A Personalised Integrated Care Platform

(Grant Agreement No. 689209)

D7.6 Second Care Management and Design Tools

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1.0	Carlos A Velasco, Yehya Mohamad, Rohit Ravindra Hegde, Yibin Jiang (Fraunhofer)	2018-10-11	Final version submitted to the European Commission

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Index:

1 Executive Summary

This deliverable presents the second version of the PICASO care management tools. These tools support the objectives of the project related to the management of care plans, which are:

- care management,
- design of appropriate care management structures and workflows (such as care services, care plans and templates, etc.).

The aforementioned care management structure design has been based on existing hospitals' models, workflows and guidelines and then aligned as much as possible to existing standards (HL7 FHIR v.3.x) aiming at reaching maximum interoperability between existing and future systems. The developed models of such structures have been populated with data coming from existing models inside the hospitals and supported with formal carer friendly design tools.

This second version of the Care Plan Manager contains fundamental architectural changes in comparison to version 1 reported in the previous deliverable. This version has been deployed in both pilots. The feedback of the clinicians during this phase will be incorporated in the final version of the prototype.

2 Introduction

Care Management is used by health professional to design the medical and clinical rationale of the different services to be available in the PICASO platform. Our services arrange their execution in a pre-described sequence to support the execution of the care plan across the different care domains. The outcome of the design is on one hand a catalogue of standard services, and on the other hand, the connecting of services into a set of clinical logistic operations defining personalised, dynamic care plans for the patients.

The subset also maintains API interfaces to workflow and skills models, legacy patient records, and standardised guidelines and knowledge databases. Finally, it introduces high-level abstraction mechanisms that make the formal carer independent of high level programming skills when defining the services and narratives.

This deliverable presents the second version of the PICASO Care Plan Manager and its associated tools.

2.1 Purpose, context and scope of this deliverable

Related objective: New care management programmes for multi-morbidity

- Create a decision support methodology for analysing conflicts, constraints and limitations from single-morbidity care plans and patient/physician/therapist preferences applied to patients with co-morbidities and multi-morbidity conditions by using the concept of constraint satisfaction problem, to allow the cares to define new care programmes for the management co-morbidities in community and home care settings.
- Develop new training programmes for the care workforce, new organisational models and new ways of exchanging medical information to improve the coordination of care management across silos.
- Specific technological innovations: Create a Care Management system based on dynamic design of complex care plans guided by narratives using goal-driven heuristic search and with secure authentication of patients and carers involved.

Related tasks:

- **T7.2 Narratives Manager and Service Catalogue [Task leader: Fraunhofer, partners: CNET] [M3-M41]**
  Modelling of narratives will be performed using knowledge representation methods, such as ontologies, frames, scripts or rules. The first goal is the design of formal description of narratives in a form of predefined workflows enabling adaptation to the needs of specific patients and concrete patient environment. This requires design of person profiles and model of the environment. Patient profiles should enable to take into account specific personal needs. Environmental model should enable to take into account specific context of the deployment area (different devices, services, situational context). The adaptability of the narrative formal description will enable reusability. The result of the modelling process will be design of formal structures representing narratives and services. Narratives are developed and stored in exchangeable knowledge representation that describes the services, the virtual objects involved and its dynamic properties (event handling, risk assessment, personalisation). Fraunhofer will perform the work assisted by CNET and with domain knowledge from WP3.

2.2 Intellectual Property (IP)

The different components of the Care Plan Manager, the Reference Data Server and the Communication Center are subject to open source and commercial licences, which are subject to the licences reflected in the IP repository being created for the project.

2.3 Content and structure of this deliverable

This deliverable starts with a short description of existing tools and models at the trials' sites. Then, we focus on the description of the Care Plan Manager, its architecture and its components. This document is an extension of the deliverables D7.1 and D7.2.

3 Existing tools and models

3.1 UDUS

UDUS runs the local clinical register at the Policlinic of Rheumatology and Hiller Research Unit Rheumatology with currently approximately 20,500 patients with rheumatic diseases, whose clinical characteristics are routinely documented in a web-based documentation application called DocuMed.rh. This system was developed at UDUS and is also able to export data to the national database run at the German Rheumatism Research Centre in Berlin. Currently care plans for all our out-patients including RA patients are already generated automatically via DocuMed.rh and stored in the system.

In addition, UDUS owns a hospital information system (called Medico, manufacturer Cerner) that interacts with the web-based documentation system DocuMed.rh and e.g. delivers laboratory data to it. The HIS is used for doing prescriptions for medication, physiotherapy and occupational therapy for our outpatients and for administrative duties (e.g. invoices). Furthermore, it is used to refer patients to other departments of the hospital for consultations electronically. The consultation results come back via the HIS to the Policlinic of Rheumatology. For inpatients the HIS is used to generate discharge letters.

From the more clinical perspective guidelines and care plans already used in the management process of patients with rheumatoid arthritis have been described in the deliverable D3.1 “Integrated Care Plan Integrated Care Plans Across Care Sectors – Analysis and Recommendations”. For example according to “treat-to-target” guidelines patients’ follow-up review/consultation with the RA Specialist are performed on a regular basis. In addition, the evidence-based recommendations for the assessment and management of cardiovascular risk in RA patients that have been published from the EULAR are supposed to be followed.

3.2 UTV / Santa Lucia

“Santa Lucia” Foundation is a landmark institution in the field of highly specialized neuro rehabilitation. Strong related health cares and research build its core activities. Rehabilitation programs affects patient with both, motor and cognitive deficits.

In the wide spectrum of illness and conditions treated, rehabilitation therapies are especially focused on patients affected by stroke and coma, spinal cord injuries, amputations, and people suffering from degenerative diseases such as Parkinson's disease.

Alongside its in-patient and day hospital, a dedicated structure exists for outpatients, of all ages, in need of extensive rehabilitation. Often patients are clinically observed for extended periods, even years. This allows the Hospital to offer a complete range of services, even to those not admitted to the Hospital.

The services for outpatients with Parkinson’s disease are:

1) Neurological Assessment with pharmacological and physio-therapy;
2) Neuropsychological Assessment with cognitive training programs;
3) Evaluation of psychopathological disorders;
4) Magnetic Resonance Imaging.

In Santa Lucia and UTV there is still a strong dependence on paper-based documentation for the care plans.

4 Care Plan Manager

4.1 PICASO Care management entities

PICASO defines the following entities:

- **Service**: A service aims to model a care plan reusable element that can be configured by a carer based on a patient's situation and executed as part of a care plan. A service can be either an automated service (e.g. scheduled reminder), a manual one (e.g. make an appointment) or a mixed (semi-automatic) one.
- **Service Instance**: A service, after being defined can be instantiated one or more times inside a care plan. A service instance also can be cloned, deleted or saved as service template by the clinician. The service instance consists of the service configuration and the service subject data, which is populated automatically by the design tools.
- **Service template**: A service template is a service in a default configuration. It is similar to an instance of a service but the template has no patient and carer information, and it is available to carers for reuse. When a template is assigned to specific care plan, the missing data are inserted automatically.
- **Care plan**: A care plan is a combination of services that targets to a specific goal for a specific patient. Apart from the services a care plan has some extra properties in order to define global attributes of the care plan like the goal, the time period, etc.
- **Care plan instance**: Similarly to service instance, a care plan instance is a care plan configured with patient's situation specific services and data.
- **Care plan template:** Similarly to service template, a care plan can be saved (removing patient/clinician data) as a template. Using this artefact the clinicians have the flexibility to store their "guidelines" and standardised "workflows" in a very easy way.
- **Service Process Model**: A Service Process Model is a service/care plan instance model enriched with runtime data.
- **Narrative**: A narrative contains a summary of the service, and may be used to represent the content of the service in a human readable format. A care plan narrative is composed as the sum of the assigned services. This is an automatically generated text based on pre-configured text templates.
- **ValueSet:** A ValueSet is a FHIR resource that is intendent to model the terminology inside a silo like a hospital. We extend this use and we use this as a mechanism to model all medical reference data and share between all PICASO "subscribers".
- **Concept:** A concept is an element of a ValueSet.

4.2 Data Modelling based on FHIR 3.0

PICASO models all entities necessary for the care management based on FHIR 3.0 introducing when necessary new PICASO FHIR extensions. This specification consists the PICASO FHIR profile.

