlenecks may be in a service. The Node drop-down contains the options:

- Executions Number,
- Traces Number,
- Duration Average,
- Duration Average by Trace,
- Duration Median,
- Duration Aggregation and
- Duration by Execution.

The option recommended by default for the Node drop-down is aggregated duration.

The Transition drop-down contains the options:

- Executions Number,
- Traces Number,
- Duration Average,
- Duration Median,
- Duration Aggregation,
- Duration by Execution,
- Transition Time Average and
- Transition Time Median.

2. Show difference maps drop-down. By selecting a workflow on this drop-down, it is compared to the current workflow (current view).
3. Statistical significance. The statistical significance is calculated between the Main View selected in the drop-down and the rest of workflows (views) available. The parameters to calculate it can be modified. To compute the Statistical Significance, click the corresponding button (red coloured in Figure 25)

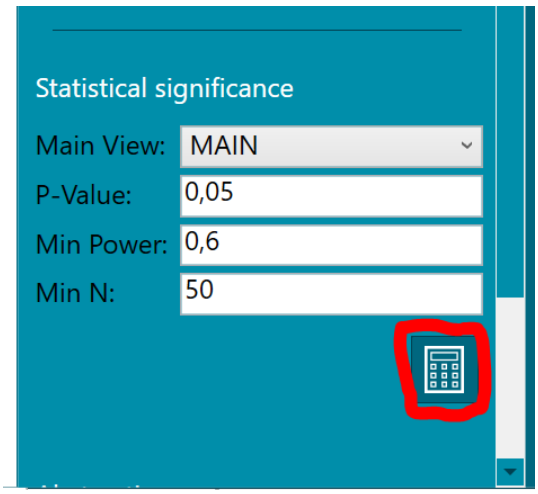


Figure 28 Compute statistical significance button

4. Abstractions. The menu also offers the possibility of showing most "common" path, deleting from the workflow the outliers based on the percentage specified in the scale. The abstraction could be extracted from

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

the current view as a new group with the corresponding button (red coloured in Figure 26).

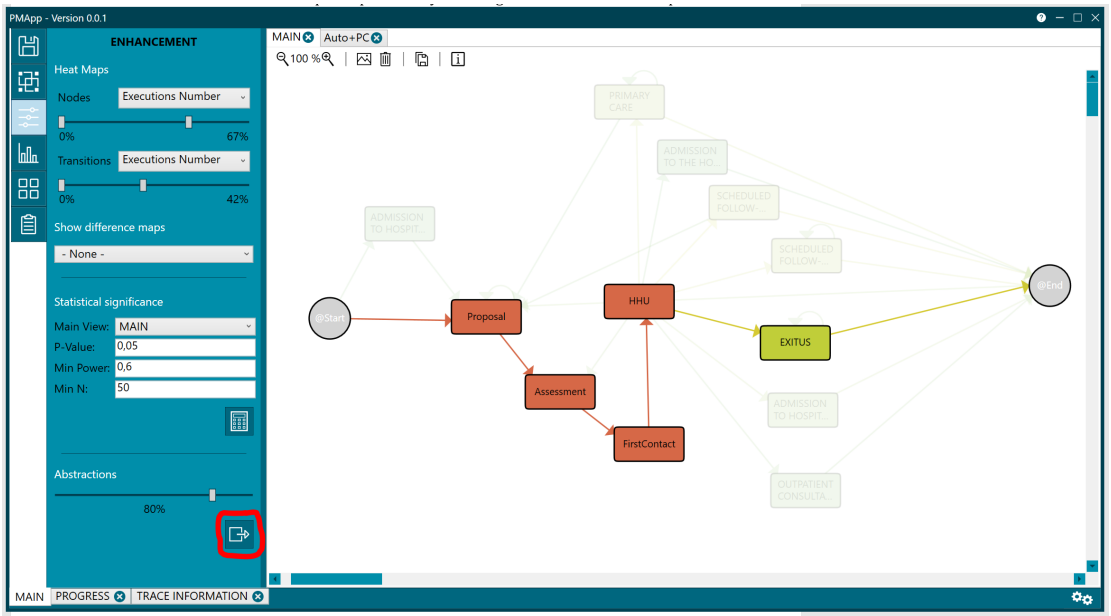


Figure 29 Abstractions possibility

5. When the mouse is over a node of the workflow, detailed statistical information appears, with information regarding the averages, median, aggregations, numbers, etc. for occurrences (e.g. people) going through that state or transition.

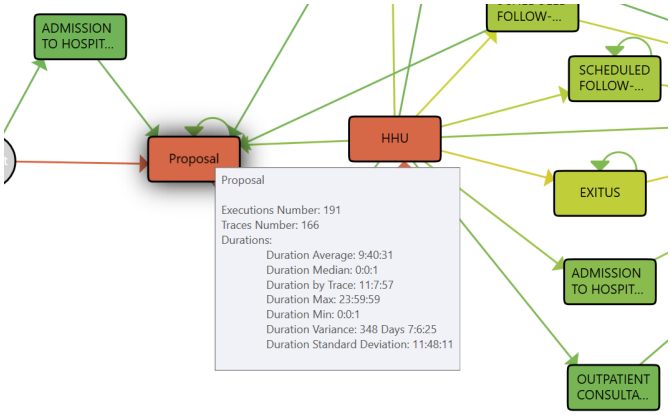


Figure 30 Statistical information of a node

4.2.7 Statistics and Charts Menu

This menu allows showing statistical information, graphs and charts.

1. The first step is select the view to be used to calculate the statistics and charts.
2. Then, it is needed to choose the type of information to visualise from the drop-down (values, partial percentages, or global percentages).
3. The variables extracted from the visible workflows are shown and can be selected.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

4. Then, it is needed to choose the flow(s) from where it wants to be shown.
5. It is indicated the Type of representation to be shown. The available options are:
    - Columns
    - Lines
    - Pie
    - Tables
6. Finally, it is needed to click on the Add Chart button below the type of representation drop-down.

