

Biomedical Informatics

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Research projects in biomedical
informatics

RETENTION

RETENTION in a nutshell

CLINICAL CASE

Heart Failure (HF)

Chronic, progressive condition

- high mortality (#%)
- frequent hospitalisations
- affecting severely the patients' quality of life

RETENTION HYPOTHESIS

Assumptions

- Remote monitoring can improve HF patient management,
- Data analytics can support early detection of symptoms and produce personalised suggestions

SOLUTION PROPOSED

RETENTION platform

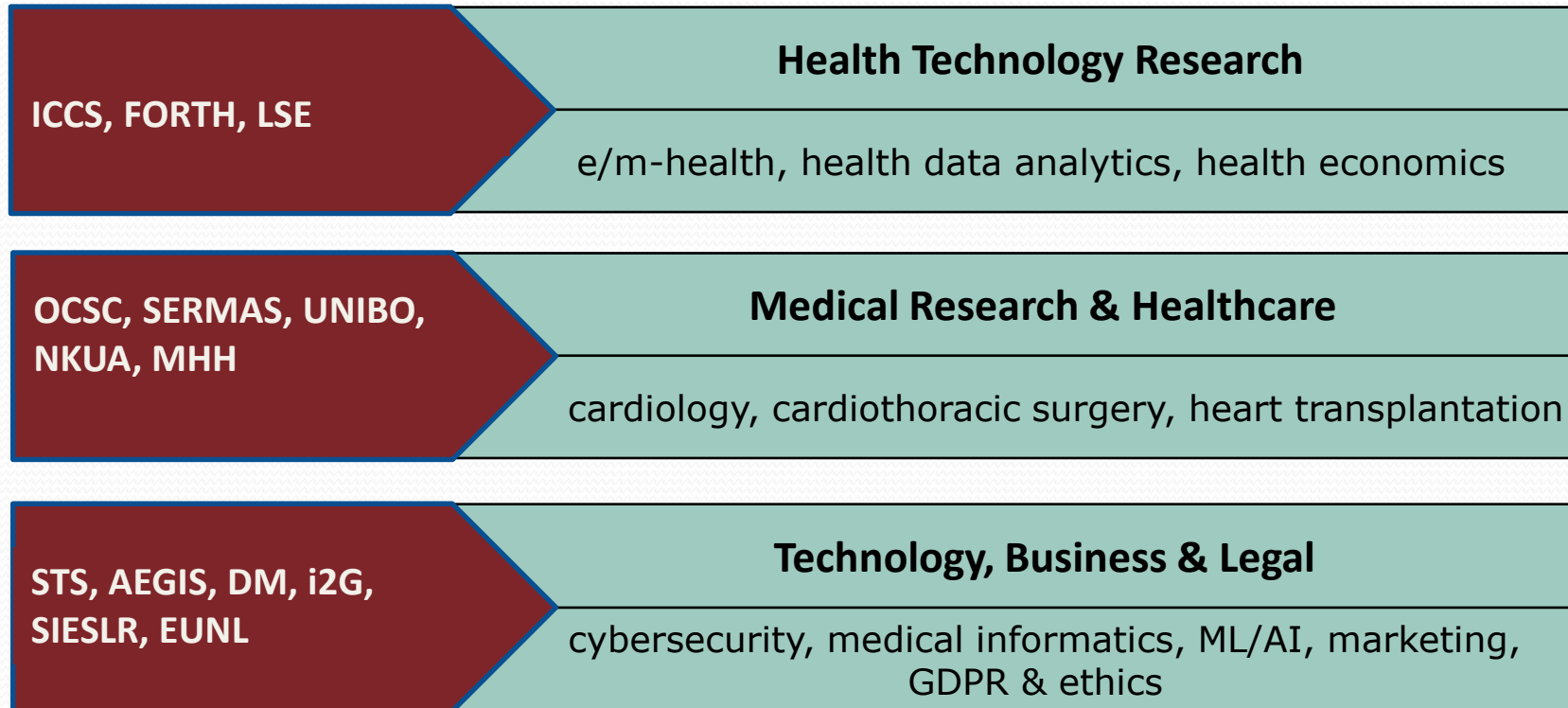
- Acquisition of clinical monitoring data
 - Recording of RWD
- Secure data transfer & visualisation
- Backend ML/AI enabled data analytics
- Production of personalised suggestions

PROOF OF CONCEPT - VALIDATION

Randomised Clinical Trial (RCT) Study

- 6 hospitals / 4 EU countries
 - 450 patients
- 3 patient subgroups (HF, LVAD, HTx)
 - 18 months follow-up
- Results and validation of the hypothesis

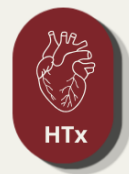
Partner profiles & roles



1 GENERAL STUDY FACTS



2 PATIENT SUBGROUPS

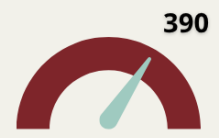


Heart Failure

Left Ventricular Assist Device

Heart Transplant

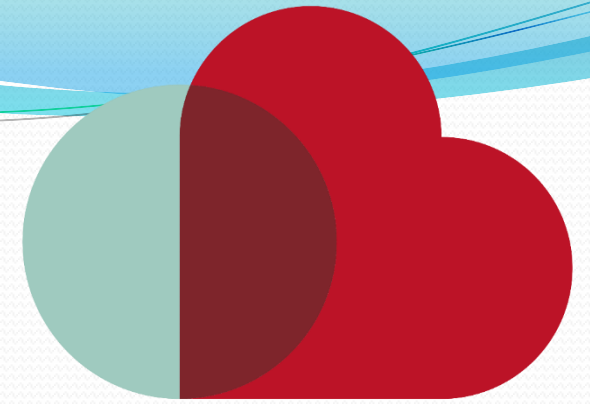
3 TRIAL STATUS & TIMELINE



All ethical approvals obtained

Multicentre randomized clinical trial in progress

Target: 450



retention

SMART HEART FAILURE MANAGEMENT

4 RETENTION PLATFORM

actively used to support:



Remote monitoring of HF, LVAD and HTx patients



Clinical follow-up and event recording



Real-world data collection at home

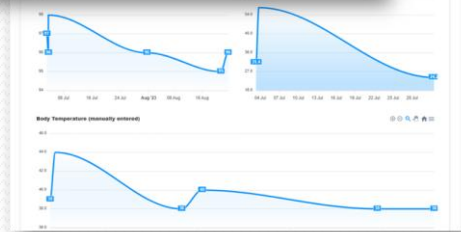
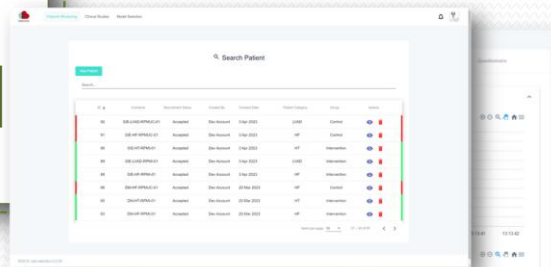
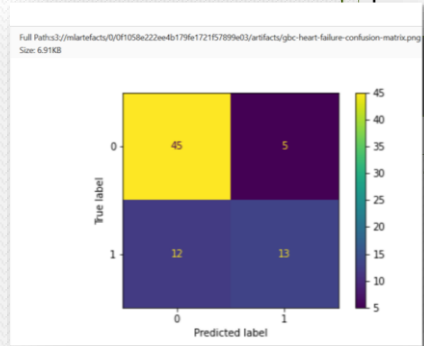
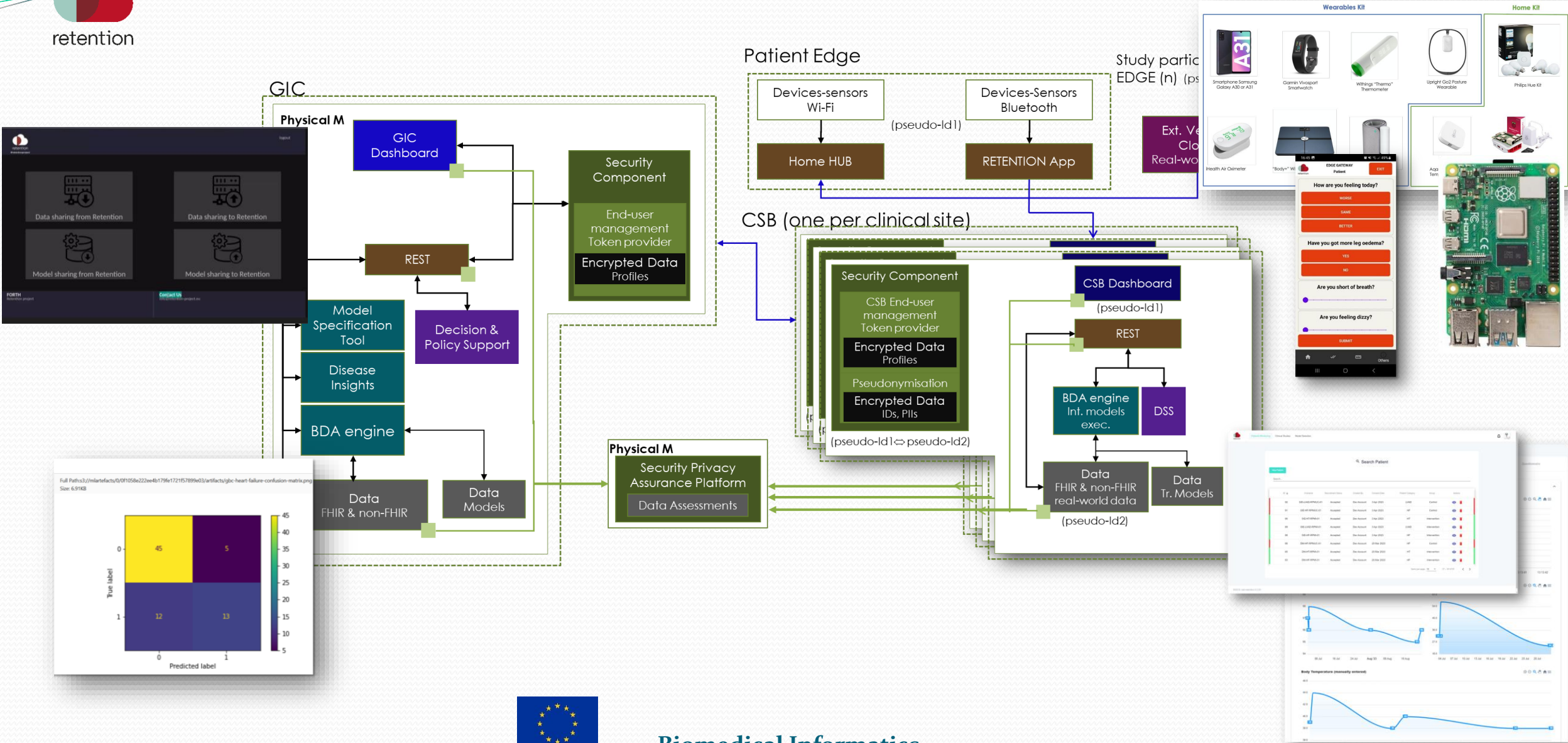
5 RESULTS & VALIDATION



RESULTS AND HYPOTHESIS VALIDATION



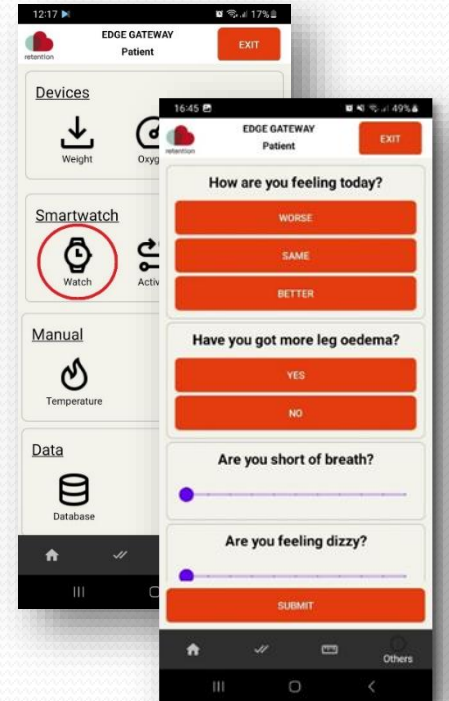
RETENTION Software Solution



Patient Edge

The Patient EDGE and the two components a) mobile application and b) the home gateway, offer continuous monitoring of patients and the collection of real-world and other data for these patients.