4.2.1 CarePlan Resource

Based on https://www.hl7.org/fhir/careplan.html

Field	Type	Comments	UI
id	string	timeuuiid generated by NM	Care plan ID
meta.versionid	int	incremental integer generated by NM	Version
text.div	string	Narrative template (dynamic text)	Generated Narrative

Field	Type	Comments	UI
status	code	https://www.hl7.org/fhir/valueset-care-plan-status.html	Status
description	string		Description
subject.reference	string	patient UPID	
period.start	dateTime	Time of start	From
period.end	dateTime	Time of end	To
author.reference	string	carer UPID	
activity[i].reference	string	References to activates – PICASO services	
contained	Resource[]	Referenced resources	

4.2.2 CarePlan Services

4.2.2.1 Base PICASO Service

This is the based structure of a PICASO CarePlan Service. This is based on Domain resource (selection). All Services inherit the following properties:

Field	Type	Comments	Default	UI
id	string	timeuuiid generated by NM	NULL	
meta.versionId	int	incremental integer generated by NM	0	
text.div	string	Narrative template (dynamic text)		
status	code	https://www.hl7.org/fhir/valueset-request-status.html	draft	Service Status
subject.reference	string	UPID (Unique Picaso ID) of the patient		
extension[0].extension[0]. valueString	string	Value of extension with name ServiceName	Service name	Service:
extension[0].extension[1].valueString	string	Value of extension with name Service ID	Service ID	
extension[0].extension[2]. valuePeriod	Period	Suspend Period of service	undefined	Suspend period
extension[0].extension[3]. valueString	string	Message to Patient when suspended	undefined	Suspend message to Patient

4.2.2.2 Health Questionnaire Service (id = HealthQuestionnaire)

Based on https://www.hl7.org/fhir/communicationrequest.html

Field	Type	Comments	Default	UI
topic.reference	string	id of selected questionnaire	NULL	Questionnaire
authoredOn[0]	dateTime			

Field	Type	Comments	Default	UI
occurrencePeriod[0]	Period		NULL	From:, To:
note[0].text	string		NULL	
note[0].time	dateTime		NOW	
note[0].author.reference	string	UPID	UPID	

4.2.2.3 Appointment Service (ID: Appointment)

https://www.hl7.org/fhir/appointment.html

Field	Type	Comments	Default	UI
speciality.coding[0]	Coding	http://hl7.org/fhir/ValueSet/c80-practice-codes		Practice Setting Code
requestedPeriod[0]	Period		NULL	Requested Period
minutesDuration	PositiveInt		15	Duration (minutes)
created	dateTime		NOW	
description[0]	string		NULL	Description
participants[0].actor.reference	string	Patient UPID	UPID	
participants[1].actor.reference	string	Clinician UPID	UPID	

4.2.2.4 Blood Pressure Measurement Service (ID: BloodPressureMeasure)

https://www.hl7.org/fhir/devicerequest.html

Field	Type	Comments	Default	UI
intent	code		active	
device.reference	string		#	Device
authoredOn	dateTime			
occurrenceTiming[0]	Timing			Measurement Timing

4.2.2.5 Weight measurement Service (WeightMeasure)

https://www.hl7.org/fhir/devicerequest.html

Field	Type	Comments	Default
intent	code		active
device.reference	string		#
authoredOn	dateTime		
occurrenceTiming[0]	Timing		

4.2.2.6 Walk Steps Service (WalkStepsMeasure)

https://www.hl7.org/fhir/devicerequest.html

Field	Type	Comments	Default

intent	code		active
device.reference	string		#
subject.reference	string		#
authoredOn	dateTime		
occurrenceTiming[0]	Timing		

4.2.2.7 Heart rate measurement Service (HeartRateMeasureService)

https://www.hl7.org/fhir/devicerequest.html

Field	Type	Comments	Default
device.reference	string		#
subject.reference	string		#
authoredOn	dateTime		
occurrenceTiming[0]	Timing		

4.2.2.8 Medication Request Service (MedicationRequest)

https://www.hl7.org/fhir/medicationrequest.html

Field	Type	Comments	Default
intent		http://hl7.org/fhir/ValueSet/medication-request-intent	
recorder.reference	string	Clinician UPID	
authoredOn	dateTime		
validityPeriod	Period	Start/end of medication	
dosageInstruction[0].additionalInstruction.coding[0]	Coding	Supplemental instruction - e.g. "with meals" http://hl7.org/fhir/ValueSet/additional-instruction-codes	
dosageInstruction[0].text	String	Additional (Patient Instruction text field - only if additionalInstruction.coding[0]=000 (other)	
dosageInstruction[0].route.coding[0]	Coding	Administration route (oral, subcutaneous, intramuscular, intraarticular, intravenous, Apply externally on skin) http://hl7.org/fhir/ValueSet/route-codes	
dosageInstruction[0].doseQuantity	Quantity		
dosageInstruction[0].timing	Timing		
medicationCodeableConcept.coding[0]	Code	See Medication below	{MedicationRequestID}Medication

4.2.3 Other Types

4.2.3.1 Medication Resource - referenced from MedicationResource

https://www.hl7.org/fhir/medication.html used by Medication Request

Field	Type	Comments	Default
id			
code.coding[0]	Code	Name of medication: (selectable from drop-down list as provided by clinicians) Pending input from UDUS/UTV/SantaLucia	
form		Type of medication (selectable): Tablet, Chewable tablet, Injection, Drops, Oral solution, Ointment, patch, http://hl7.org/fhir/ValueSet/medication-form-codes	

4.2.3.2 Medication Statement

https://www.hl7.org/fhir/medicationstatement.html

Field	Type	Comments	Default
id			
basedOn[0]	MedicationRequest		
subject.reference	String	UPID	
reasonNotTaken[0]	Coding	http://hl7.org/fhir/ValueSet/reason-medication-not-taken-codes	NULL

4.2.3.3 Timing Datatype

https://www.hl7.org/fhir/datatypes.html#timing

Field	Type	Comments	Default
boundsPeriod.start	Period		now
period	positive int		1
periodUnit		https://www.hl7.org/fhir/valueset-units-of-time.html	wk
dayOfWeek	code[]	https://www.hl7.org/fhir/valueset-days-of-week.html	Day now
frequency	positive int		1
timeOfDay	string[]	For every next occurrence (start from earlier to later) the time of the day. Should calculate repeated occurrences and use same array index for getting the time.	[12:00]
when	code[]	https://www.hl7.org/fhir/valueset-event-timing.html similar to timeOfDay if when[i]=undefined means no event for this occurrence TODO: add more in ref system	[]

4.2.3.4 Communication Resource (HealthCare Communication component)

https://www.hl7.org/fhir/communication.html

Field	Type	Comments	Default

id	string	timeuuid generated by NM	NULL
subject.reference		UPID	
category.coding[0].code	code	https://www.hl7.org/fhir/valueset-communication-category.html	instruction
recipient.reference	string	List of IDs of clinicians / roles	
sent	dateTime		
sender.reference	string	UPID	
payload[0].contentString	string	Message	

4.2.4 FHIR PICASO Extensions

4.2.4.1.1 Notification Extension

Used by the services for configuring reminders.

Field	Type	Comments	Default	Values
NotificationType: [1..1]	string			
NotificationCondition: [0..1]	Extension	systolicRange: [0..1] Range diastolicRange: [0..1] Range noMeasurementDays: [0..1] Integer highlight: [0..1] Boolean heartBeat [0..1] Range	undefined	
NotificationMessage: [1..1]	string	when not done	""	
NotificationTime	postitive int[]	Number of minutes after every occurence of service's timing or 0 (not notification)	[10]	
NotificationMeans: [1..1]	string		reminder	http://hl7.org/fhir/ValueSet/communication-category
NotificationEmail: [0..1]	string	mail address to send	undefined	

4.2.5 Other Data requirements

- List of clinicians (UPID, display name) from ODS
- List of patients (UPID, display name) from ODS

4.3 Care Plan Manager

The aim of this tool is to allow the creation, integration and effective sharing of a Patient pathway between all involved professional carers. Every organisation/physician uses a number of standard care plans for various diseases management actions. These care plans are expressed in a narrative form and are stored as Narrative templates in the Process Model repository through the Careplan Orchestrator component. A narrative template uses in a specific arrangement standard services stored in the service catalogue with open data fields for specific service parameters. In order to develop a Patient Pathway, a physician or an assistant instantiates one of the existing templates and fills the missing services' data with specific patient data. The resulting patient's pathway is then stored for in the Process Model Repository for optimisation and service orchestration.