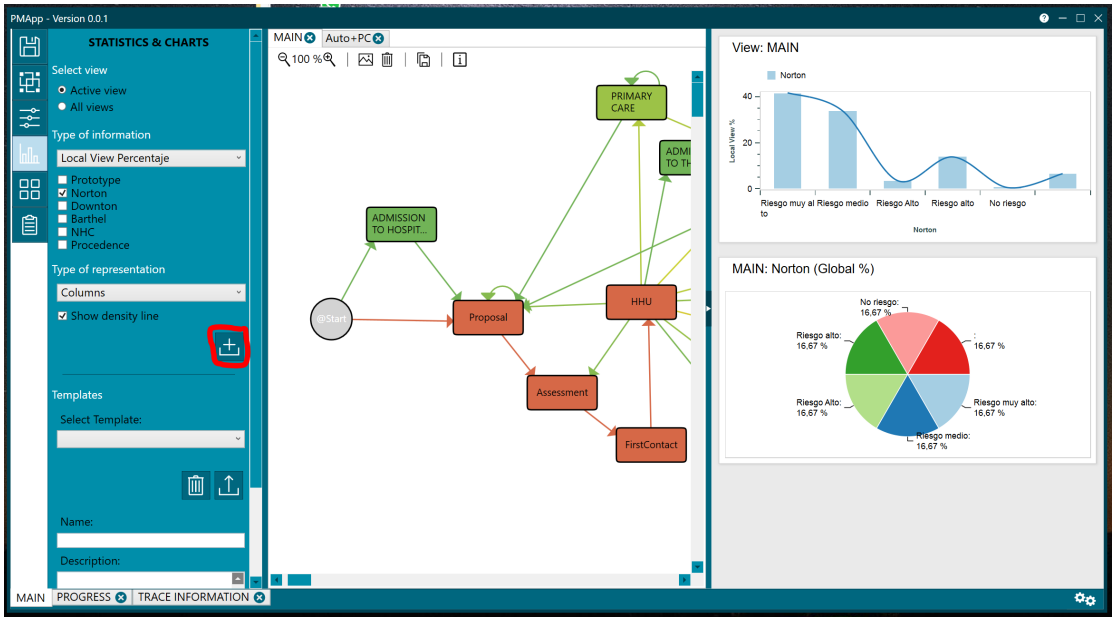


Figure 31 Statistics and chart option

7. Templates. Templates for statistics and charts could be created and used with a predefined configuration for a concrete analysis.

4.2.8 Advanced views

Within the Advanced views menu there is available one advanced view option in this Dashboard version, this is clustering. Clustering is a technique that involves the grouping of data points, in this case flows. Given a set of flows, a clustering algorithm is used to classify each flow into a specific group. In theory, flows that are in the same group should have similar properties and/or features, while flows in different groups should have highly dissimilar properties and/or features.

First, it should be selected the corresponding distance type from the drop-down options: Topological, Heuristic or Levenshtein. Then, the needed parameters, the similitude percentage, and the join groups smaller than, and click “Calculate clustering” button.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 825750

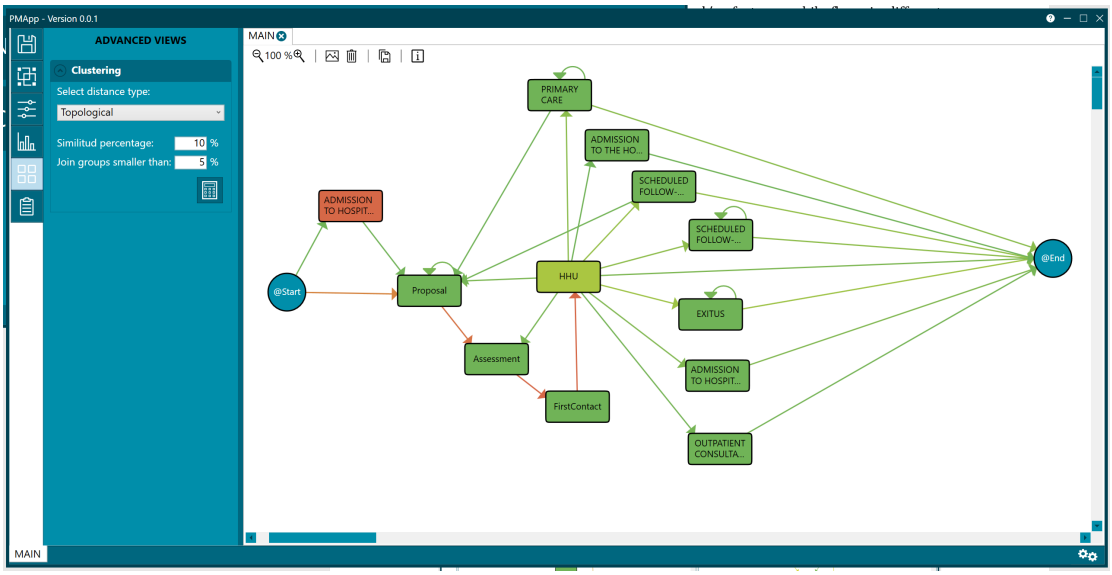


Figure 32 Advance views -> clustering

After clicking the calculate clustering button, and the corresponding process, it will appear a new perspective with the clustering results (Figure 30).