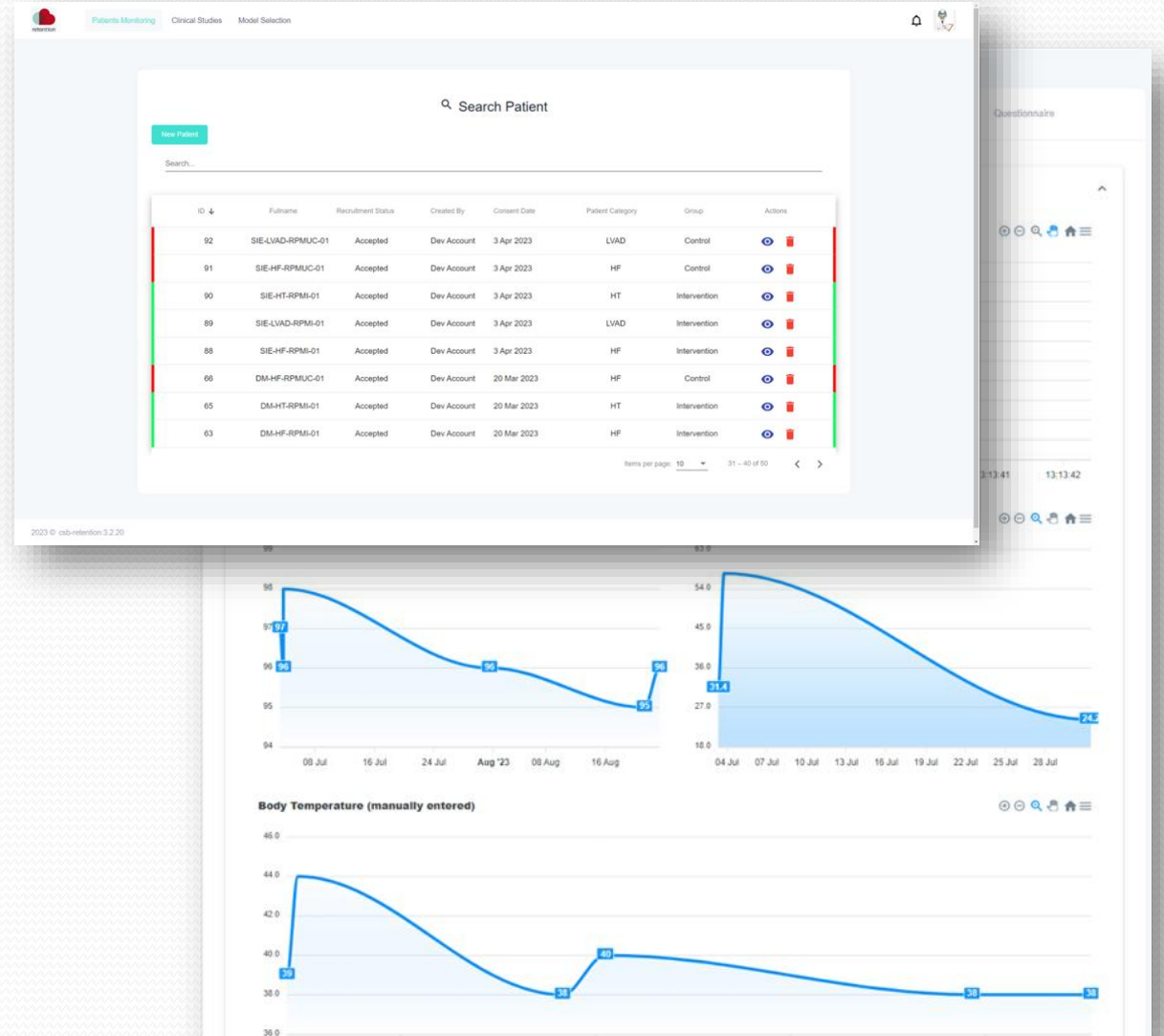
- A set of components deployed at the patients' environments, integrating smart home devices as well as medical devices on the patients themselves.
- at least 5 devices per patient.
- The RETENTION mobile application is able to gather data and "push" them to the CSB



Clinical side backend

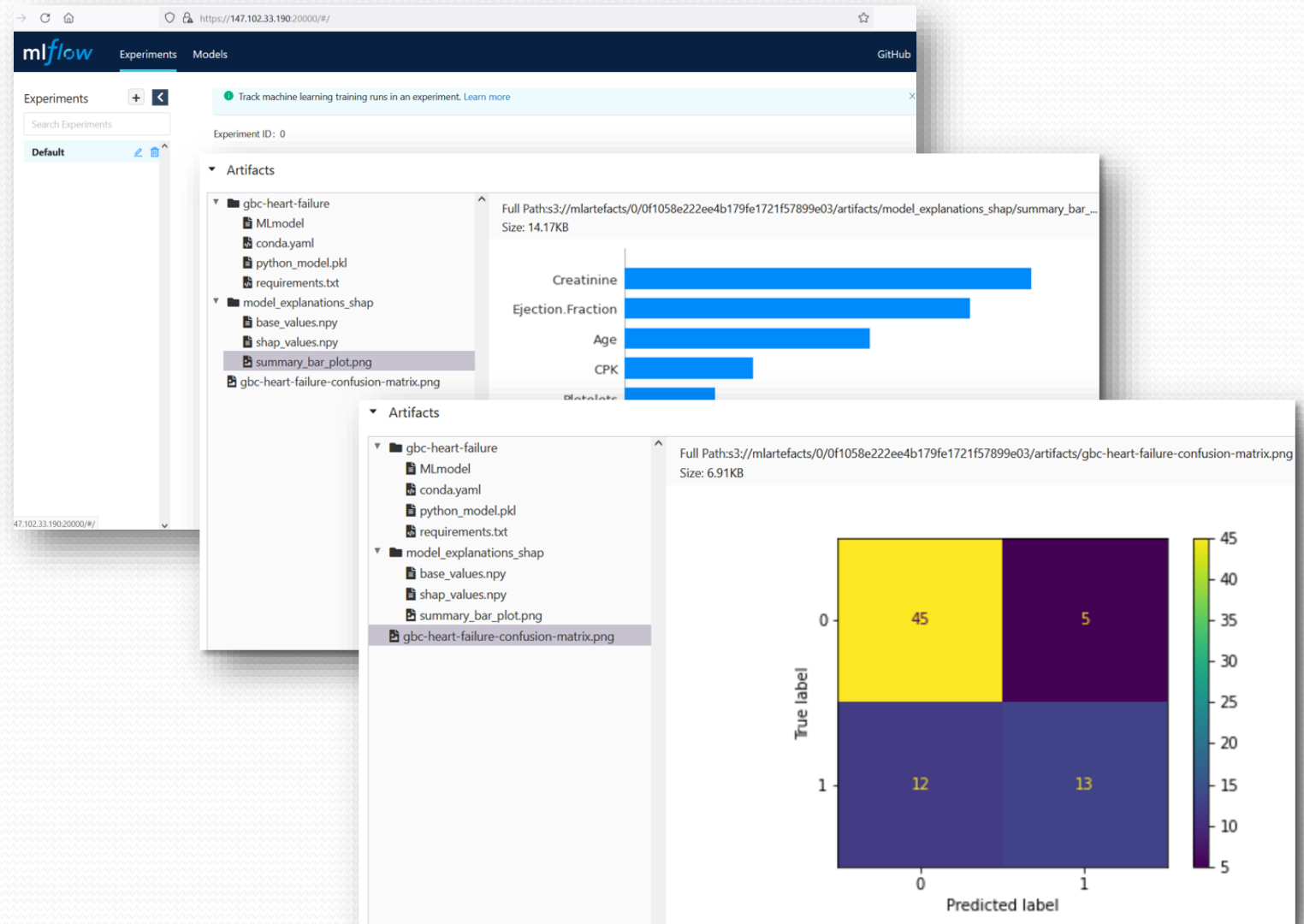
The CSB dashboard offers the medical team the tools they need to administer, follow, and take “informed” decisions about their patients

- per hospital backend instances of the platform, responsible for patient data ingestion, local decision making, analytics & interventions,
 - A web application-visualization for the clinicians.
 - databases
 - A decision support system
 - the execution of the RETENTION AI models
 - All data are protected



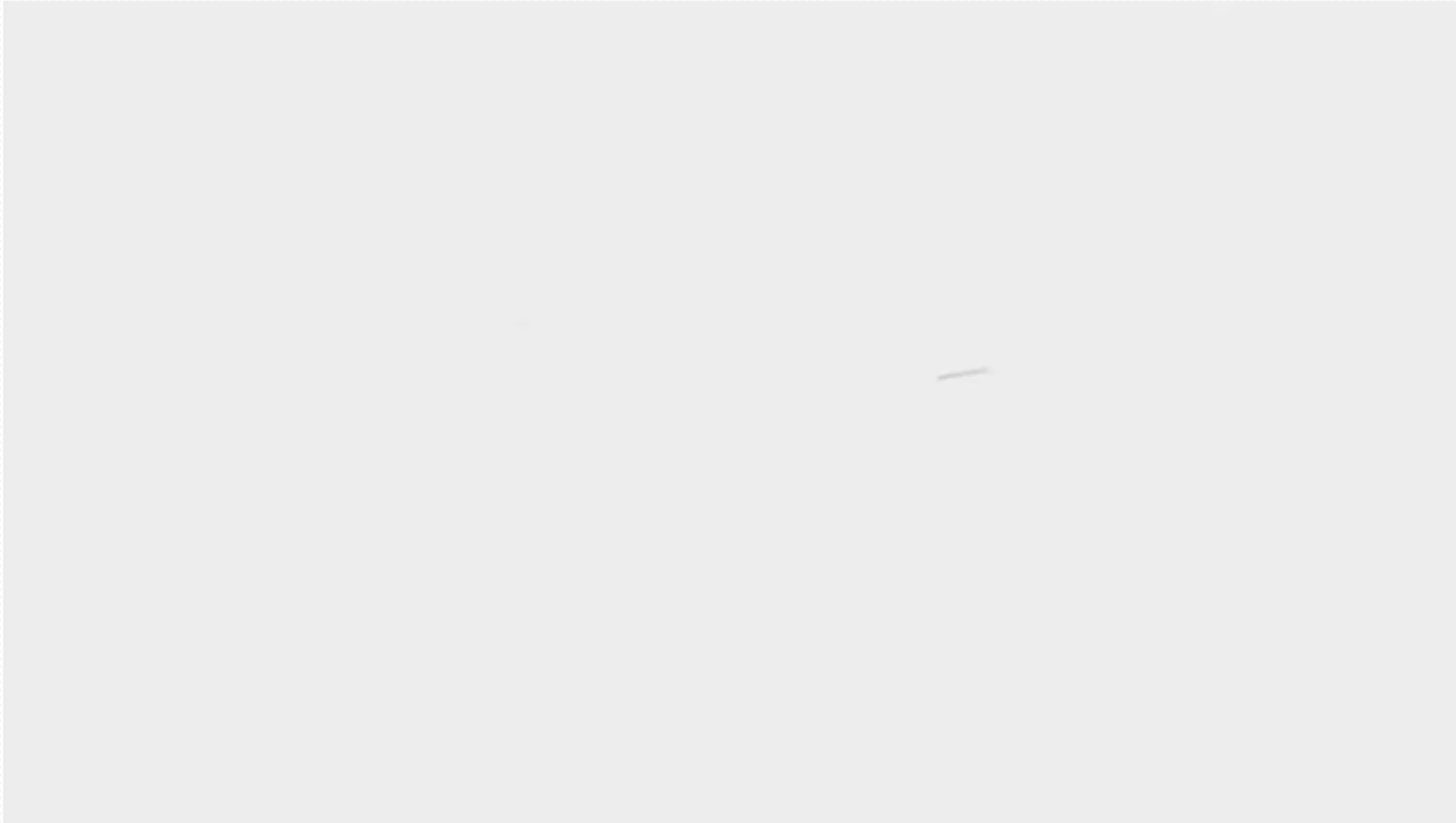
Global Insights Cloud

The GIC functions as the main statistical and AI component, that will host the AI, policy making, and big data software mechanisms, offering the Data scientist, clinical expert, or healthcare policy maker, the tools to take “good” the necessary decisions about Heart Failure disease management.