Current major features:

- FHIR v3.0 compatible
- Reusable FHIR compatible Angular 4 components
- Create a new care plan from scratch or based on an existing template
- Load existing care plan per patient
- Save care plan in JSON FHIR v3.0 format
- Save care plan as template
- Add services (see list of existing services in 4.2.2 and 4.2.3)) based on existing templates or not
- Clone services
- Delete service
- Save services as template
- Active medication Plan for quick glance of medication timings

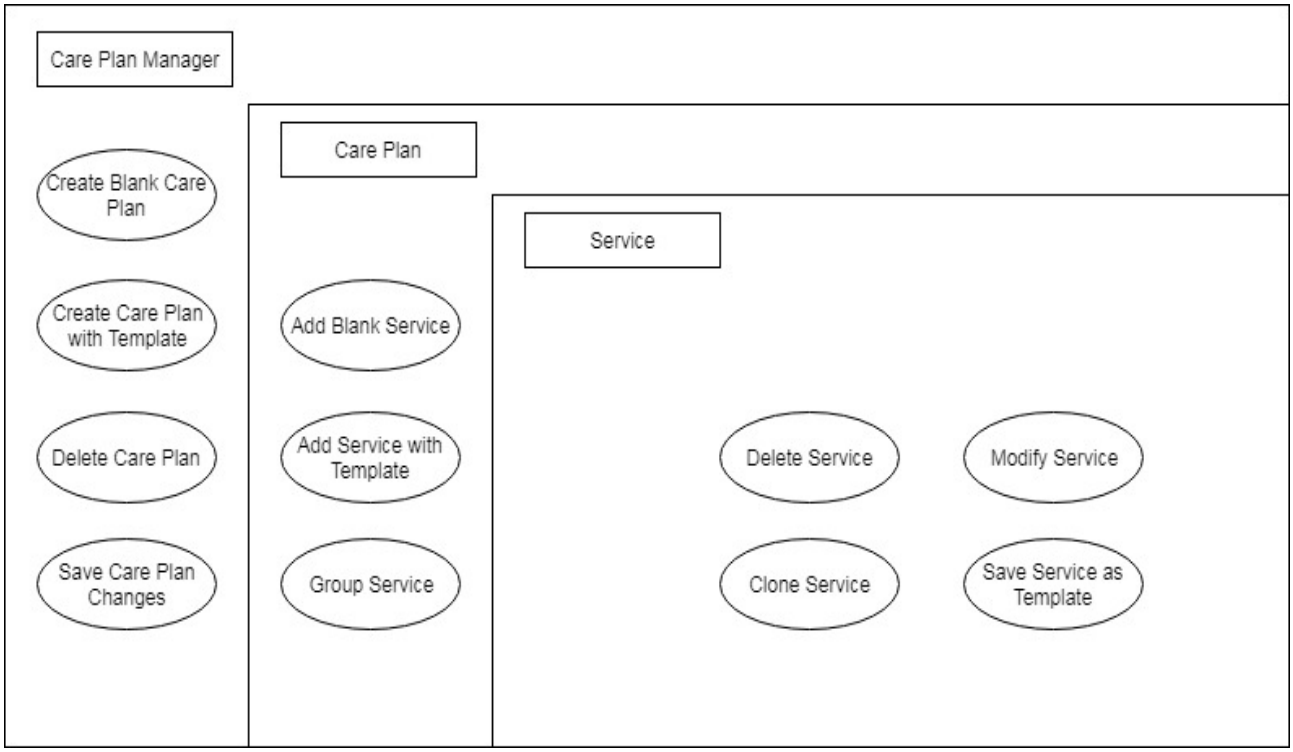

Figure 1: Care plan manager components diagram

Figure 1 displays the Care Plan Manager, which contains the care plan, and which have services like medication, blood pressure measurement, weight measurement, step measurement, heart rate measurement, health rate measurement, health questionnaires and appointment request. When there is no care plan in the Care Plan Manager, a new care plan can be created with or without a template, if a template exists in the Care Plan Manager. Besides, the Care Plan Manager can delete and save changes when there is a care plan. Therefore, the Care Plan Manager can manipulate the care plan. In the care plan, the service can be added with or without a template if a template exists and the service can be grouped according to the service type. As to each service, it can be modified, cloned, deleted and saved as a template for future use.

4.4 Care Plan Manager User Interface

The User Interface provides a visual aid for clinicians to create a care plan. Figure 2 depicts a care plan where a clinician can provide basic information of a care plan like description, status and timing. This helps other care providers to differentiate care plans for a patient.

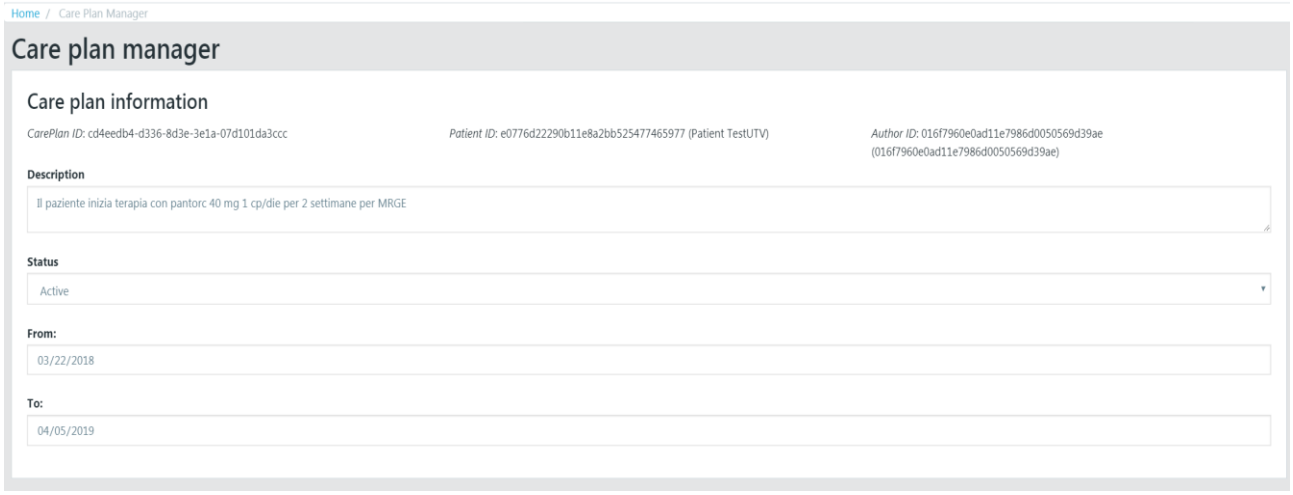

Figure 2. Care plan information

Figure 3 lists all the services defined for a patient in grouped view. Each kind of services are grouped together for better readability. Each service can be expanded by clicking on the 'plus' icon to modify the service. There are two more buttons, which are used to save a care plan after modifying it. You can also delete a care plan by clicking on the delete button

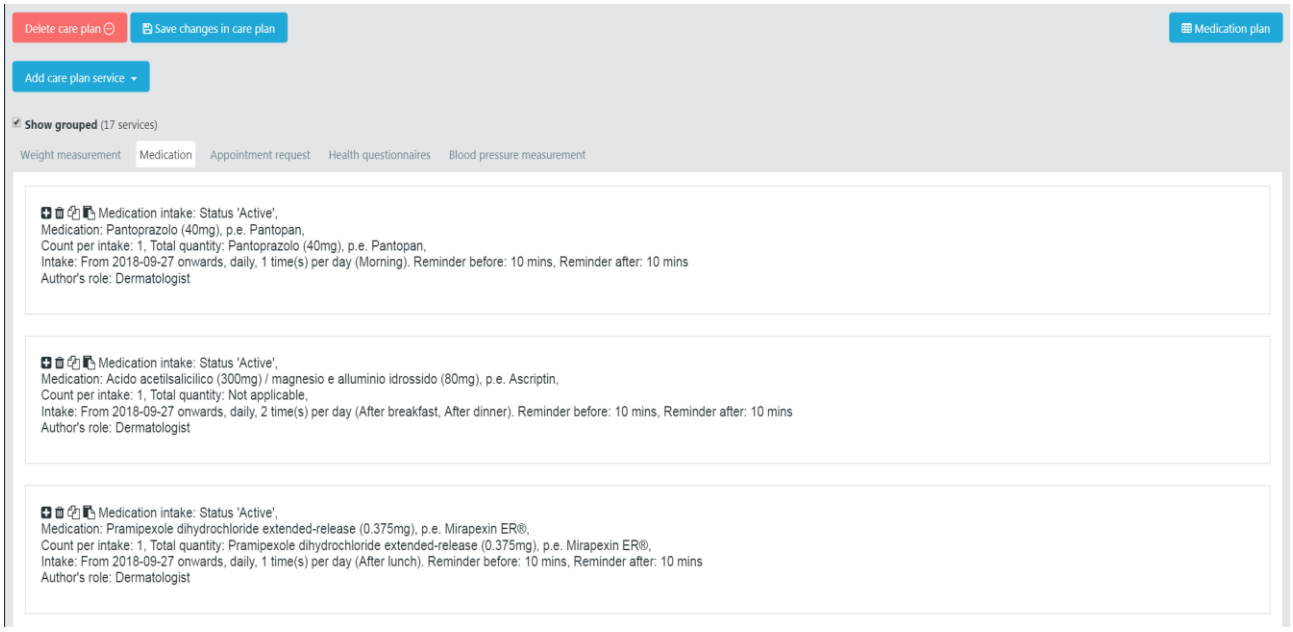

Figure 3. List of services defined in the care plan

Figure 4 provides a list of available services that can be added to the care plan. Each of these services can be added either from a pre-saved template or create a new service from the blank template.