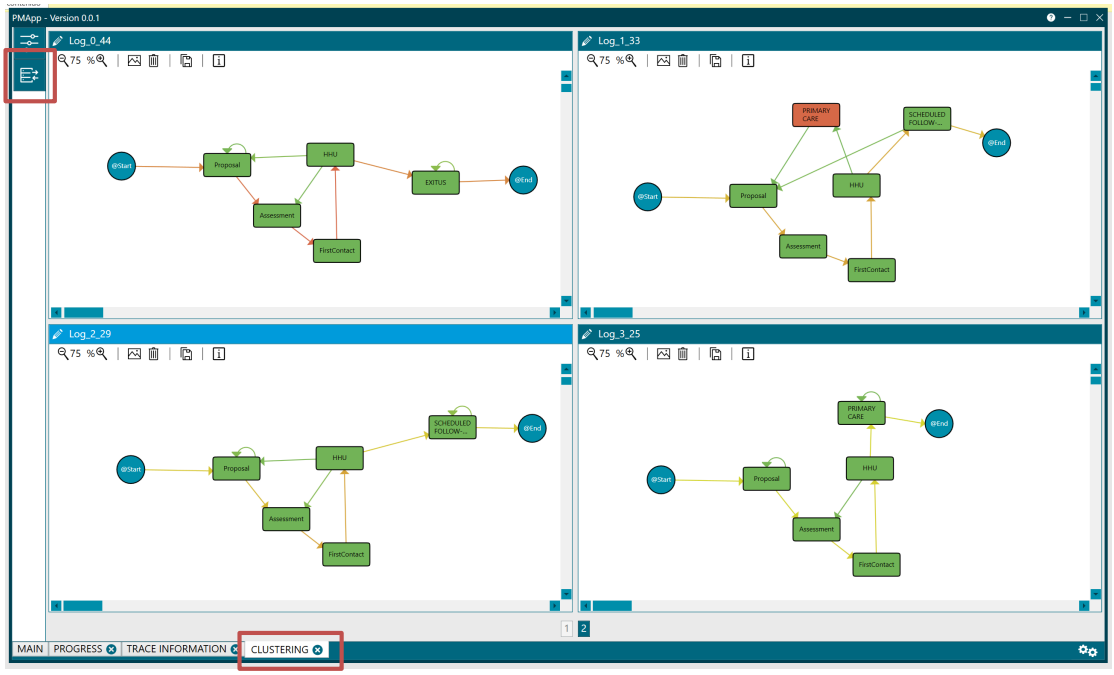


Figure 33 Cluster groups

In this new perspective, the name of each group could be changed, and this new classification could be added as a new parameter to the main perspective, adding the clustering as a trace property.

4.2.9 Report Menu

This option will show an independent window with a report of the data process during the mining execution.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

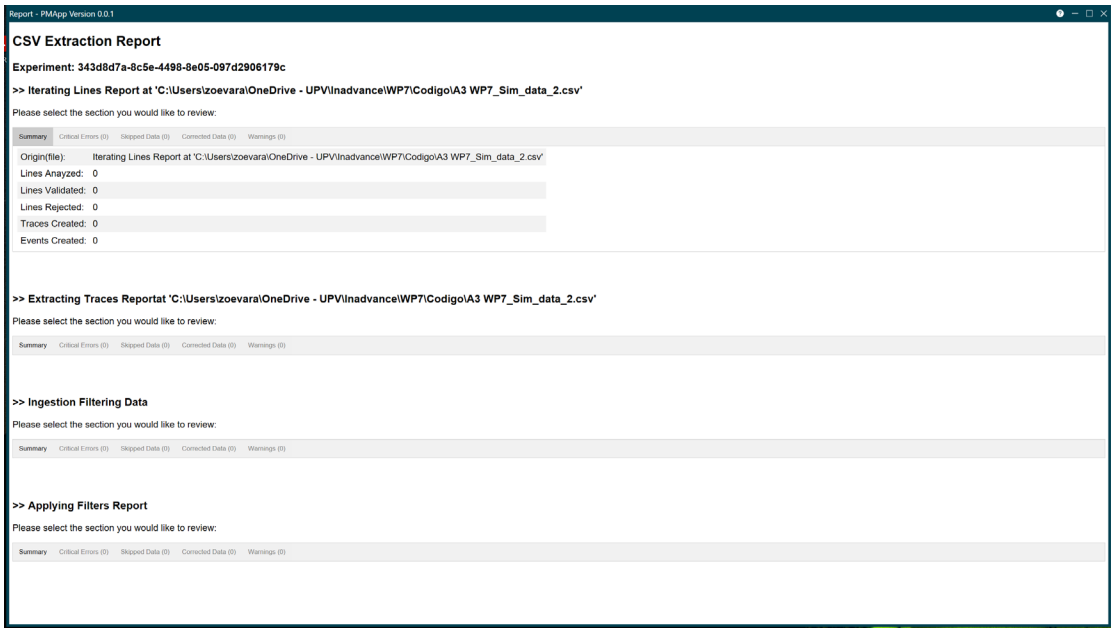


Figure 34 CSV extraction menu

4.3 Use Cases

With the objective of facilitating the learning process for the dashboard and its use, joint with the Functional Dashboard, it has been included two use cases corresponding with two of the study sites: one for HULAFE and another for SCMA. These two examples of use have been created with simulated data, this means the data follow HULAFE and SCMA pathways, however no real patients are behind these data, and consequently we have not to deal with ethical or privacy conflicts.

The following two sections present the examples, how to prepare and use them, and the results, this is a "Data-Rodeo". A Data-rodeo covers the five steps included in the PM data flow (Figure 12), from the data ingestion until the results visualisation.

The needed files to manage both Data-Rodeos are included in the .zip file together with the dashboard installer.

4.3.1 HULAFE Data-Rodeo

The HULAFE Data-Rodeo has been created with data from HULAFE hospital, concretely; HULAFE team provided a simulation of their database from the Home Hospitalisation Unit (HHU). This database was made up with the variables of interest for the project, and the provided data simulate, in certain way, the behaviour of the unit's episodes. In consequence, twelves patients' prototypes were generated with different behaviours and pathways. In addition to the HHU episodes, different scales that are usually evaluated in the hospitalisation episodes have been added, such as Norton, Downton or Barthel scales. With all this information, a simulated database was generated to be analysed with the dashboard.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

The required files for the HULAFE Data-Rodeo are included in the HULAFE sim folder. This folder contains the following files:

- A3 WP7_Sim_data_2.csv: the file with the simulated data to be analysed.
- runner_simulador_HULAFE.rjson: the corresponding "runner" for the experimentation. A runner is an implementation of the data flow (Figure 12), with all the steps configured, so a healthcare professional with no background on PM analysis can visualise the results and interpret them under their clinical knowledge.
- posTPA.json.tpa: the TPA position path for a better visualisation.