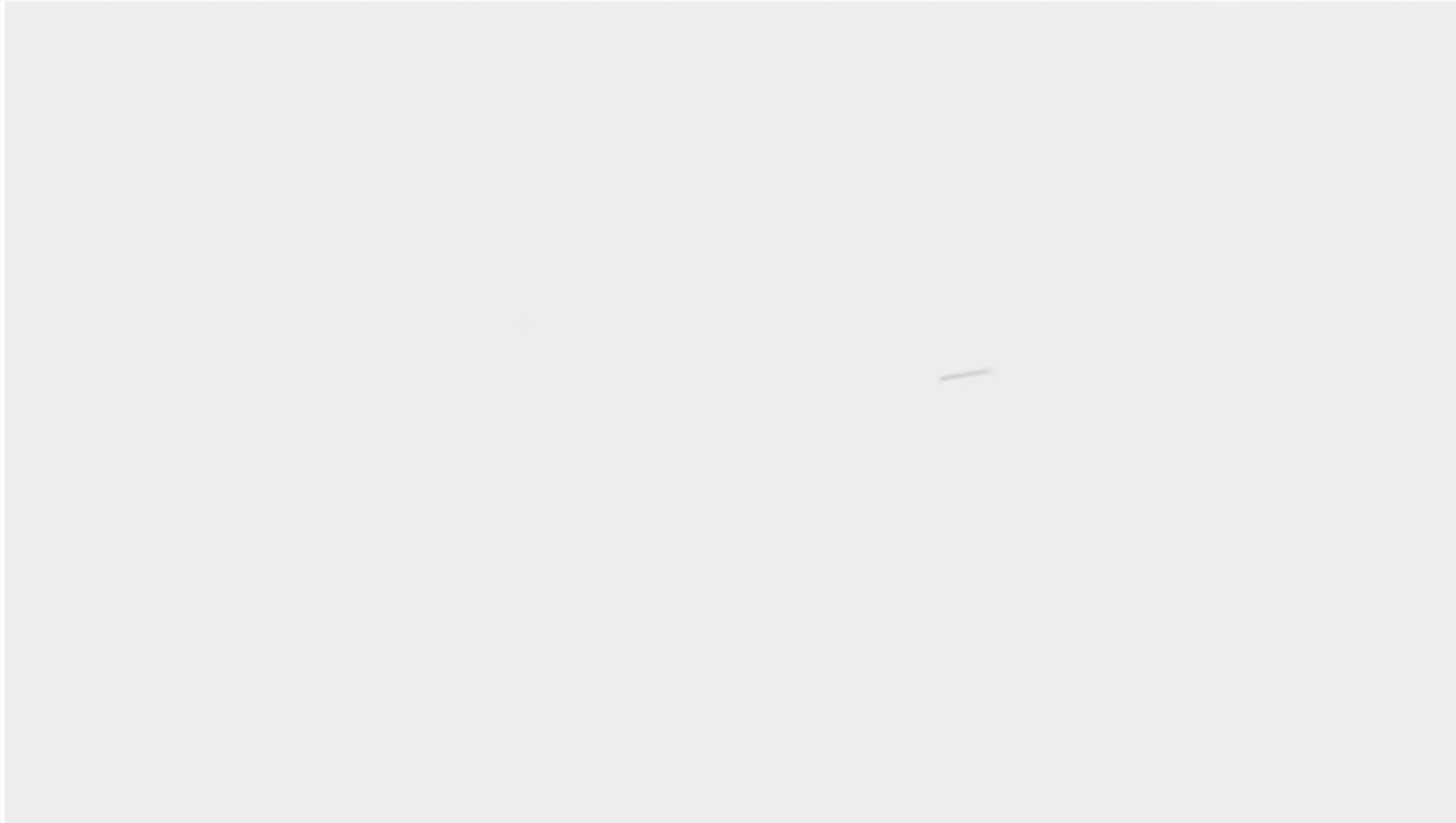


RETENTION Dashboard (HCP view)





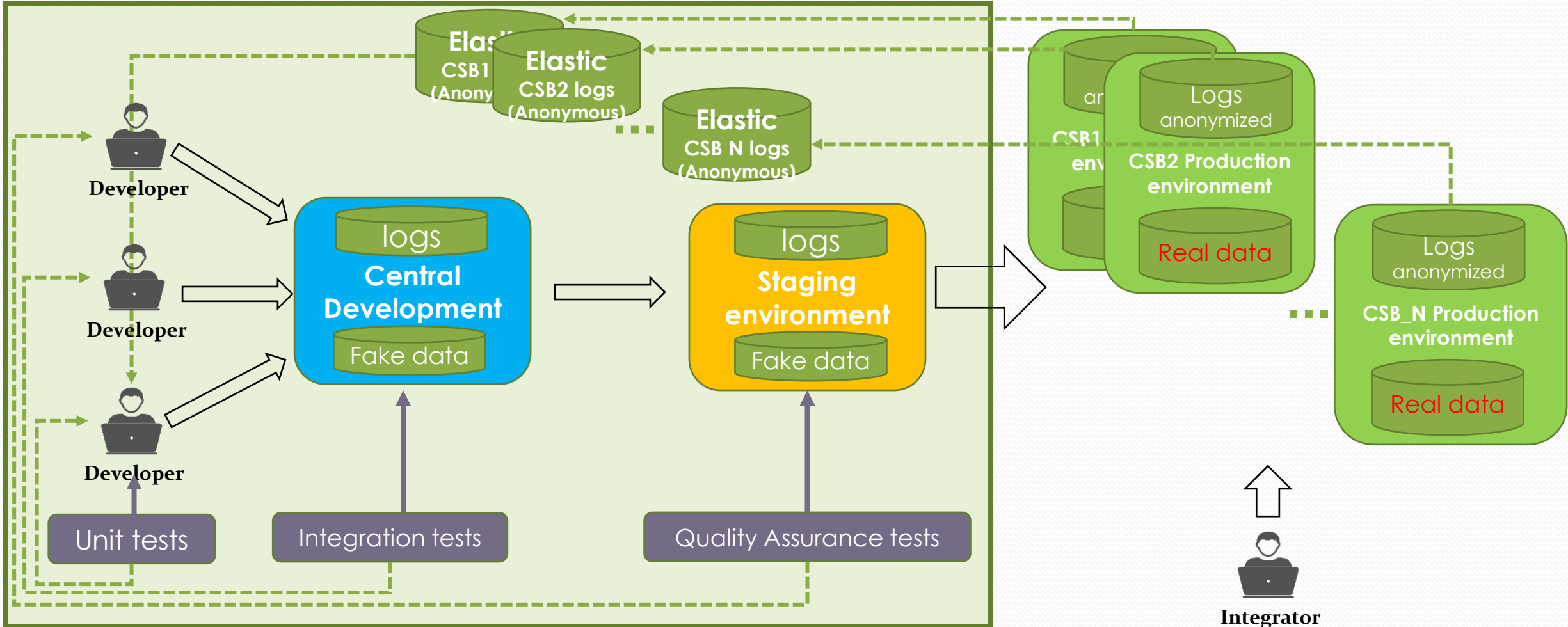
RETENTION App (Patient view)



Software Development lifecycle

Integrator's access

Developer's access



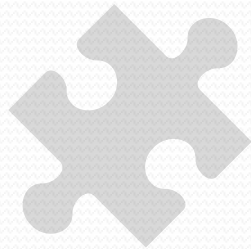


Platform problems' discussion

REPORT

Healthcare team: report issues to basecamp
Patients: report to clinical site (1st level support by technicians)

1



FIXES

1. Reproduce the error
2. provide fix
3. Test the fix

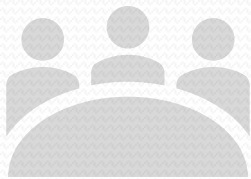
3



2

REPRODUCE

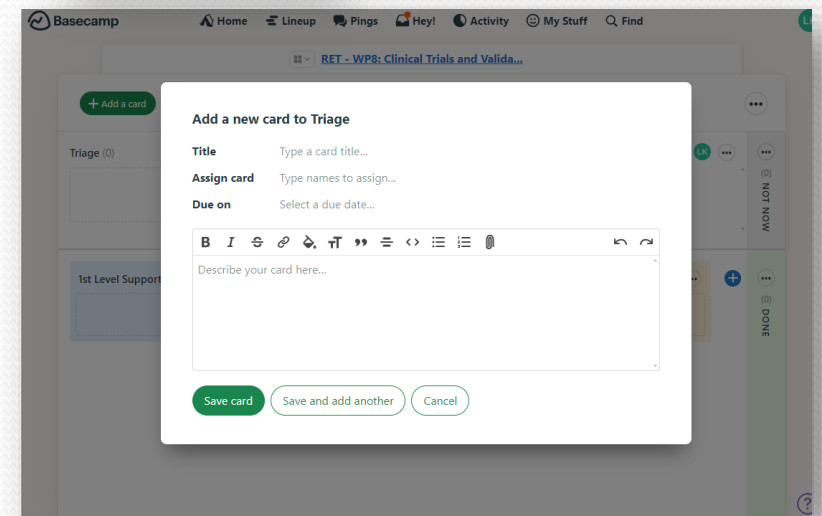
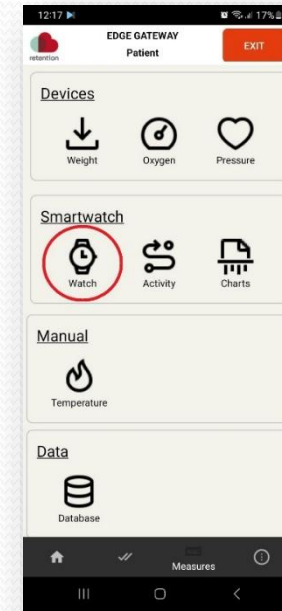
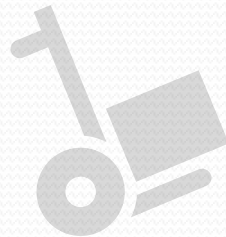
Export anonymized logs from the production to the development environment



4

UPDATE

Updated version is provided to the integrator who is responsible to deploy it at the CSB



Smart Bear

Smart Bear aim

The development of an **innovative platform** to support the healthy and independent living of elderly people with the following conditions: **Hearing Loss, Cardio Vascular Diseases, Cognitive Impairments, Mental Health Issues, Balance Disorders, and Frailty**

The platform support interventions on:

- **lifestyle**
- **medically-significant risk factors, and**
- **chronic disease management**

The platform is based on or integrates:

- **medical sensing** off-the-shelf devices
- **big data analytic** capabilities (data management and analytics)
- **security and privacy** preserving, and security assurance mechanisms



CLINICAL OBJECTIVES

Reducing morbidity through

Active monitoring of vital, behavioral and environmental parameters

Integrated care

Improving quality of life through

Active prevention through proactive lifestyle and wellbeing activities

Support at home

5 countries

5 years

> 4000
EU citizens

≥ 65 yo
males and
females

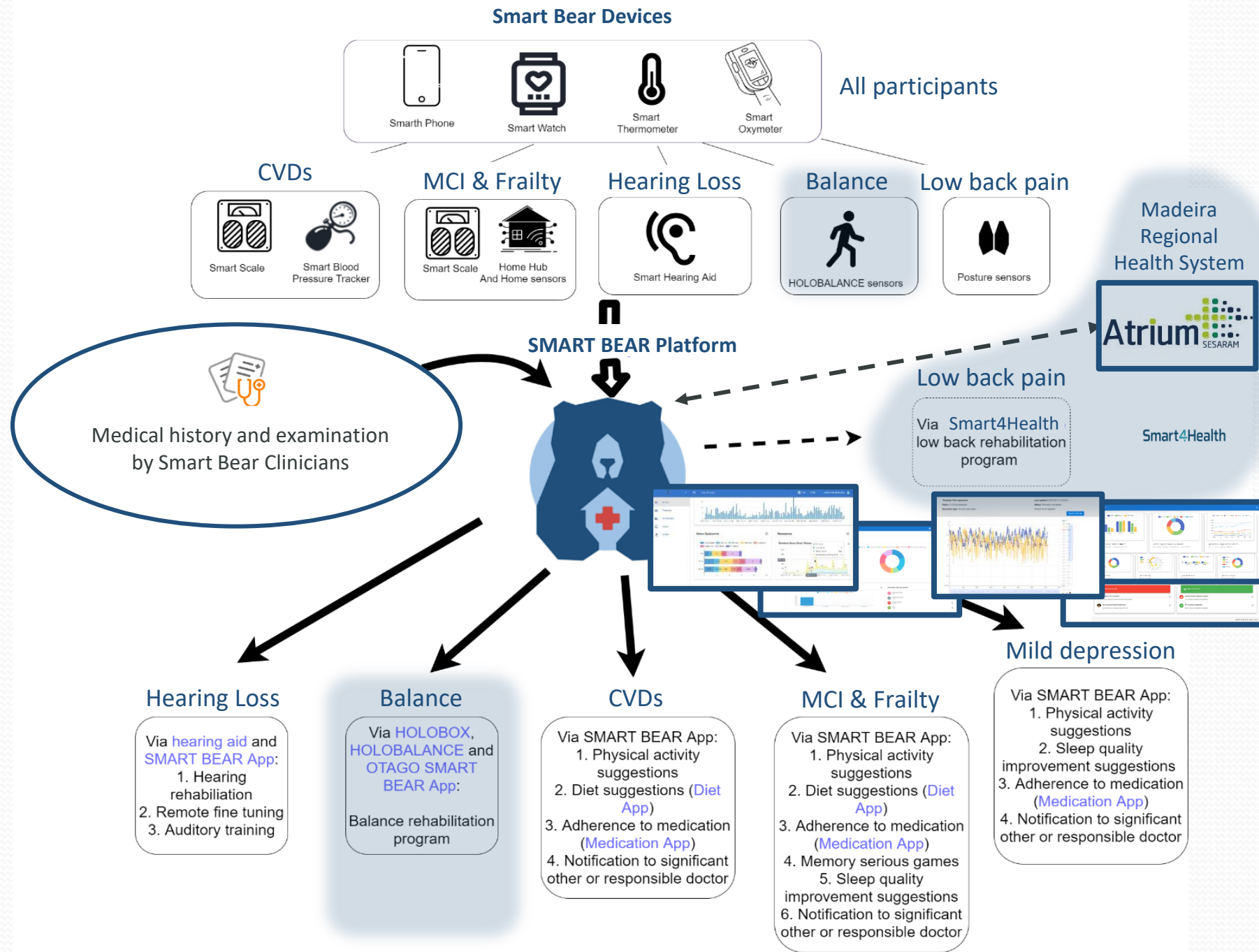
≥ 2 comorbidities

Montreal Cognitive Assessment (score > 18)