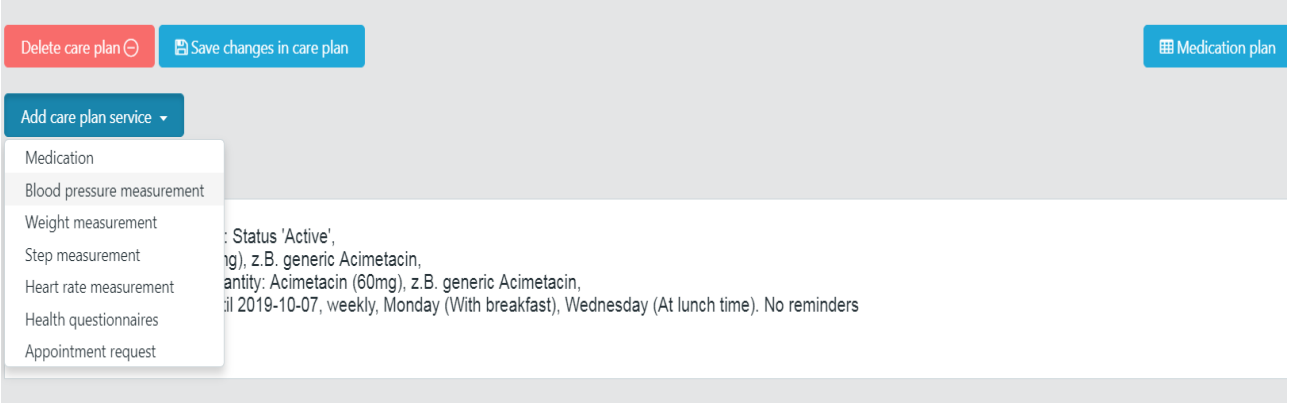

Figure 4. Selecting type of service to add to a care plan

Figure 5 lists all available Medication templates to create a medication service.

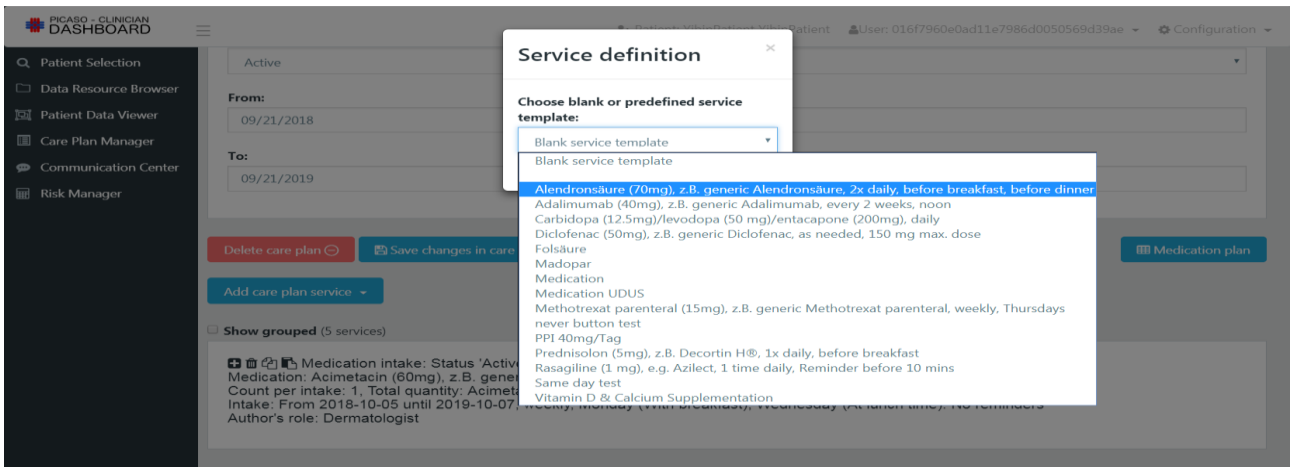

Figure 5. Selecting a template to add as a service

Figure 6 depicts a medication service where a clinician can select: Status, Medication, Form of medication, Quantity of medication, Route through which medication should be taken, any further instruction that need to be indicated to the patient and the timing of the medication.

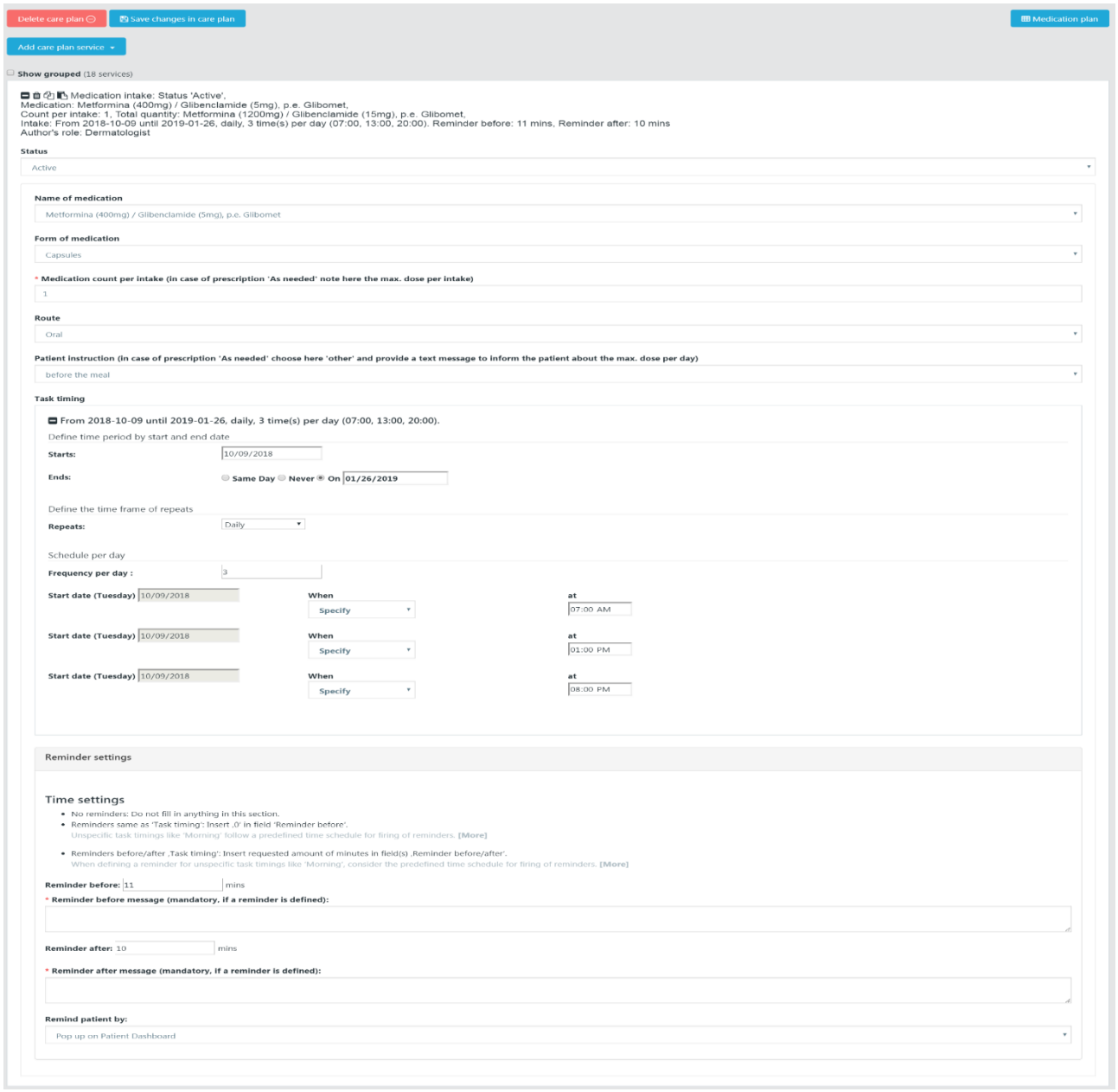

Figure 6. Medication service example

Creating a template out of a service can be achieved by clicking on the ‘save service as a template’ button on the service. Then, the clinicians can give a suitable name for the template which is shown on Figure 7.