To manage the corresponding runner, click the "Open" button into the main dashboard window (Figure 17). Then, select the "runner_simulador_HULAFE.rjson" file (Data file extension: .rjson). A new configuration windows will be opened where to specified the appropriated files to execute the runner, in this case the CSV data file, and the TPA position path, select the corresponding files in your computer and accept (the runner can be also saved with the new routes prior to accept).

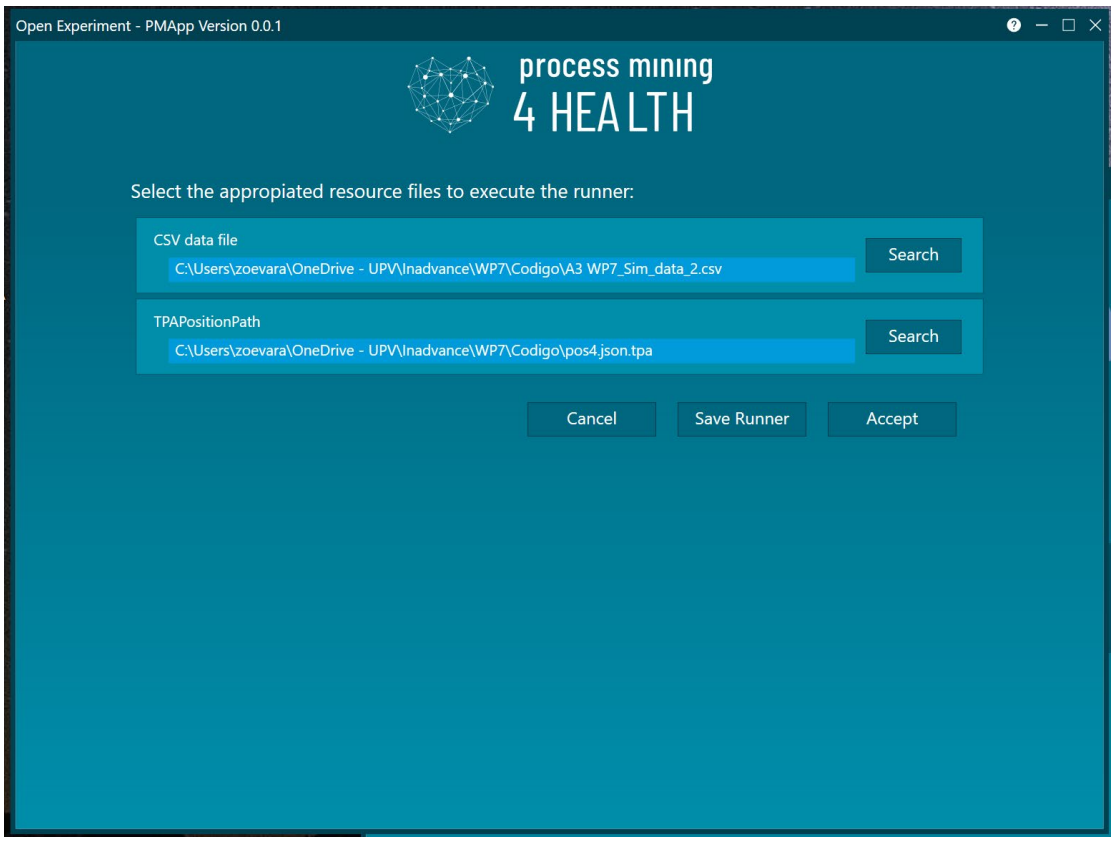


Figure 35 HULAFE Runner configuration

In this case, the appropriate files should be:

- A3 WP7_Sim_data_2.csv: the data file to be analysed.
- posTPA.json.tpa: the TPA position path for a better visualisation.

After clicking into the "Accept" button, the PM processes will be applied and after its finalisation, the main Dashboard screen will be shown.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

In order to save changes into the configuration of the runner, click “Save runner” button and the runner will keep new files’ paths.

The results from the PM analysis will be shown into the main Dashboard perspective (Figure 33):

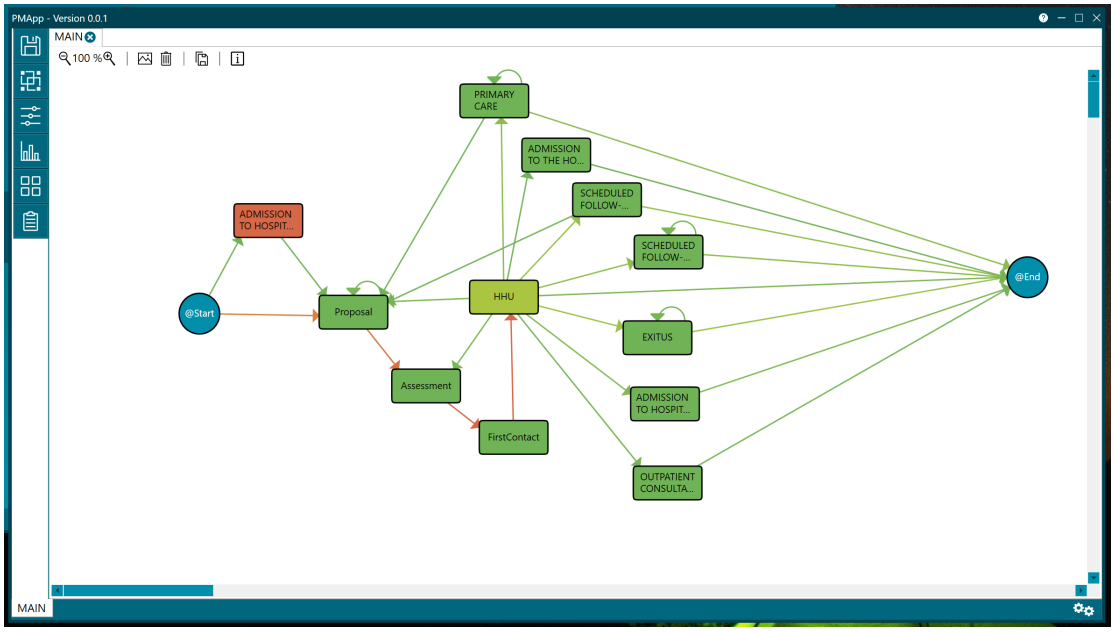


Figure 36 Dashboard results screen

The perspective shows the HULAFE care flow for the HHU unit for the different prototypes of patients. Views for the different variables could be obtained into the Groups menu, in this case for Prototype, Norton, Downton, Barthel, Medical history number (NHC), Procedence, Functional status, Age, and Risk of Falls (Figure 34).