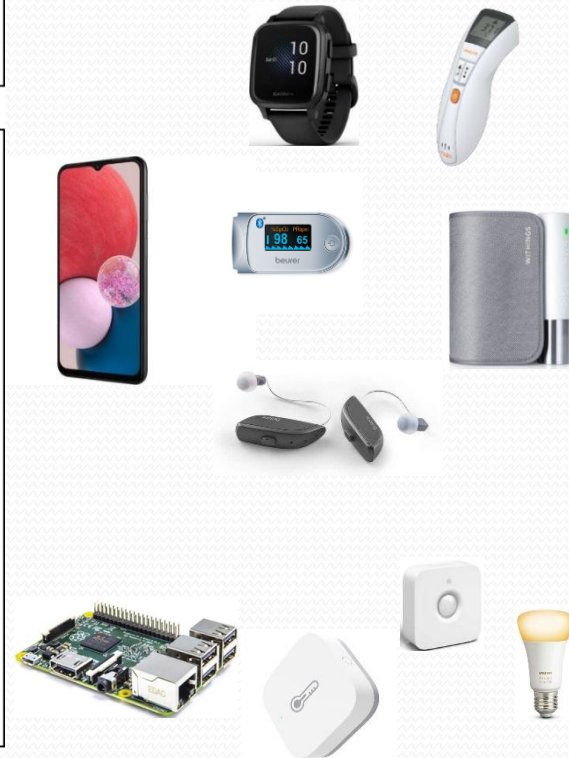
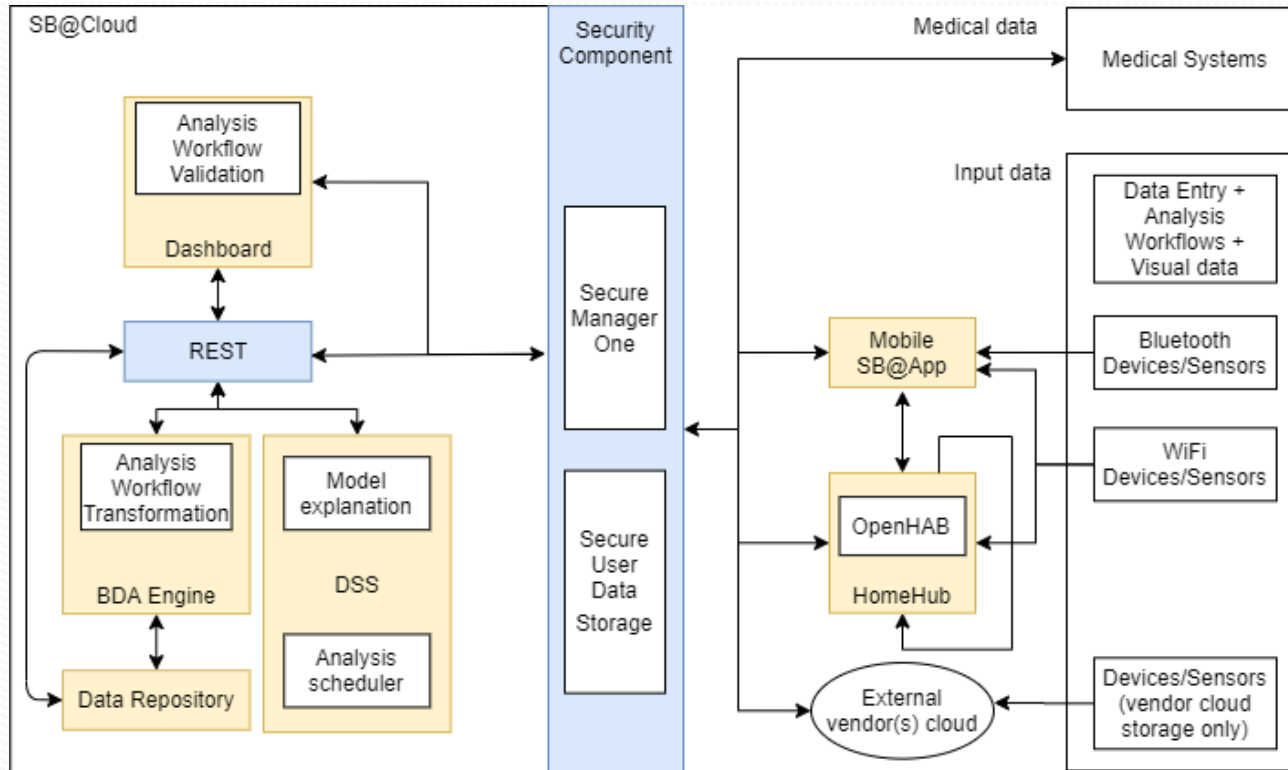
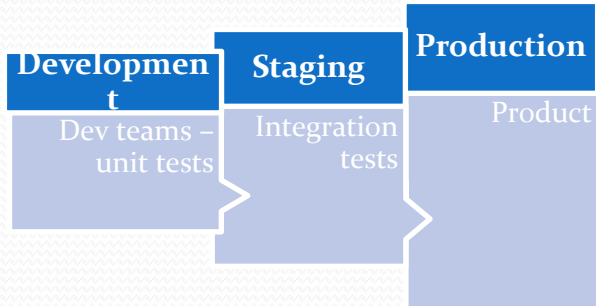
Health Utility Index (HUI3, score = 1-4)



The SMART BEAR ecosystem in a nutshell



SmartBear Architecture



SmartBear - Data collection tools at patient edge

- **HomeHub**
 - Raspberry PI
 - Humidity and temperature sensor
 - Smart bulb
- **SB@App**: A mobile app.
 - Smart watch
 - Smart blood pressure monitoring
 - Smart scale
 - Smart oximeter
 - ...
 - Cognitive games
 - Questionnaires
 - Medication management
 - Reminders

17 devices integrated
> 160 Data Measurements
~5K active devices

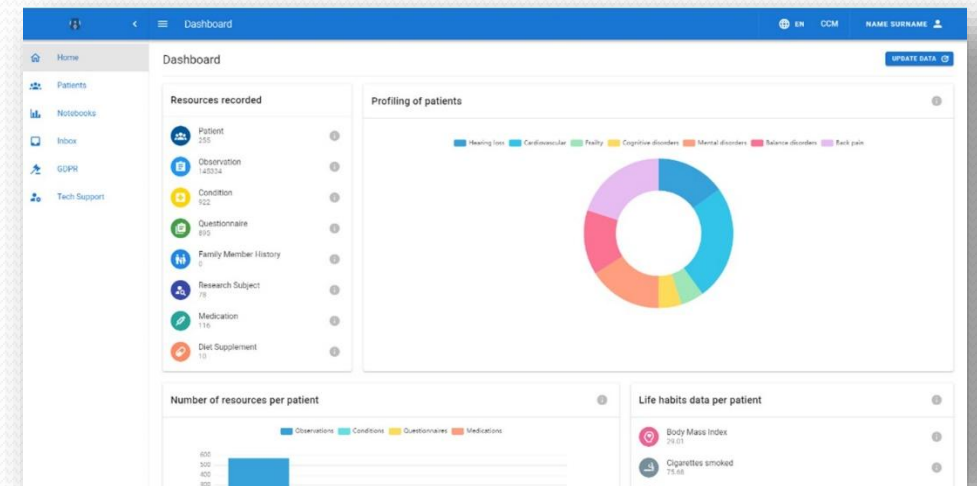
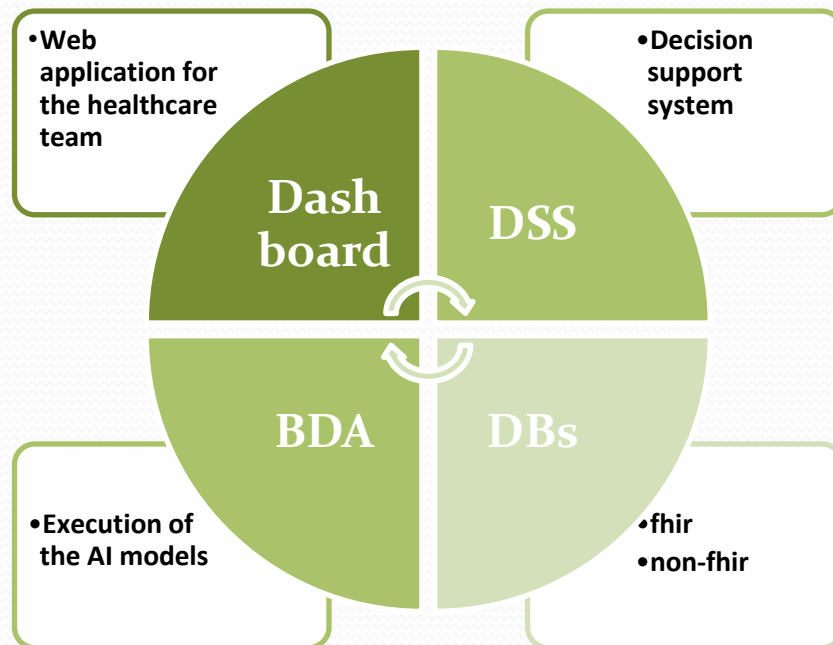


SB@Cloud

The SB@Cloud offers the medical team the tools they need to administer, follow, and take “informed” decisions about their patients.

SB@Cloud is responsible for patient data ingestion, local decision making, analytics & interventions.

~6M assessments



CardioCare

CardioCare Project

- **CARDIOCARE** - An interdisciplinary approach for the management of the elderly multimorbid patient with breast cancer therapy induced cardiac toxicity
 - Improve early detection and management of cardiotoxicity in the elderly breast cancer patient
 - Provide innovative patient-oriented tools and mHealth based supportive interventions to better monitor and improve intrinsic(mental and physical) capacity and QoL in these patients.
- An eHealth mobile application (**ePsyncHeart**) was designed and developed to support the user-friendly collection of data and the monitoring of patients' **intrinsic capacity** and **QoL**
- **Continuous monitoring of specific aspects of intrinsic capacity (the composite of all physical and mental abilities an individual can draw on at any point in time, serving as a key indicator for healthy aging):**
 - mobility and locomotion (activity, distance, gait speed, balance, falls)
 - vitality status (ECG, HRV, exercise, energy (calories burned) state, sleep overview/ fatigue, grip strength)
- **Wearable sensors and mobile devices:**
 - Heart Rate Chest Sensor
 - Smart Watch
 - Hand grip electronic dynamometer
 - Mobile phone

Mobile App Data Flow

Measure:
• ECG
• Heart Rate



Measure:
• Steps
• Sleep
• Heart Rate
• Exercise
• Calories



Patient reports:
• Grip strength
• Questionnaires
• PROMs & PREMs
• Expressive Writing & Best Possible Self