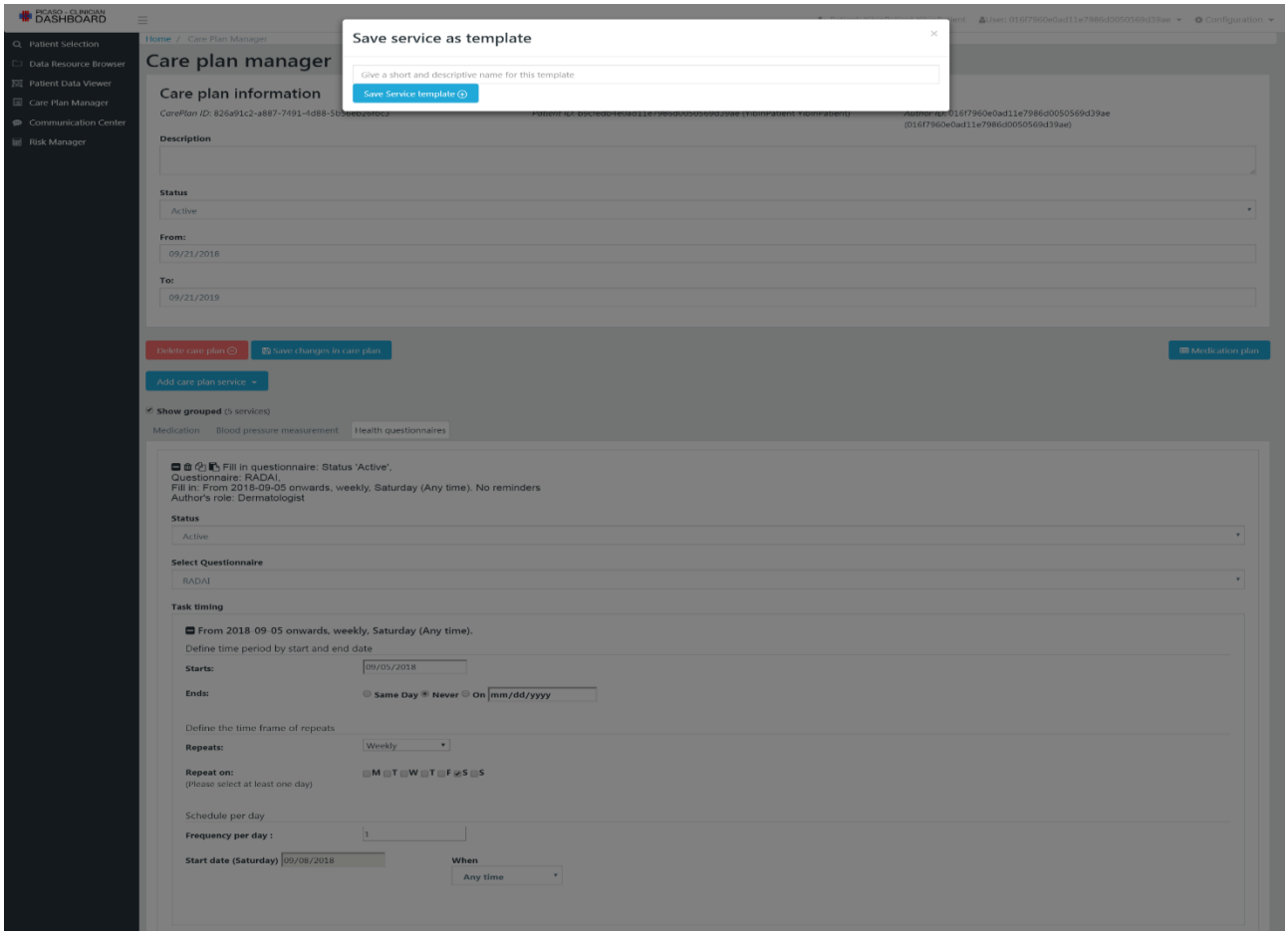

Figure 7. Creating a Health questionnaire template

There can be more than 6 medications per care plan, which makes it difficult for medical professionals to go through the summary of each medication service and see the timing and medication the patient is taking. To provide a quick glance of all the medications in the care plan, the 'Active medication plan' option is depicted in Figure 8 as a table with just medication and timing.

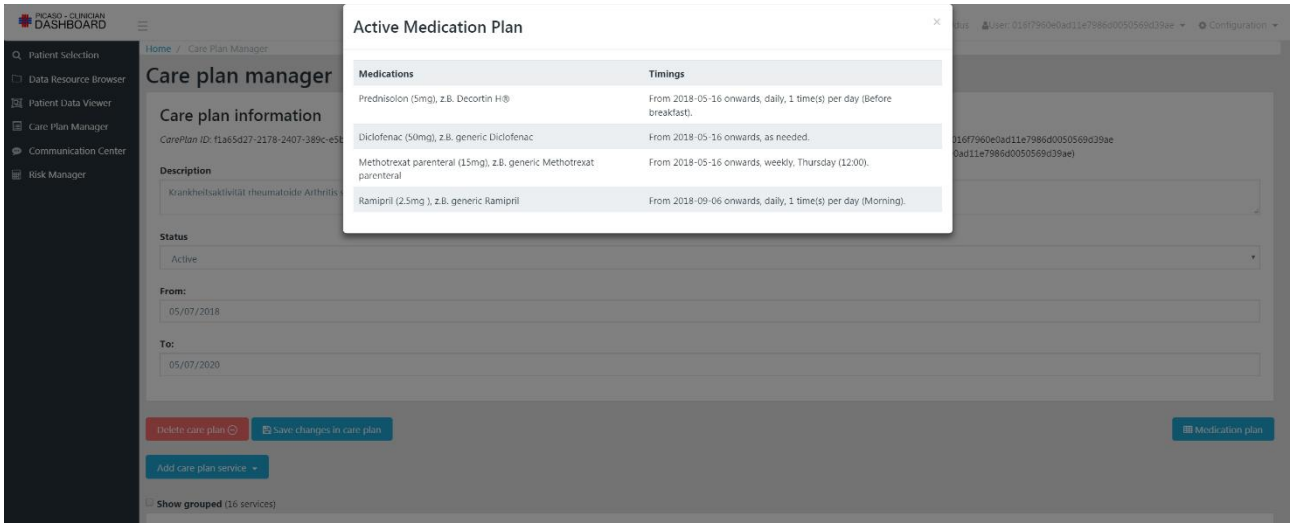

Figure 8. Active medication plan

4.5 Care Plan Manager User Interface workflow

In the following, we summarise some of the workflows that the clinician can select to control the care plan of a given patient.

Use case 1: If the user wants to add a new empty service from a new empty care plan, the workflow is shown in Figure 9. First, the user should login in the Clinician Dashboard and then select a patient from the patient list. After that, the user goes to the Care Plan Manager. If in Care Plan Manager there is no existing care plan, the user can create a new empty care plan without the template. Next, the user can add a service such as a medication from the service list. If the care plan exists, the user can directly add the service from the service list.

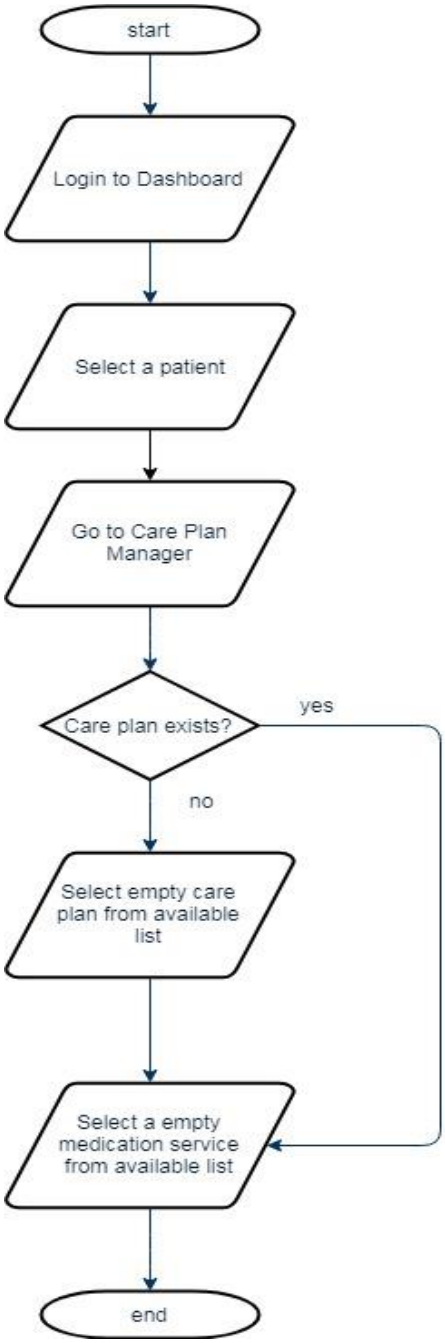

Figure 9. Workflow to create a service for an empty care plan

Use case 2: Clinicians do not want to create the same medication service for different patients. If you allow them to create a template, they can add a medication service to the patient care plan easily while prescribing medication. If you want to add an available service template which is saved by you. You can just go to care plan manager in the existing care plan, then click on 'Add care plan service' then select a template which was saved by you or your colleague, and then click on add service.