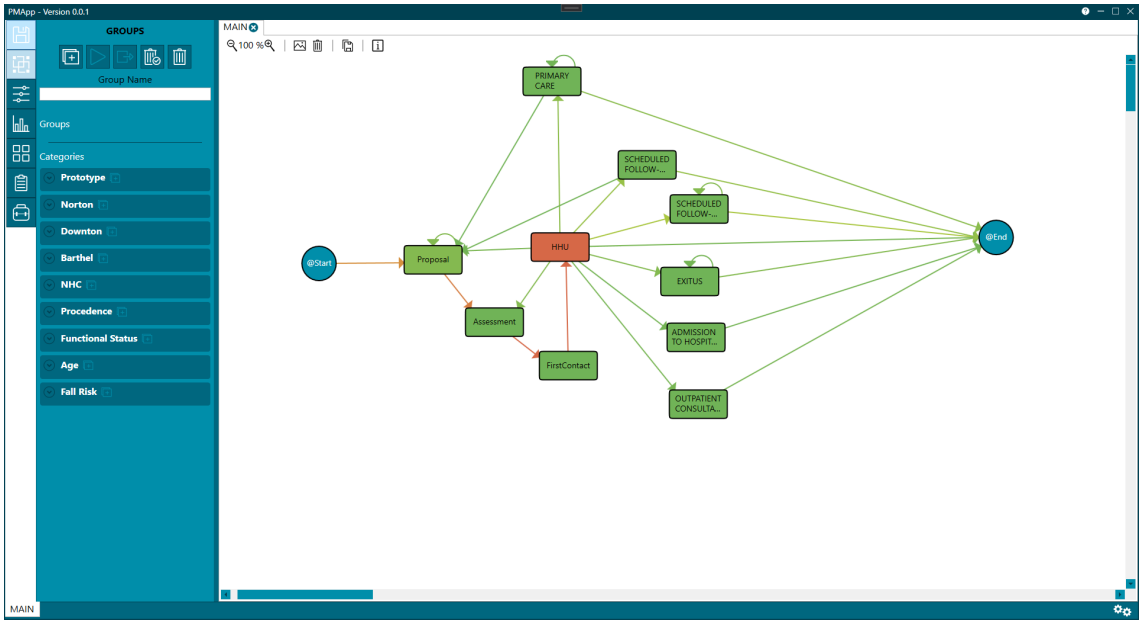


Figure 37 HULAFE example main perspective

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 825750

In the same way, different statistics could be computed and added to the different groups and views:

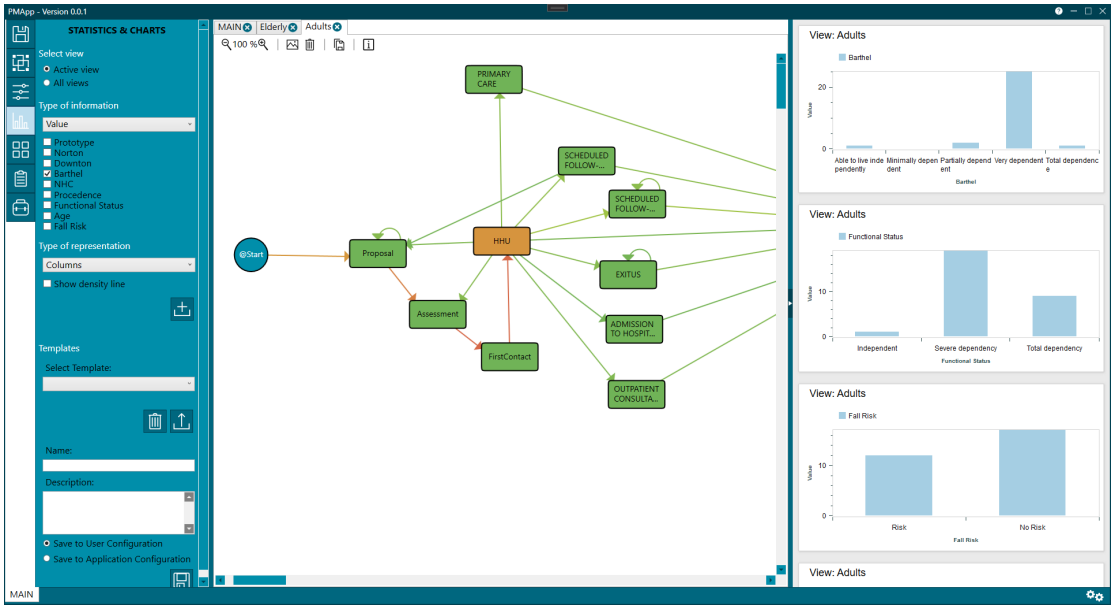


Figure 38 HULAFE example statistics

The end-user could "play" with the dashboard and its functionalities in order to analyse the data, and look for new clinical evidence.