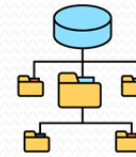
Online database



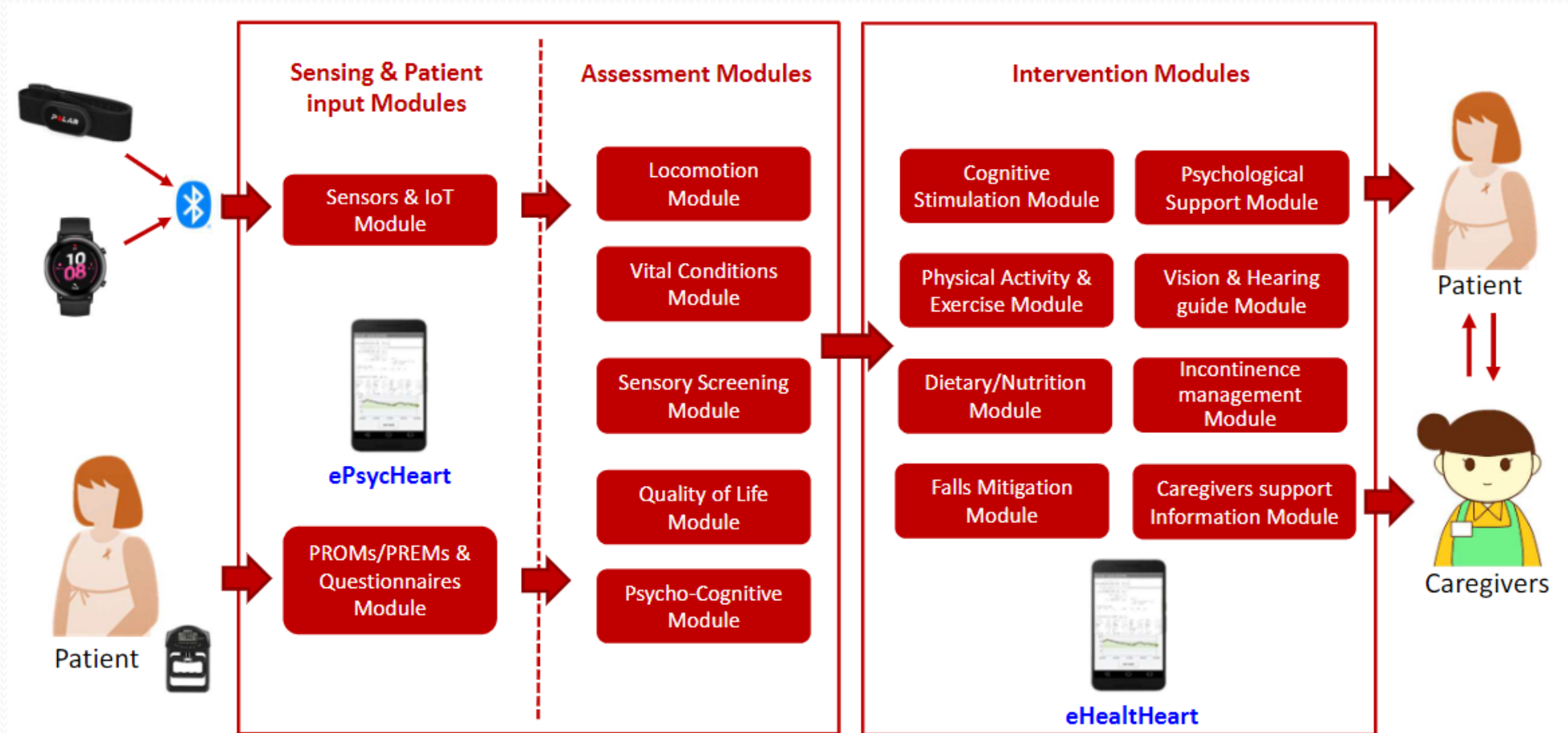
Analytics:
• A.I.
• Machine Learning



Clinical & Lab evaluations

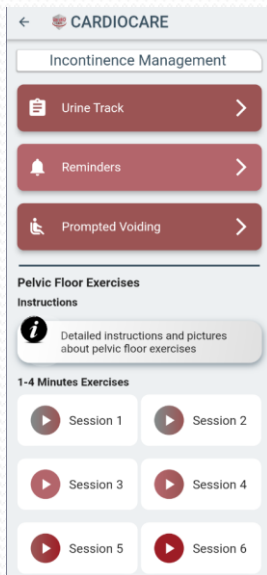


ePsyHeart modules



Urinary Incontinence

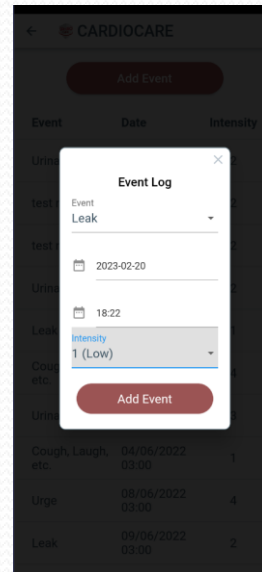
Home screen



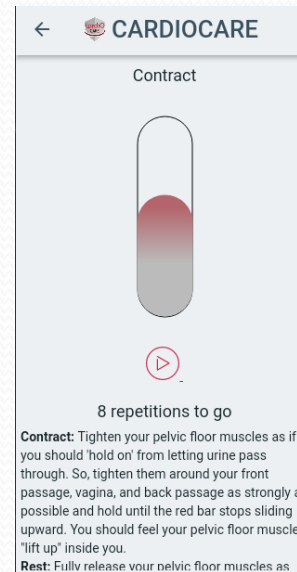
Events List

Event	Date	Intensity
Urination	09/06/2022 03:45	2
Cough, Laugh, etc.	09/06/2022 04:32	2
Leak	09/06/2022 03:00	2
Urination	07/06/2022 03:00	2
Leak	01/06/2022 03:00	1
Cough, Laugh, etc.	06/06/2022 03:00	4
Urination	08/06/2022 03:00	3
Cough, Laugh, etc.	04/06/2022 03:00	1
Urge	08/06/2022 03:00	4
Leak	09/06/2022 03:00	2

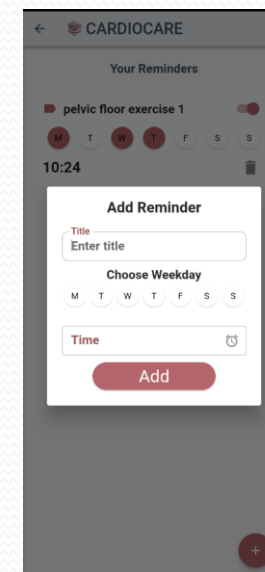
Add Urination Event



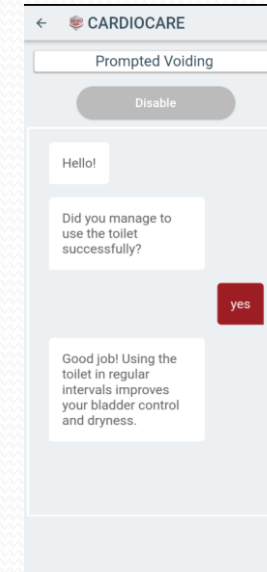
Pelvic Floor Exercise



Reminders



Prompted Voiding



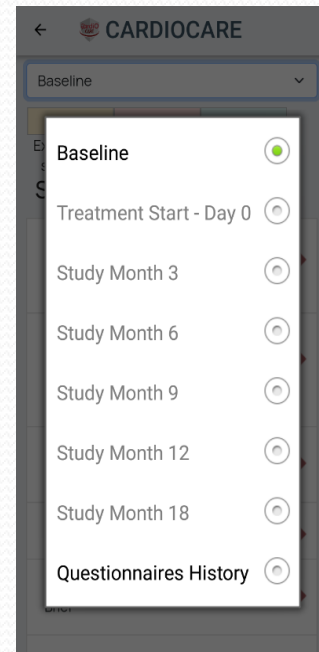
- **Urinary incontinence** in patients undergoing breast cancer therapy, particularly those with treatment-induced cardiac toxicity, is a common issue due to weakened pelvic muscles and side effects from medications or therapies. This condition can significantly impact their QoL.

- **Prompted voiding:** A functionality to remind the patient to use the toilet and also to keep track if the patient used successfully or not the toilet.
- Add Urination event
- Available 6 **pelvic floor exercises**
- Reminders for the pelvic floor exercises

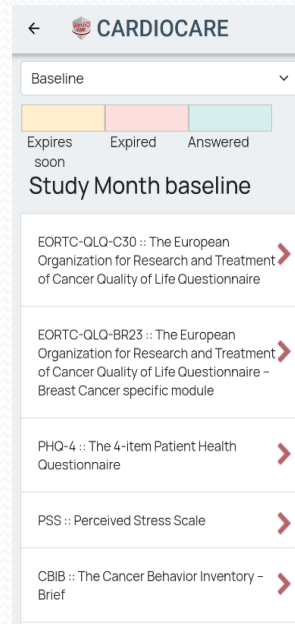
Questionnaires

- **Questionnaires:** A functionality for the patient to answer to questionnaires in specific periods, in order to give information about their condition during the treatment periods.
- Patient can answer specific questionnaires during specific periods. The questionnaires are available for 2 days for every period.

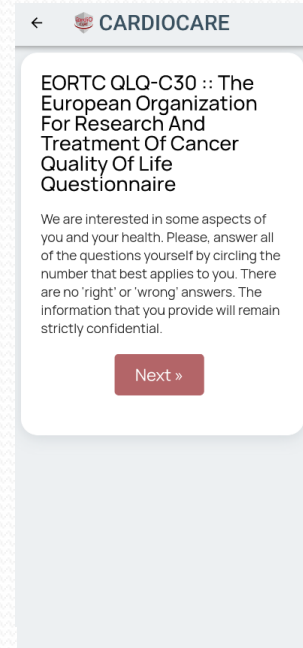
Questionnaire
Periods



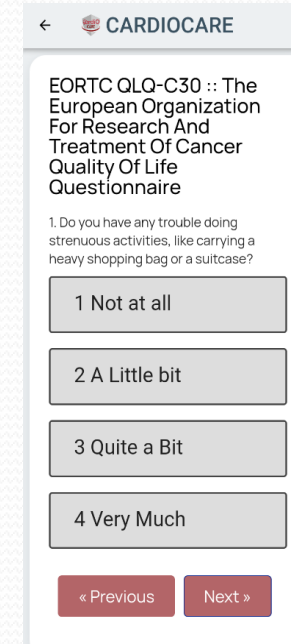
Questionnaires
List



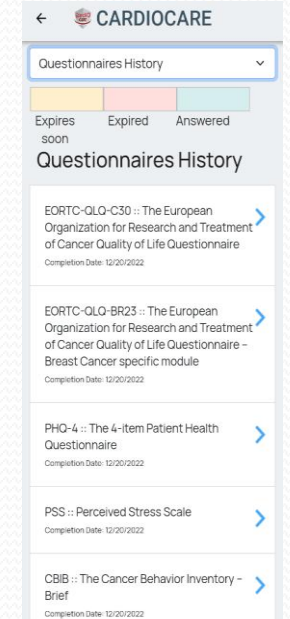
Questionnaire
Description



Questions



Questionnaire
History



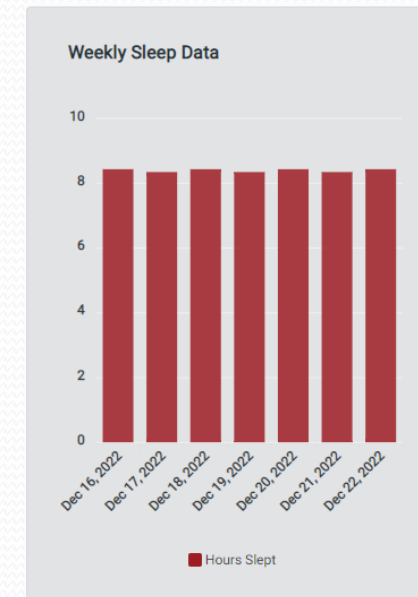
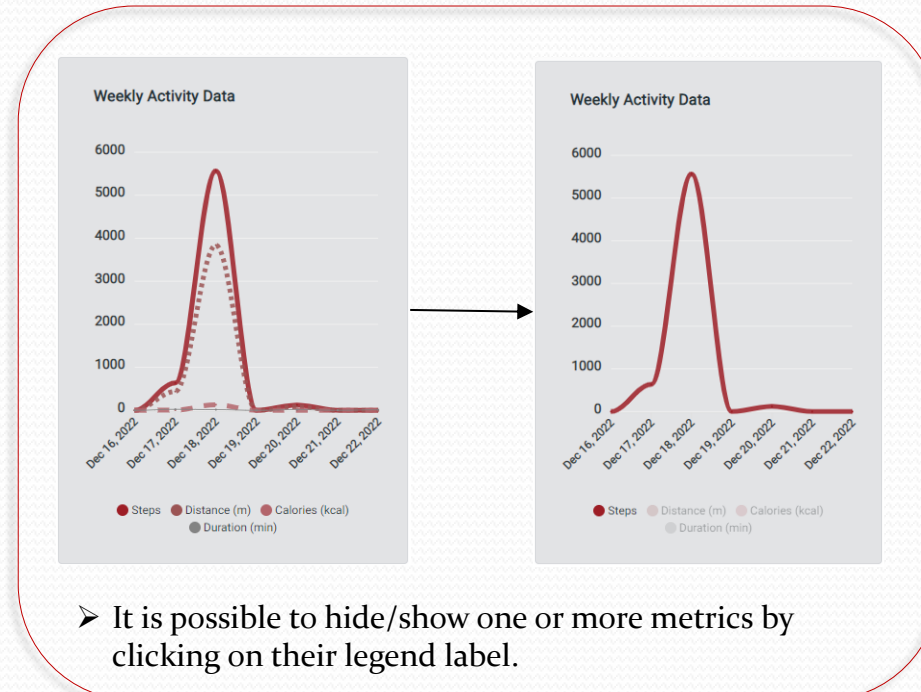
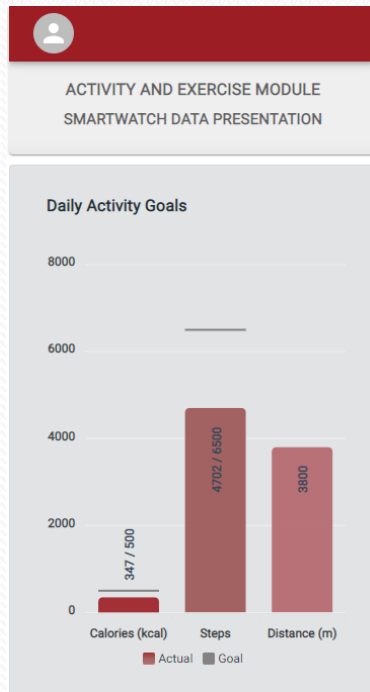
Nutrition Questionnaire

- **Nutrition Questionnaires:** A functionality for the patient to answer to questionnaires in specific periods, in order to give information about nutritional habits during the treatment periods.
- Patient can answer the nutrition questionnaire during specific periods. The questionnaires are available for 2 days for every period.

The image displays five sequential screenshots of a mobile application interface for a nutrition questionnaire. Each screen is titled and shows the following content:

- Home screen:** Shows a menu with 'My Challenges' (Questionnaires, Nutrition, Physical Activity) and a grid of challenge categories: Mobility & Vitality, Cognitive Stimulation, Education & Training, Geriatric Syndromes Assessment, Vision & Hearing, and Psychology & Wellbeing.
- Questionnaire List:** Shows a 'Baseline' dropdown, a progress bar for 'Expires soon', 'Expired', and 'Answered', and a 'Study Month baseline' section with a 'NUTRITION :: Nutrition Questionnaire' button.
- Questionnaire Answers:** Shows the 'Nutrition Questionnaire' title, 'Completion Date' (12/21/2022), and question 0: '0. Gender. Please select one of the following options: Woman'. Below is question 1: '1. Please estimate your average food use as best you can, and please answer every question - please answer ALL questions. Beef: roast, steak, mince, stew or casserole: Once a week. Beefburgers: 2-4 per week. Pork: roast, chops, stew or slices: Once a week.' with an 'OK' button.
- Questionnaire Start:** Shows the title 'EORTC QLQ-C30 :: The European Organization For Research And Treatment Of Cancer Quality Of Life Questionnaire', an introductory paragraph, and a 'Next »' button.
- Questions:** Shows the instruction '1. Please estimate your average food use as best you can, and please answer every question - please answer ALL questions.' followed by 'TABLE1: MEAT AND FISH (medium serving)' and '1. Beef: roast, steak, mince, stew or casserole'. Below are four radio button options: 'Never or less than once/month', '1-2 per month', 'Once a week', and '2-4 per week'.