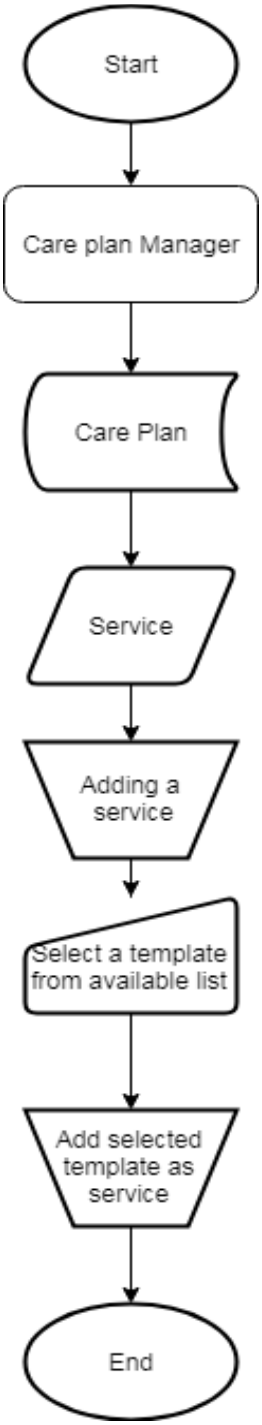

Figure 10. Select a template to create a care plan for the patient

4.6 Communication Center

The Communication Center provides clinicians a way to quickly exchange information between them in regard to the care plan of a given patient. It also provides a way to review previous recommendations or messages

exchanged. Figure 11 depicts all the communications related to a fictitious patient exchanged by different clinicians. Clinicians can also scroll down to see all the history of communications.

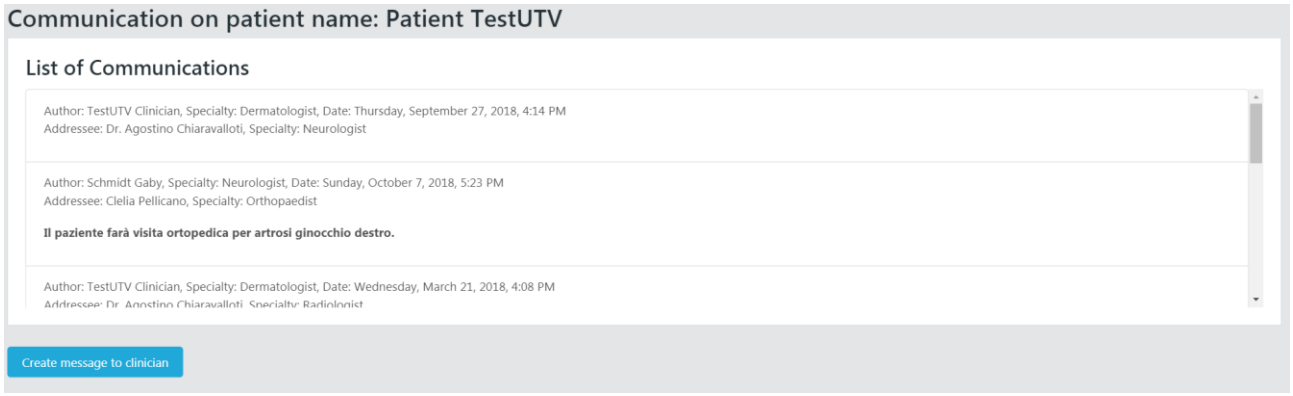

Figure 11. List of communications

A clinician can create a new message to a colleague by giving a speciality and the name of the clinician. This message can be securely sent over email as well. This process is shown in Figure 12.

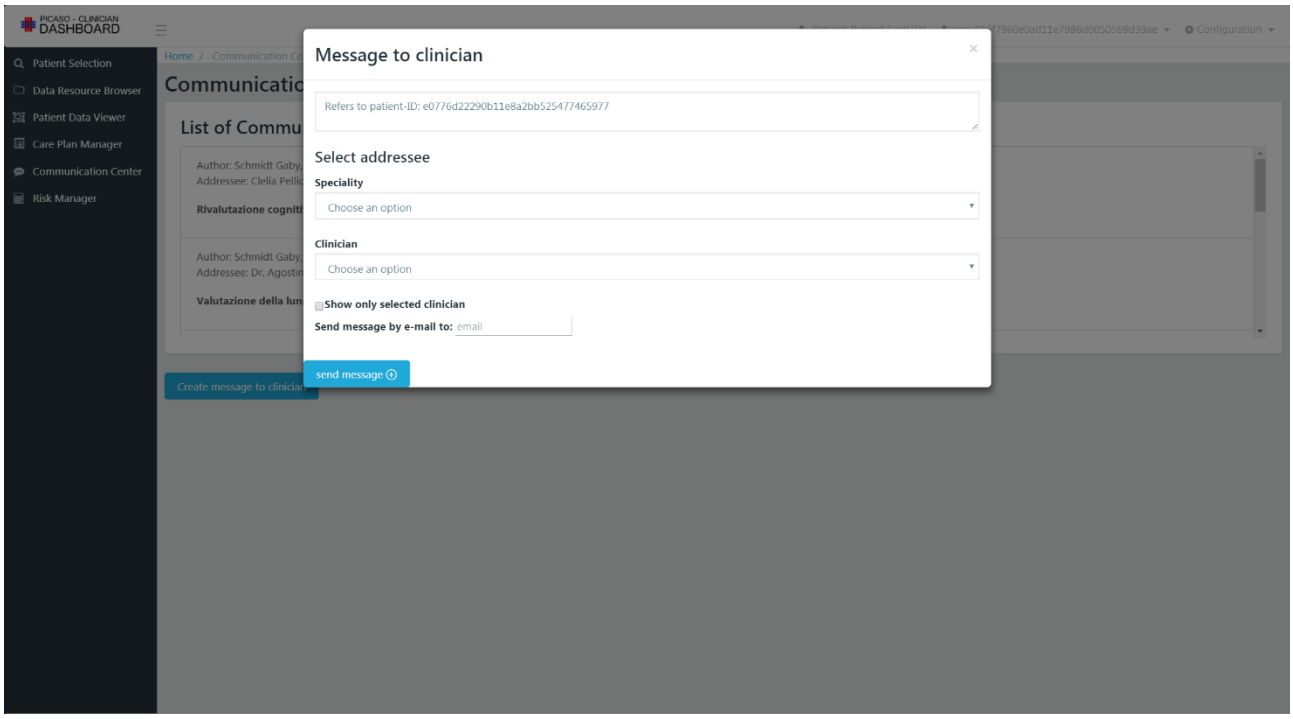

Figure 12. Creating a message to a clinician

A typical workflow is presented in Figure 13. Let us say that a patient has come to see a radiologist. The radiologist does not have to depend on what scans need to be done based on the patient's explanations. The radiologist can see which doctor has requested the scan by logging in to the dashboard, select the patient and read the complete message sent to him in the communication centre. If there is a need to clarify the message, the radiologist can create a message to the original author by clicking on 'Create message to clinician'.

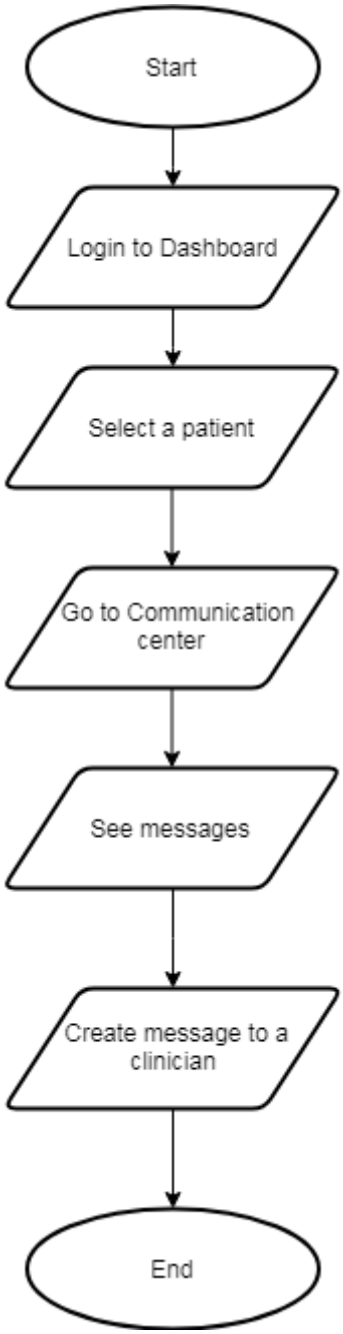

Figure 13. Workflow example in the Communication Center

4.7 Reference Data Server

This component allows the management of PICASO reference data including both clinical reference data and more PICASO trial generated data. It has been developed based on the definition of the FHIR Terminologies and has been further extended in order to support all required PICASO reference data. Some parts of the API as shown in Figure 14.