4.3.2 Amadora Data-Rodeo

In the case of SCMA Data-Rodeo, the point of departure was the provided pathway to be implemented within InAdvance Palliative Care intervention, (included in Figure 5). Based on this pathway, the "Simulator" of the Dashboard was used to simulate the pathway in a very simple way, for the following variables:

Variable	Values	Distribution
Gender	Female	55%
	Male	45%
Age	30-39	2%
	40-49	3%
	50-59	10%
	60-69	15%
	70-79	20%
	80-84	26%
	85+	24%
Blood Pressure	Normal	30%
	Elevated	30%

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

	High Blood Pressure stage 1	20%
	High Blood Pressure stage 2	15%
	Hypertensive crisis	5%
Blood Glucose	Normal	25%
	Prediabetes	40%
	Diabetes	35%
BMI	Underweight	25%
	Normal	25%
	Overweight	25%
	Obese	25%

Figure 39 SCMA Simulated data

With this simulator has been obtained a data file to be used with the Dashboard, the needed files to start with the SCMA Data-Rodeo are included into the AMADORA sim folder. The folder contains the following files:

- SCMA_sim_data.ecsv: the file with the simulated data to be analysed.
- runner_simulator_SCMA.rjson: the corresponding "runner" for the experimentation. A runner is an implementation of the data flow (Figure 12), with all the steps configured, so a healthcare professional with no background on PM analysis can visualise the results and interpret them under their clinical knowledge.
- posTPA_SCMA.json.tpa: the TPA position path for a better visualisation.

To open the corresponding runner, click the "Open" button into the main dashboard window (Figure 17). Then, select the "runner_simulator_SCMA.rjson" file. A new configuration windows will be opened where to specified the appropriated files to execute the runner, in this case the ECSV data file (SCMA_sim_data.ecsv), and the TPA position path (posTPA_SCMA.json.tpa), select the corresponding files in your computer and accept (the runner can be also saved with the new routes prior to accept).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

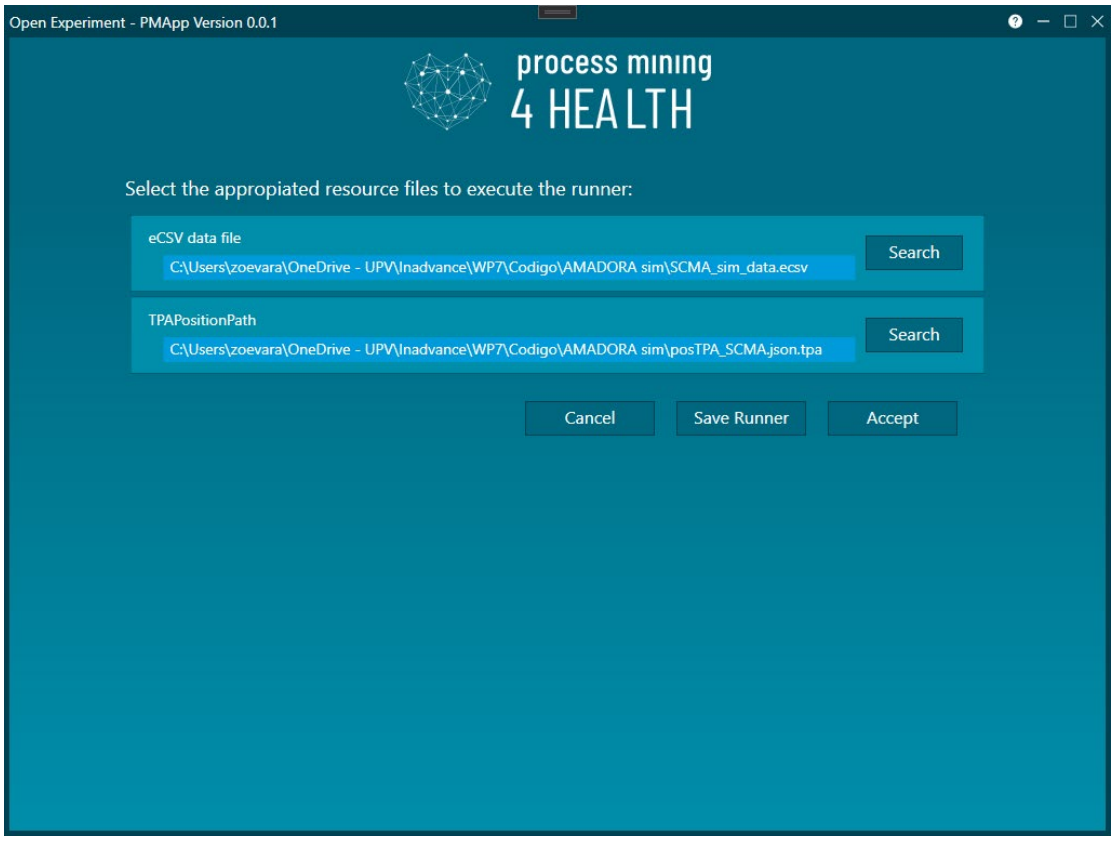


Figure 40 SCMA runner configuration

After clicking into the "Accept" button, the PM processes will be applied and after its finalisation, the main Dashboard screen with the results will be shown.