Physical Activity Module

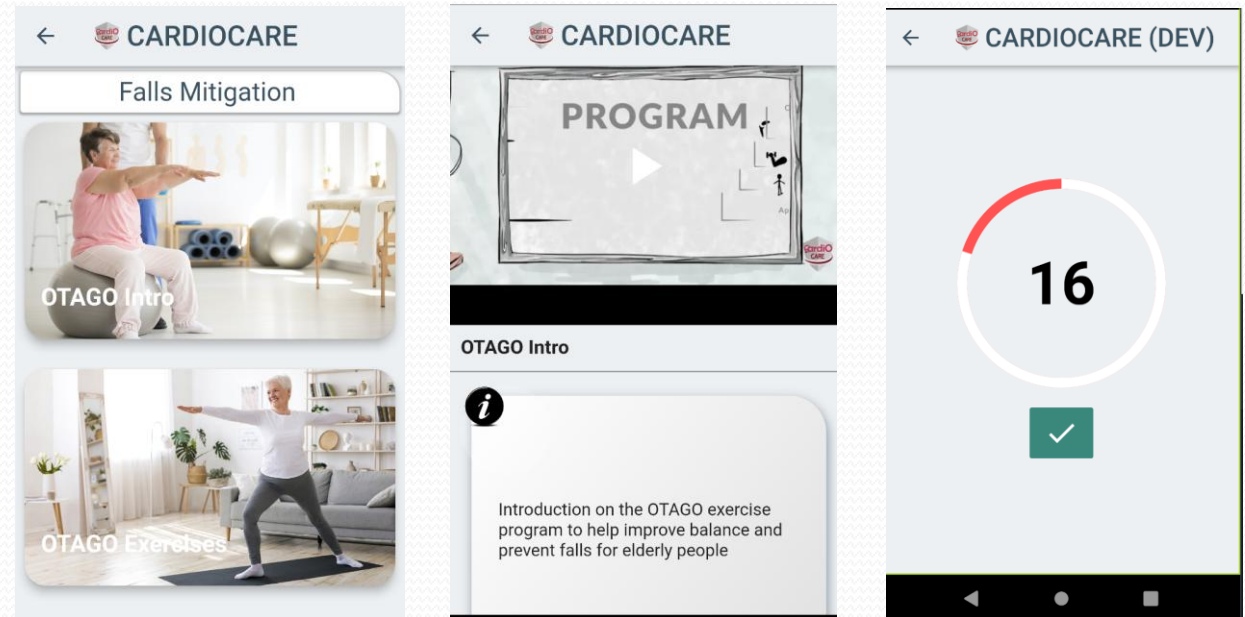


- **Daily Activity Goals:** A bar chart presenting the daily activity goals and their completion rate, as recorded by the smartwatch.
- **Weekly Activity Data:** A line chart presenting the weekly activity smartwatch data (steps, distance, calories, duration of physical activity).
- **Weekly Sleep Data:** A bar chart presenting weekly sleep duration, as recorded by the smartwatch.

Fall Detection

- **Fall Detection:** A functionality of the mobile to record data from gyroscope and accelerometer in background. Those data are used in order to detect possible falls of the patients.
- This recording can be optionally disabled if the patient doesn't wish to have their data recorded.
- **If a fall is detected, an alert will sound and a countdown will begin.** If the patient clicks the check button, it signifies he is fine, and the alarm will be turned off. Otherwise, a notification will be sent to the server within 20 seconds for a verified fall.

Training Video



- **Video List:** A functionality to give the patients the ability to watch training videos in order to improve their balance and strength.

Expressive Writing

- **Expressive Writing:** Patients express their deepest feelings, thoughts and experiences using free text.
- Free text form with instructions, date, timer and word counter
- Feedback
- Available reminders

Expressive Writing Form

← CARDIOCARE

Expressive Writing: Your thoughts and feelings about cancer

In the box below, express your thoughts and your feelings writing about a major life event or a traumatic experience over 3 or 4 consecutive days. Try to let go and just write for at least 15-20 minutes. You might write about how the outbreak is affecting you and the people around you. Or how are you dealing with feelings such as anxiety or isolation? Really try to address those issues most important for you. Please write continuously for the entire time, and don't worry too much about spelling or punctuation errors.

All information will be kept anonymous and confidential.

Date: 22/2/2023

Timer: 00:00:00

Submit

Expressive Writing Feedback

← CARDIOCARE

Expressive Writing: Feedback

For this writing exercise, you were asked to write 15-20 minutes about a major life event or a traumatic experience over 3 or 4 consecutive days. Before looking at your feedback, it's important that you know that you are the real judge of your writing. Did you find it helpful? Are you thinking about the topic in a different way than when you started?

Date: 22/2/2023

Time Taken: 00:00:26

Word Count: 5

Your Writing

Test Test Test Expressive Writing

Home icon

Reminders

← CARDIOCARE

Your Reminders

Add Reminder

Title

Enter title

Choose Weekday

M T W T F S S

Time

Add

+ icon

Best Possible Self

- **Best Possible Self:** Patients describe how they imagine themselves in the future in the best possible version of them using free text
- Free text form with instructions, date, timer and word counter
- Feedback
- Available reminders

Best Possible Self Form

← CARDIOCARE

Best Possible Self

Please, now write down for about 15-20 minutes about your life goals, imagining yourself in the future once everything has turned out at best. The only rule is to write continuously. If you run out of things to write, simply repeat what you have already written. Don't worry about grammar, spelling, or sentence structure. Don't worry about deleting something. Just write.

All information will be kept anonymous and confidential.

Date: 22/2/2023

Timer: 00:00:00

Submit

Best Possible Self Feedback

← CARDIOCARE

Best Possible Self: Feedback

Now, I would like you to imagine the things you wrote as vividly as possible. Think about your best self for 1 minute. Imagine your ideal future life with as much detail as possible. Please, start thinking and continue for 1 minute. Please, read it daily for as long as the intervention duration.

Date: 22/2/2023

Time Taken: 00:00:19

Word Count: 6

Your Writing

Test Test Test Best Possible Self

Home icon

Reminders

← CARDIOCARE

Your Reminders

Add Reminder

Title

Enter title

Choose Weekday

M T W T F S S

Time

Add

+ icon

ABCDE

- **ABCDE:** Patients recall an adverse event and explain the causes for that and related consequences, dispute them and reflect on their influences on emotions and behaviors using free text
- 5 free text forms with instructions, date, timer and word counter
- Feedback
- Available reminders

ABCDE Forms

The ABCDE Forms app interface consists of four sequential screens, each with a timer and a 'Next' button. The screens are:

- (A) Adversity:** Includes instructions to think about an adverse event and describe it. Date: 22/2/2023. Timer: 00:00:00.
- (B) Beliefs:** Includes instructions to reflect on thoughts and interpret the event. Date: 22/2/2023. Timer: 00:00:00.
- (C) Consequences:** Includes instructions to focus on feelings and write them. Date: 22/2/2023. Timer: 00:00:00.
- (E) Energy:** Includes instructions to read previous entries and write thoughts. Date: 22/2/2023. Timer: 00:00:00.

ABCDE Feedback

The ABCDE Feedback app interface shows a summary of the user's input for two sections:

- (A) Adversity:** Date: 22/2/2023, Time Taken: 00:00:10, Word Count: 2. Includes a 'Your Writing' section.
- (B) Beliefs:** Time Taken: 00:00:15, Word Count: 5. Includes a 'Your Writing' section.

Below the feedback, there are 'Test Test' sections for both (A) and (B), and a 'Test Test Test Test Beliefs' section for (B). A 'Next' button is visible at the bottom.

Reminders

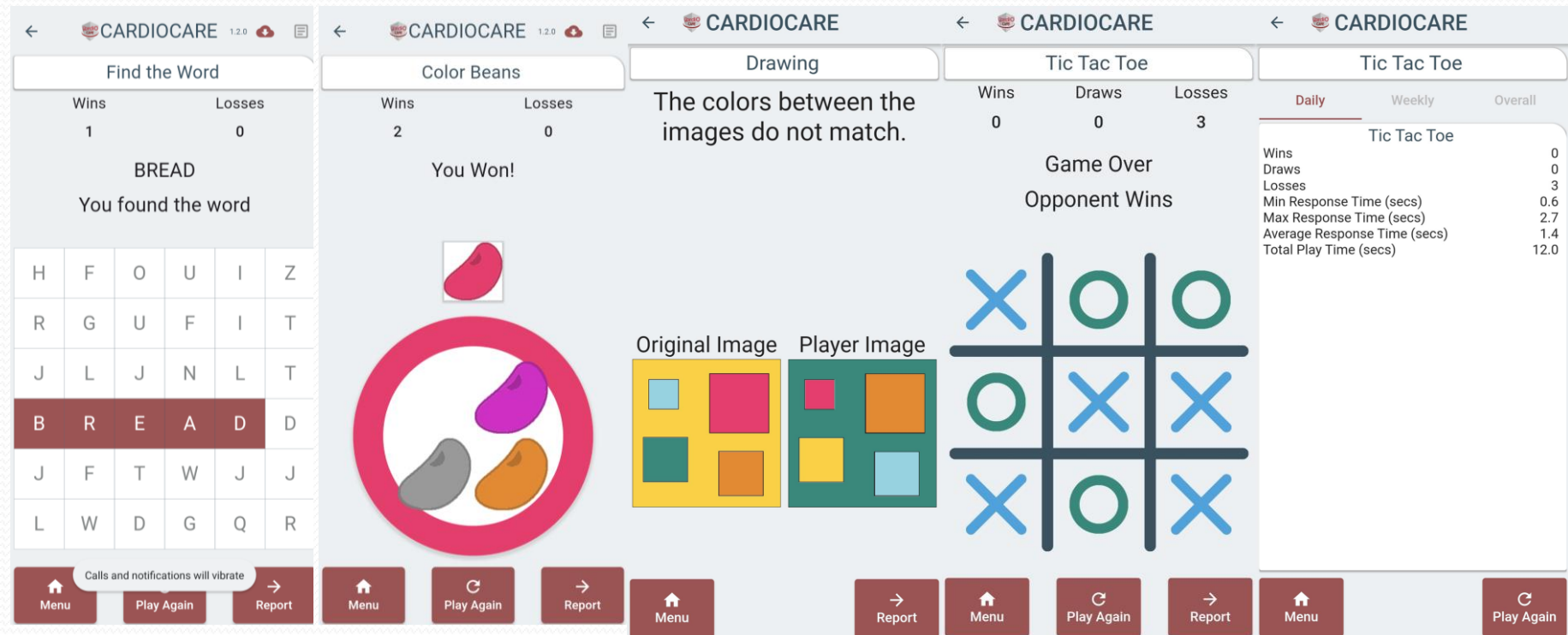
The Reminders app interface features an 'Add Reminder' form with the following fields and options:

- Title:** A text input field with the placeholder 'Enter title'.
- Choose Weekday:** A row of seven circular buttons labeled M, T, W, T, F, S, S.
- Time:** A time selection field with a clock icon.
- Add:** A large red button to submit the reminder.

A plus sign (+) button is located at the bottom right of the screen.