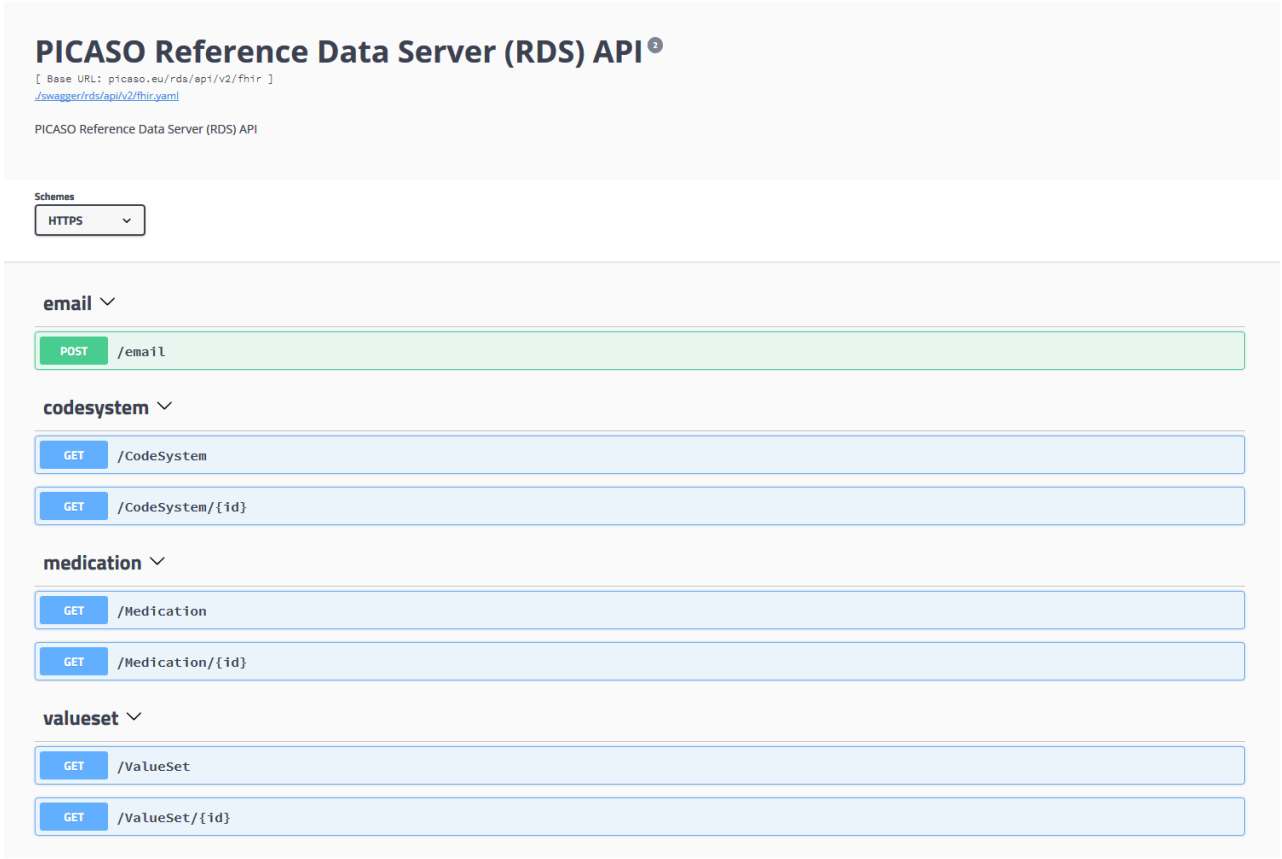

Figure 14: Overview of Reference Data Server API

Figure 15 shows the UI of Reference Data Server.