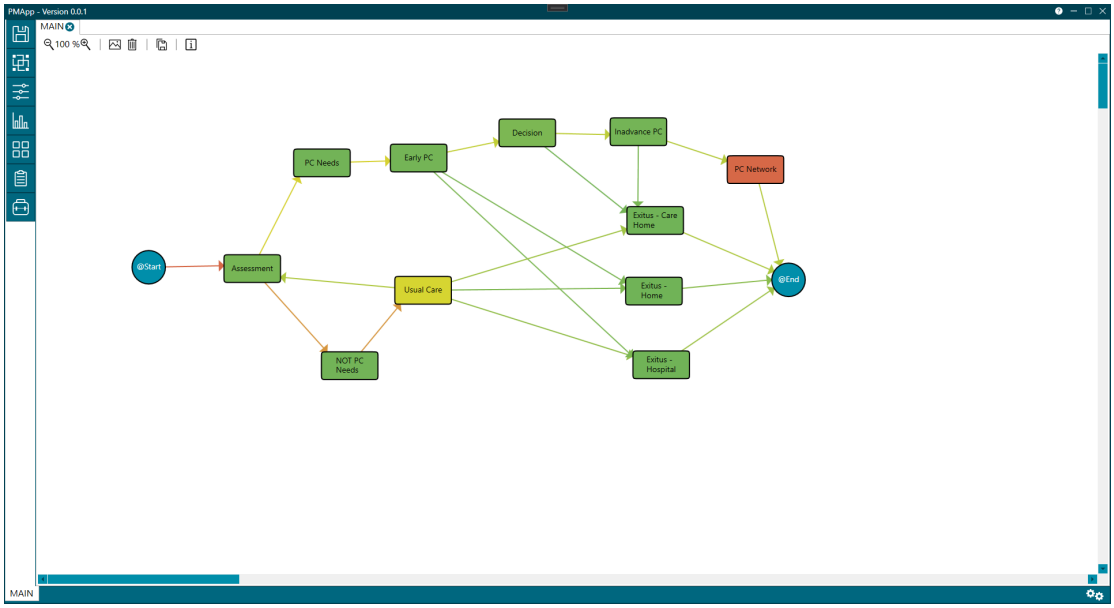


Figure 41 SCMA main perspective's results

As in the previous example, different groups for the different variables could be done, and statistics for them will be included into the Dashboard, as in Figure 39.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

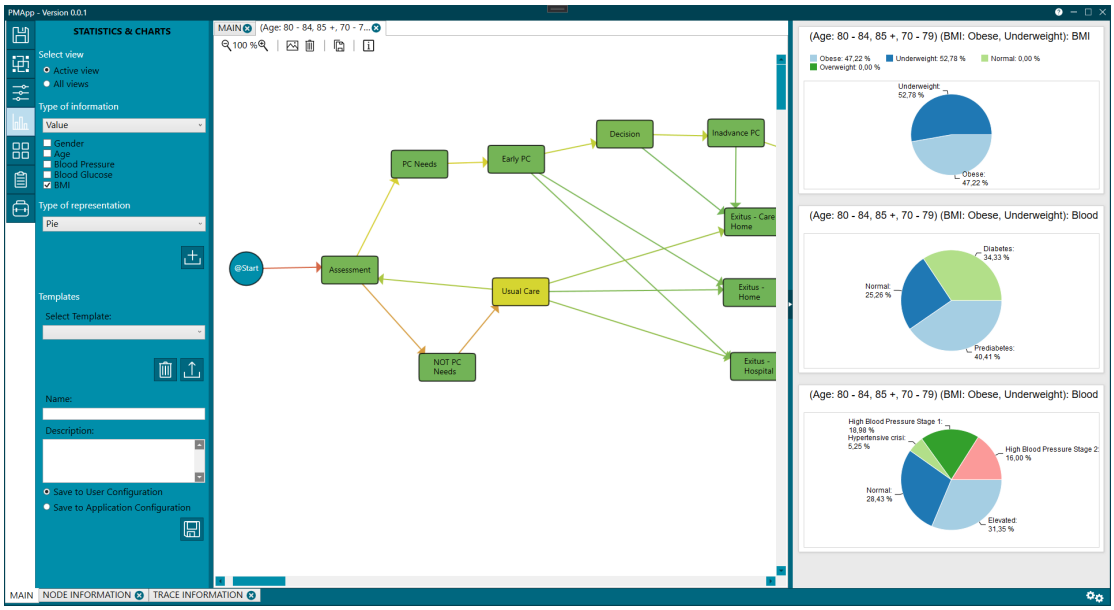


Figure 42 SCMA example statistics and groups

The Dashboard also shows complete information for each node, transition, and trace, as in Figure 40.

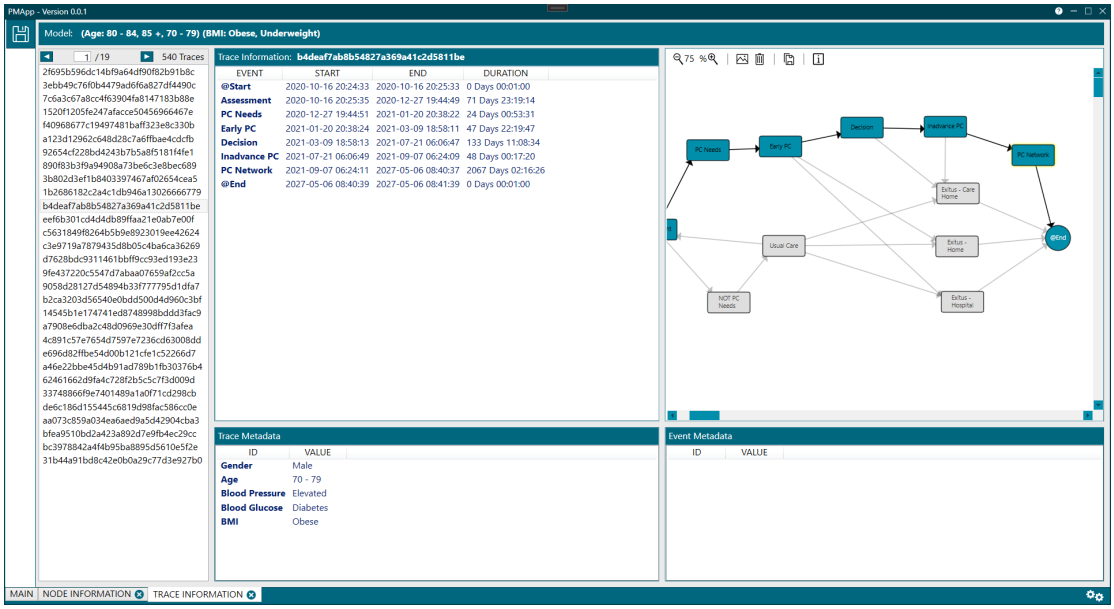


Figure 43 SCMA example: trace and node information

The end-user could “play” with the Dashboard and its functionalities in order to analyse the data, and look for new clinical evidence.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 825750

5 Quality check

As established in the deliverable D1.2 (Quality Handbook) –specifically at an amendment done on January 2020-, the quality of the dashboard developed during InAdvance project, will be evaluated by using a usable checklist based on the following criteria:

1) Product quality model
    a. Usability
    b. Functional suitability
    c. Functional completeness
    d. Functional appropriateness
    e. Performance efficiency
    f. Resource utilization
    g. Time behaviour
    h. Compatibility
    i. Interoperability
    j. Appropriateness recognisability
    k. Learnability
    l. User error protection
    m. User interface aesthetics
    n. Accessibility
    o. Usability
2) Universal design principles (if relevant)
    a. Principle 1: Equitable Use
    b. Principle 2: Flexibility in Use
    c. Principle 3: Simple and Intuitive Use
    d. Principle 4: Perceptible Information
    e. Principle 5: Tolerance for Error
    f. Principle 6: Low Physical Effort
    g. Principle 7: Size and Space for Approach and Use

For that, a checklist was provided for quality control checklist for deliverables consisting in software products.

The current functional dashboard has been developed as a general tool, this means it does not take into consideration specific needs or circumstances of each study sites, as this work will be done during the next period and coinciding with the availability of the framework valuation for the trials. On the other side, the target user of the dashboard is the expert, not in the sense of an experienced user of the dashboard, but an expert in her/his field of knowledge; this is, nurse, manager, physicians, social worker, psychologist, or physiotherapist. Therefore, it is assumed a user with expertise in the healthcare domain, and in the PC follow-up

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

and management. This will be taken into consideration during the quality assessment.

Based on this, it was conducted the product quality model check, but not the universal design principles, as it does not apply in this case. Preliminary results from the quality check throw that some improvements should be implemented regarding resource utilization, as it has been prioritised easiness of installation and compatibility rather than efficiency. The compatibility is other factor that the dashboard does not accomplish, as the tool has some needed requirements to be installed and used. During the last stage of the development, will be studied the possibility of working with several operating systems, as Windows 10 is the current needed one. Finally, the learnability is another of the property worst qualified for the dashboard, the main reason is the steep learning curve that supposes the use of such tool for health professionals. To improve this part tooltips and explanations will be added in several sections.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

6 Conclusions and future work

The functional version of the InAdvance Dashboard has been developed following an iterative co-creation design process where care pathways of pilots have been considered jointly with the clinical insights, and some particular needs by each pilot. The result is a complete functional dashboard that implements Process Mining techniques in the analysis in order to incorporate the temporal perspective of the healthcare process, ranging from simple mapping of variables into meaningful intervals to more complex patients' behaviours. The dashboard also includes statistical analytics for a quick assessment of the control's levels of specific parameters. This co-creation process also concluded the impossibility of using and integrating the dashboard with the existing legacy systems at the pilots' premises in time and manner. Finally, the dashboard was implemented to ingest data from CASTOR. The document supports the Functional Dashboard Installer that supposes the real result of the current task 7.2 in the framework of the WP7. Together with the installer, two examples have been implemented, with two objectives. On the one hand, the examples are used in the current document to illustrate the main dashboard's functionalities. On the other hand, they could be used to start playing with the Dashboard, as both examples include simulated data from HULAFE and SCMA uses cases respectively.

This new version of the dashboard supposes a great advance compared to the previous mock-up version. In the first place, this is a complete functional tool whereas the previous version implemented some minor functionalities in order to be tested by the end-users in the first step of the iterative co-creation design process. Secondly, the look and feel has been absolutely redesigned taking into consideration end users' needs and feedback. Moreover, the in-depth analysis of some of the study use cases pathways has resulted into the implementation of two PM Data-Rodeos. This has allowed defining two examples of use and the incorporation of some particularities in the dashboard.

The document also presents a preliminary set of Process Indicators for appraising the PC interventions during the pilots. These PIs will allow the analysis from a temporal perspective focusing on the outcome's evolution to appraisal the intervention from two different aspects the care process and the patients' outcomes.

Although the current version of the dashboard could be used for each pilot site in order to analyse its own data, there is still pending work to deliver the last and final version of the dashboard, such as implementing the designed PIs, or the full ingestion data from CASTOR. Moreover, the presented appraisal plan for the PC interventions will be revised during the trials duration and adapted if needed, based on the pilot site needs. Results from this appraisal will feed WP6 and WP8 and will be evaluated together with the pilot sites.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750

7 References

Adonizio, C. S. (2019). Building a real-time clinical dashboard to identify and target supportive care interventions in patients with cancer: The Lung Cancer Report Card (LCRC). *Journal of Clinical Oncology, 37*(31), 66.

Badgeley, M. A. (2016). EHDViz: clinical dashboard development using open-source technologies. *BMJ Open, 6*(3).

Caban, J. J. (March de 2015). Visual analytics in healthcare–opportunities and research challenges. *Journal of the American Medical Informatics Association, 22*(2), 260-262. doi:https://doi.org/10.1093/jamia/ocv006

Campbell, H. H. (1998). Integrated care pathways. *Bmj, 316*(7125), 133-137.

Feathers, L. M. (2018). P-67 Using the integrated palliative outcome score data to transform clinical care. *BMJ Supportive & Palliative Care*, 8.

Hartzler, A. L. (2016). Design and feasibility of integrating personalized PRO dashboards into prostate cancer care. *Journal of the American Medical Informatics Association, 23*(1), 38-47.

Ibanez-Sanchez, G. F.-L.-M.-T. (2019). Toward value-based healthcare through interactive process mining in emergency rooms: The stroke case. *International journal of environmental research and public health, 16*(10), 1783.

Tan, A. D. (2020). Design and implementation of a clinical decision support tool for primary palliative Care for Emergency Medicine (PRIM-ER). *BMC Medical Informatics and Decision Making, 20*(1), 13.

Van Der Aalst, W. (2016). *Data Science in Action. In: Process Mining.* Berlin: Springer, Berlin, Heidelberg.

Wilbanks, B. A. (2014). A review of dashboards for data analytics in nursing. *CIN: Computers, Informatics, Nursing, 32*(11), 545-549.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825750