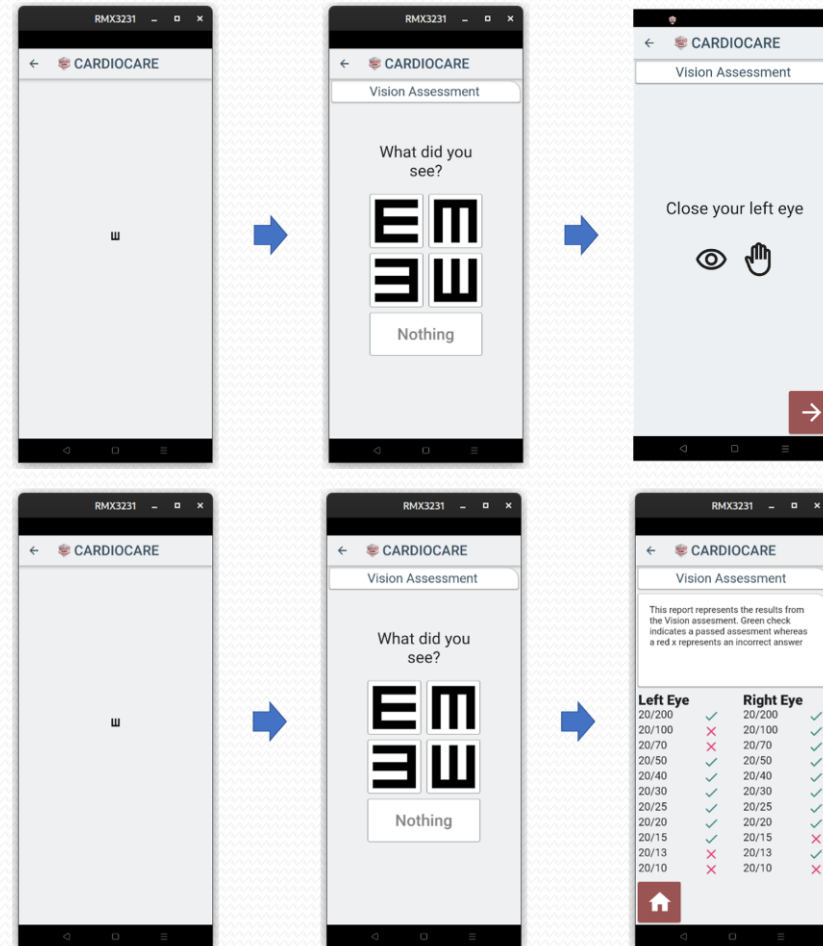
Cognitive Simulation Games

- Tic Tac Toe
- Drawing
- Color Beans
- Find the Word



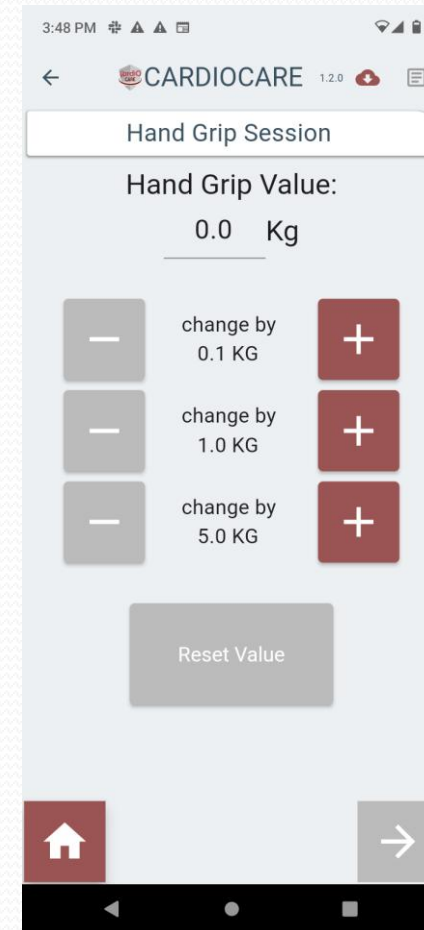
Vission Assessment

- Evaluate the patients' ability to see fine details and recognize letters.
- Simulates the equivalent ophthalmologist test in digital form



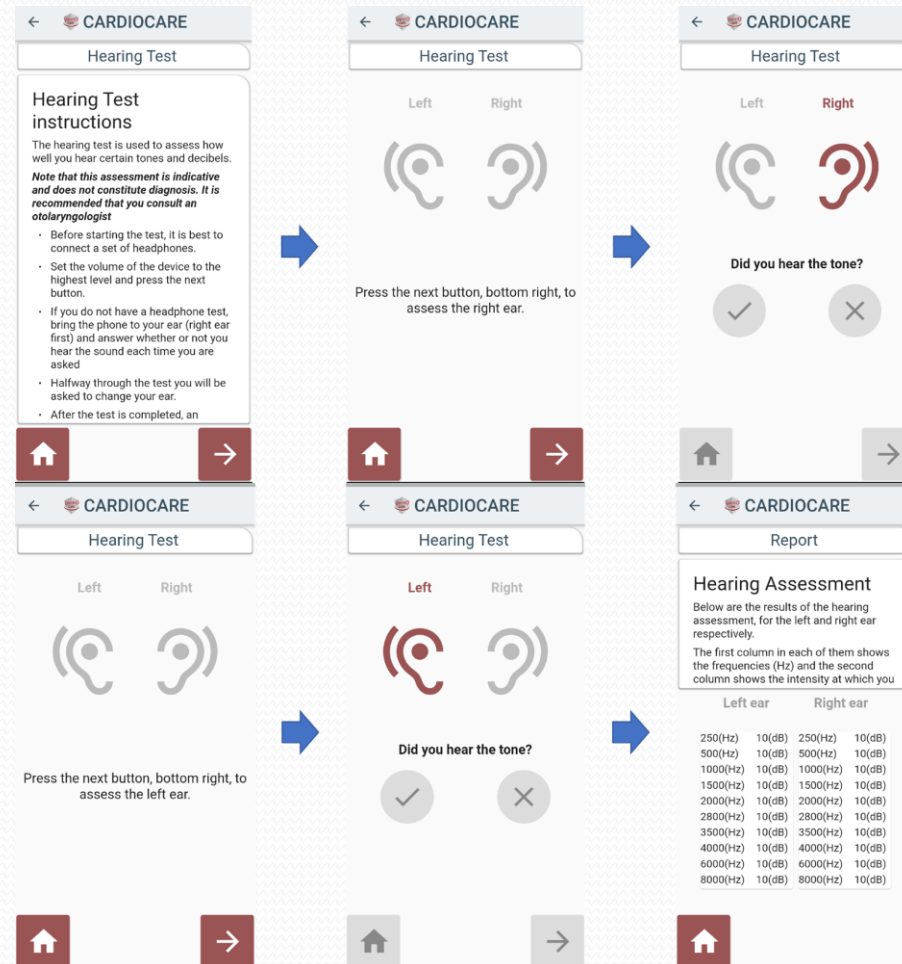
Hand Grip Session

- Overall muscle strength
- Patients record their strength by using the dynamometer (Hand Grip)



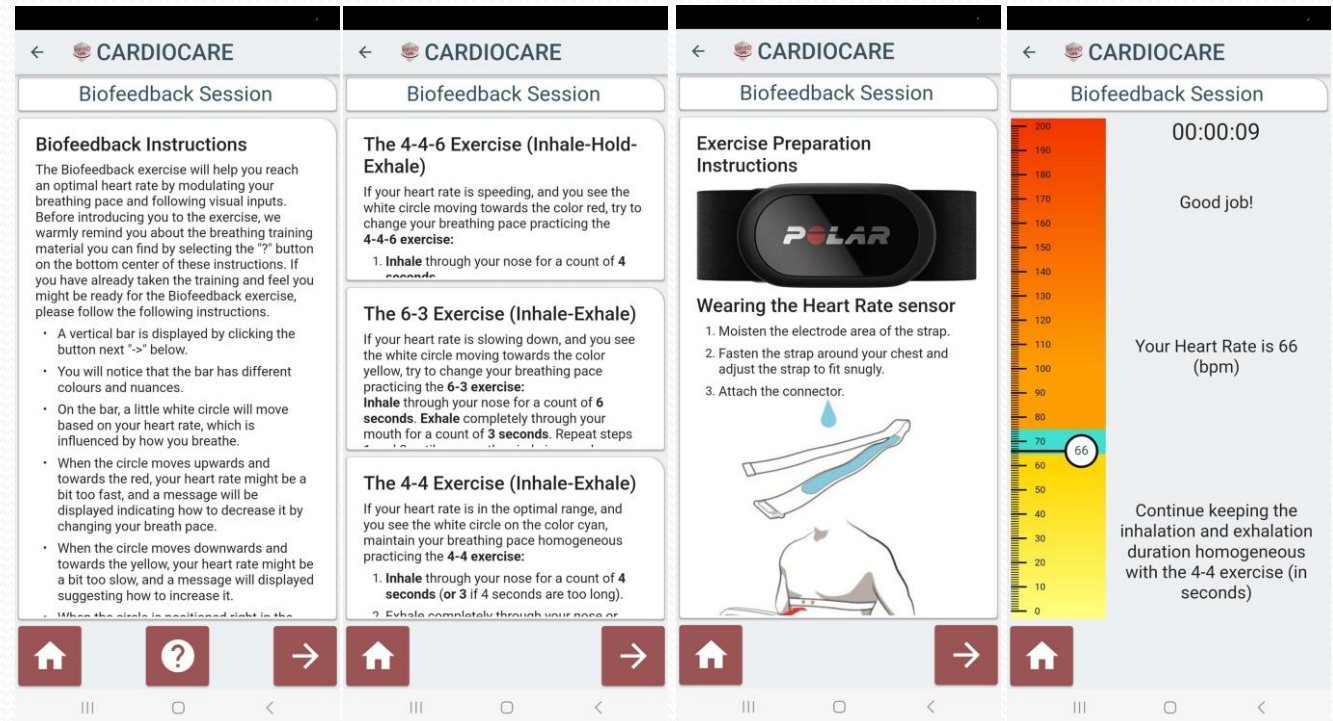
Hearing Assessment

- Evaluate the patients' ability to perceive specific tones and sound levels at various decibels.
- Presents sounds using various frequencies and volumes



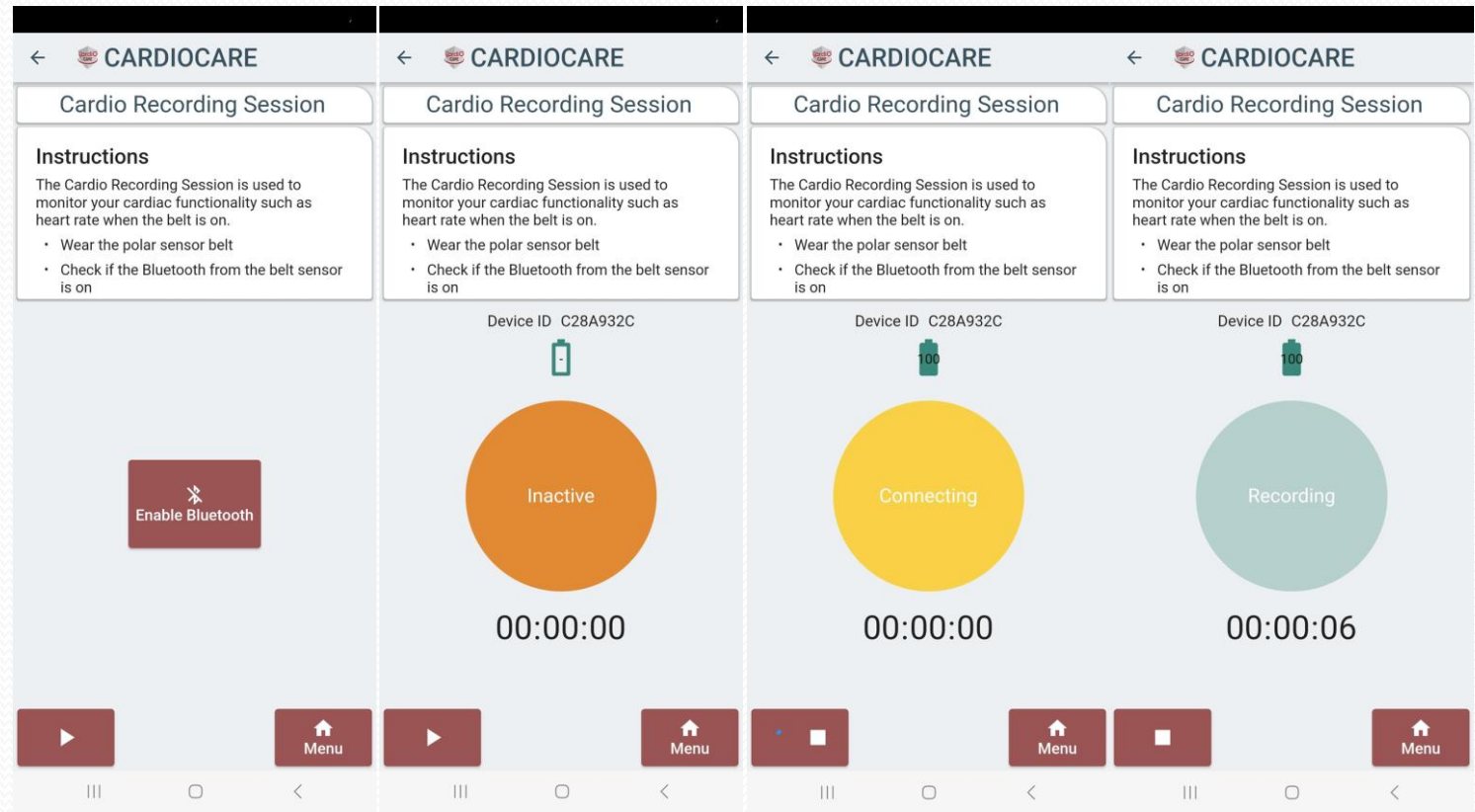
Wellbeing – Biofeedback

- Biofeedback exercises helps patient reach an optimal heart rate by modulating breathing pace