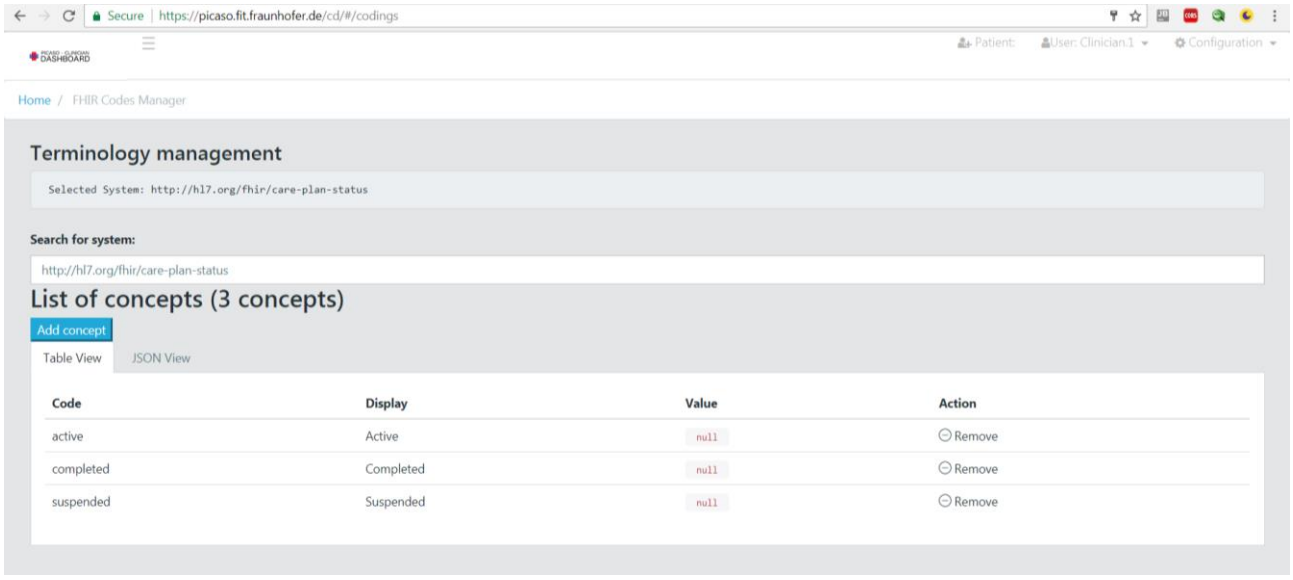

Figure 15: Reference Data Server UI – list of concepts in selected system

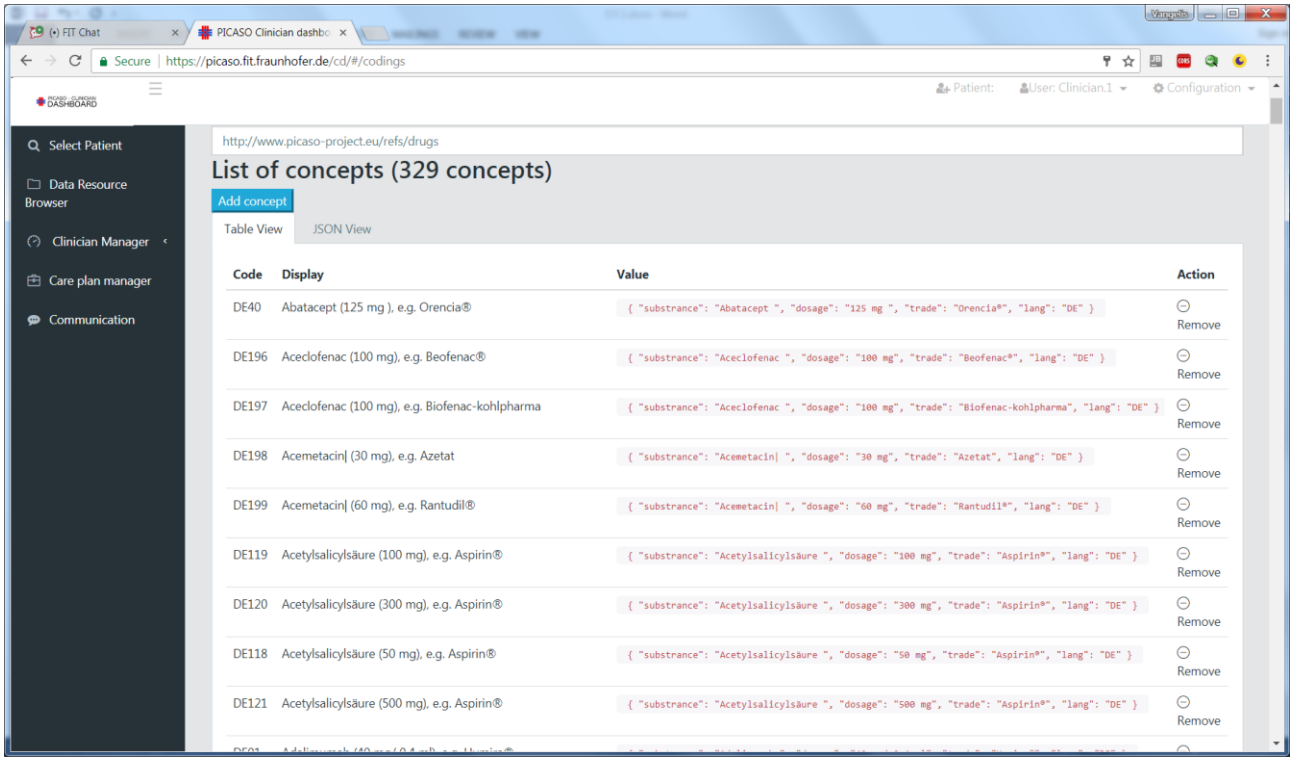

Figure 16: Reference Data Server UI – list of concepts - PICASO valueset

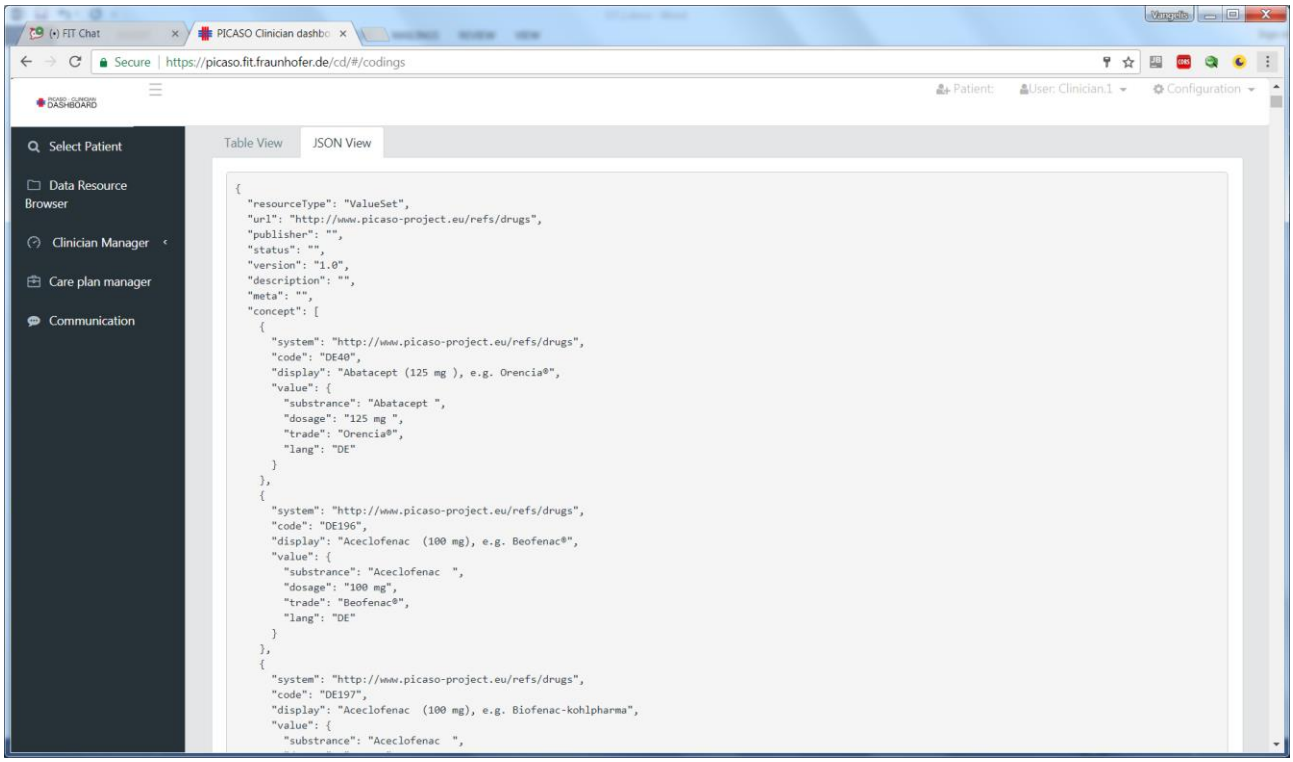

Figure 17: Reference Data Server UI – list of concepts – JSON view

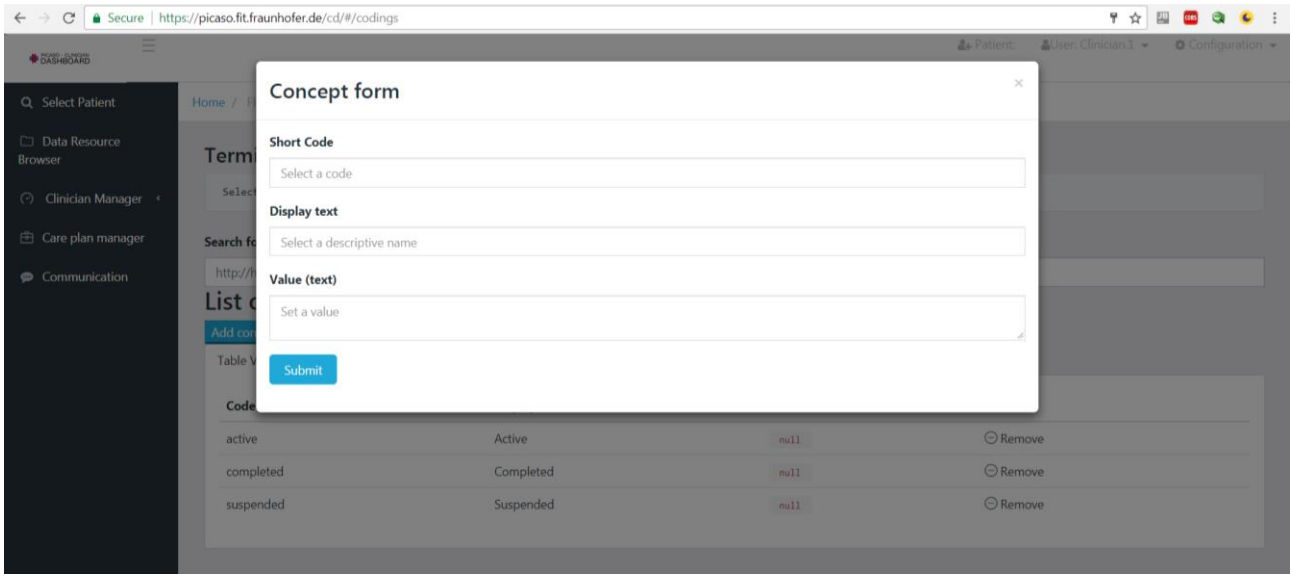

Figure 18: Reference Data Server UI – form for adding concept in a ValueSet

4.7.1 Current systems used by PICASO components

These are the ValueSet systems that are currently exposed through the Reference Data Server API.

Table 1: List of systems used in PICASO

System
http://hl7.org/fhir/encounter-type
http://hl7.org/fhir/observation-category
http://hl7.org/fhir/practitioner-specialty
http://hl7.org/fhir/sid/icd-10
http://hl7.org/fhir/ValueSet/additional-instruction-codes
http://hl7.org/fhir/ValueSet/care-plan-status
http://hl7.org/fhir/ValueSet/communication-category
http://hl7.org/fhir/ValueSet/days-of-week
http://hl7.org/fhir/ValueSet/event-timing
http://hl7.org/fhir/ValueSet/manifestation-or-symptom
http://hl7.org/fhir/ValueSet/medication-codes
http://hl7.org/fhir/ValueSet/medication-form-codes
http://hl7.org/fhir/ValueSet/medication-request-intent
http://hl7.org/fhir/ValueSet/observation-codes
http://hl7.org/fhir/ValueSet/reason-medication-not-taken-codes
http://hl7.org/fhir/ValueSet/request-status
http://hl7.org/fhir/ValueSet/route-codes
http://hl7.org/fhir/ValueSet/units-of-time
http://hl7.org/fhir/ValueSet/v2-0276
http://www.picaso-project.eu/refs/devicerefs
http://www.picaso-project.eu/refs/disease-type
http://www.picaso-project.eu/refs/questionnaires
http://www.picaso-project.eu/refs/medication-units
http://www.picaso-project.eu/refs/drugs
http://www.picaso-project.eu/refs/fhir/event-timing

5 Implementation

The tools presented before have been developed with the following technologies:

- NodeJS: https://nodejs.org/
- Express: http://expressjs.com/
- Angular 4: https://angular.io/
- CoreUI: https://coreui.io/
- Cassandra DB: https://cassandra.apache.org/

6 Conclusions

We have presented in this document the complete set of care plan management tools that has been deployed in the pilots, based upon the designs presented in the 1st phase of the project, together with the feedback provided by the clinicians afterwards, and by incorporating the different requirements.

This second version of the Care Plan Manager contains fundamental architectural changes in comparison to version 1 reported in the previous deliverable. The feedback of the clinicians during this pilot phase will be incorporated in the final version of the prototype.

7 List of Figures and Tables

7.1 Figures

7.2 Tables