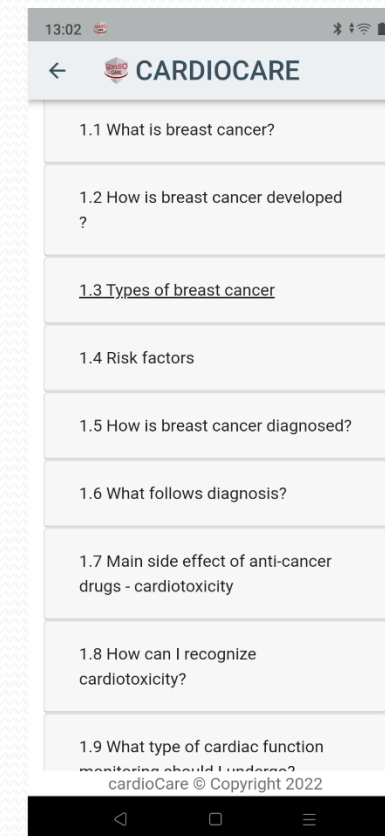
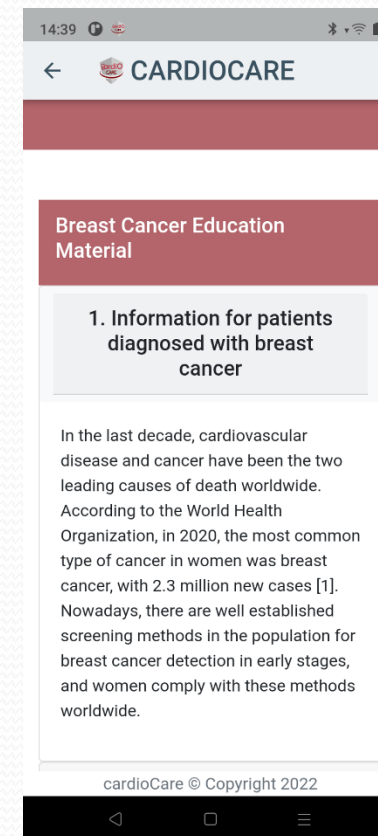
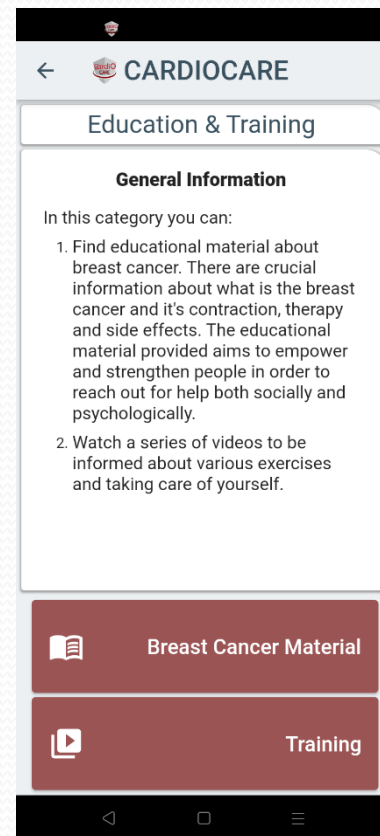
Cardio Recording Session

- Monitors your cardiac functionality such as heart rate when the Polar belt is on



Education & Training

- **Education & Training:** acts as the information hub for Breast Cancer related material in the form of articles and training videos.

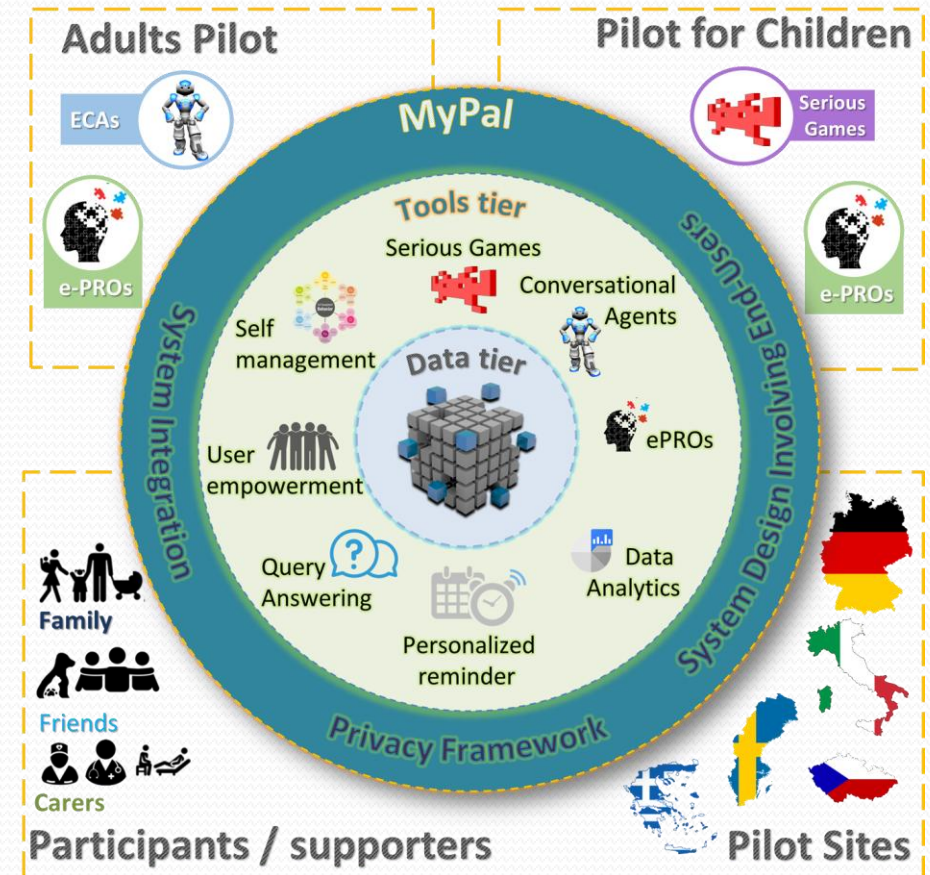


MyPal

MyPal

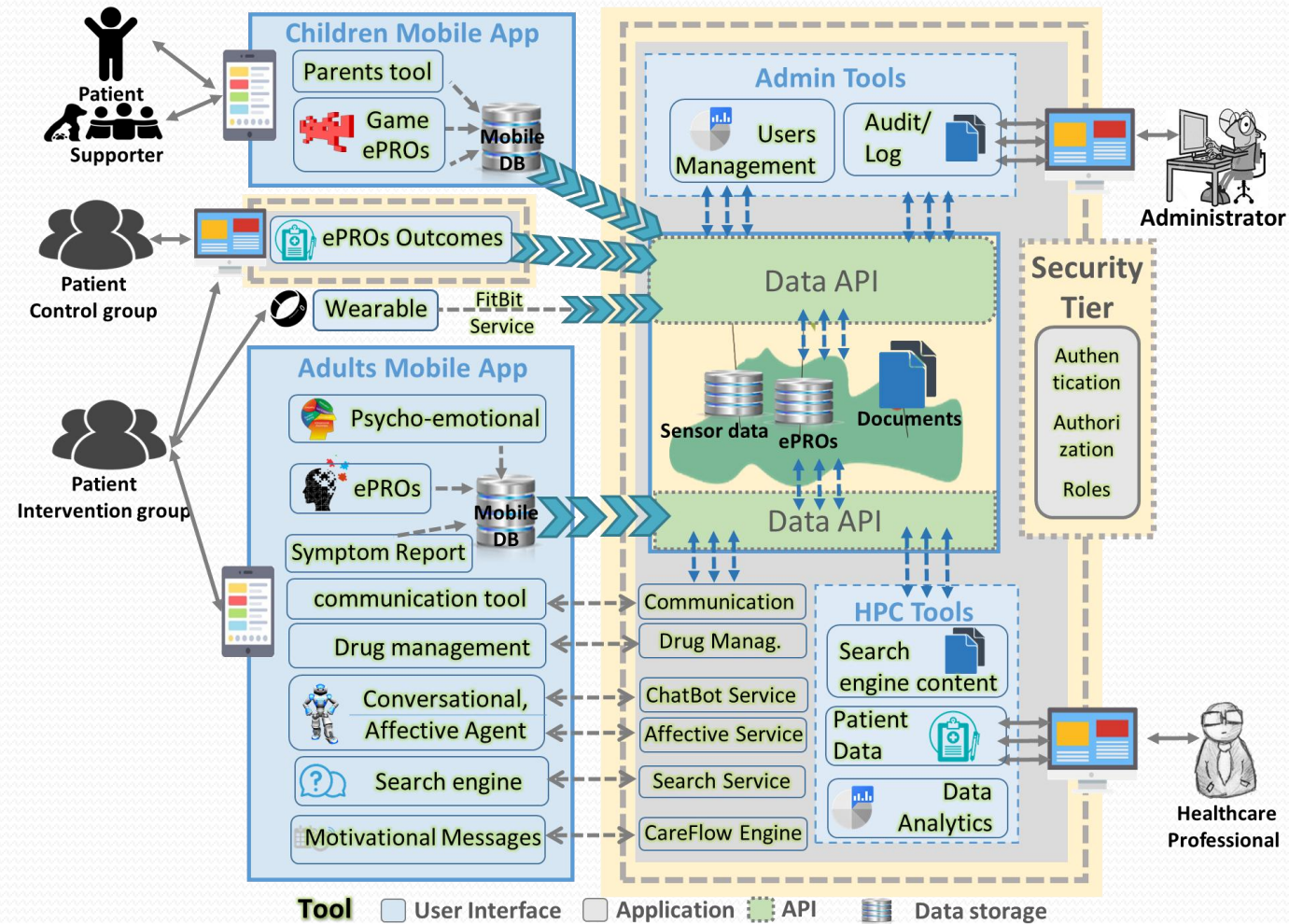


- Fostering Palliative Care of Adults and Children with Cancer through Advanced Patient Reported Outcome Systems
- MyPal aims to foster early palliative care for cancer patients by leveraging patient reported outcome (PRO)
- to empower cancer patients and their caregivers in capturing more accurately their symptoms/conditions, communicate them with a seamless and effective way to their healthcare providers

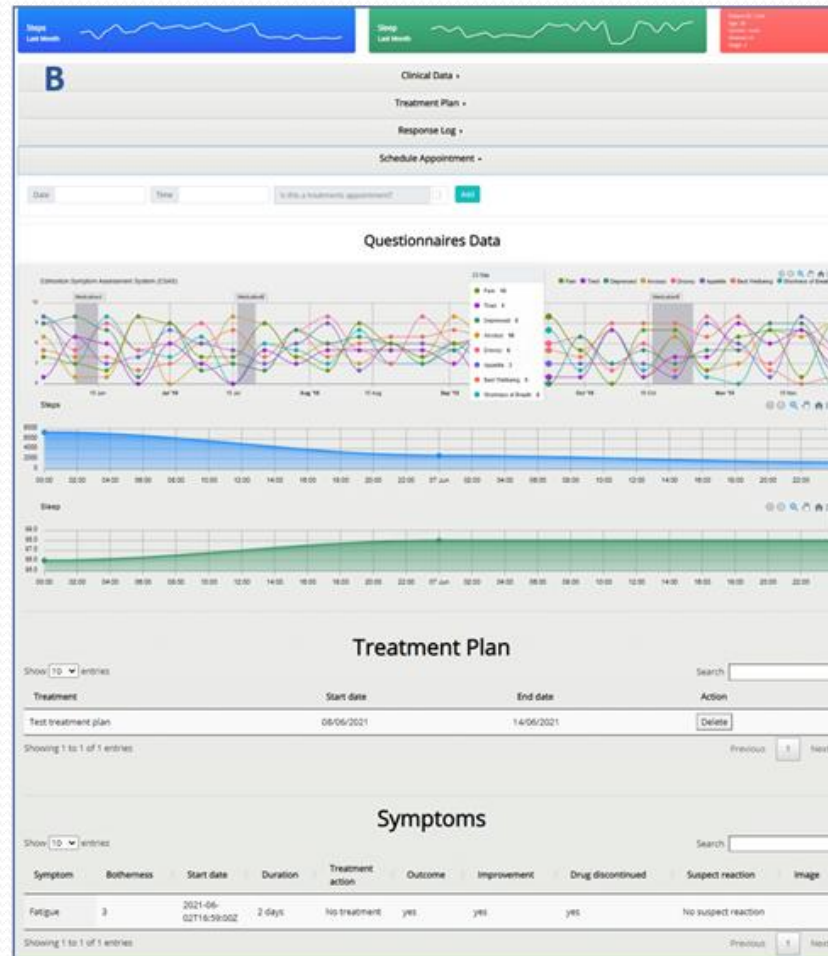
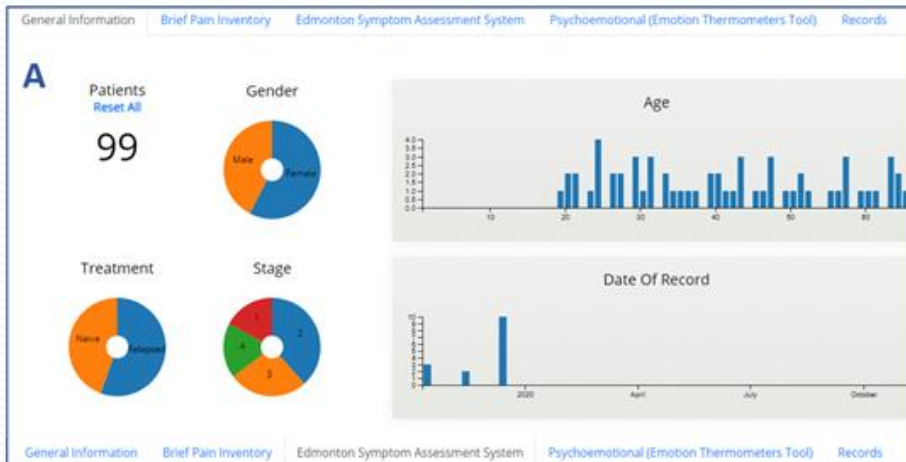




MyPal Architecture



HCP tool



C

My Notifications

In the table above you can find the latest entries made by patients (since your last login).

Show 10 entries

Patient	Week	BPI	ESAS	Emotional
demotest2	Week 2	Missed	Missed	New Entry
demotest2	Week 3	Missed	Missed	New Entry
demotest2	Week 1	New Entry	New Entry	New Entry
demotest2	Week 4	Missed	Missed	New Entry
engshdemo	Week 1	New Entry	New Entry	New Entry
engshdemo	Week 6	Missed	Missed	New Entry
engshdemo	Week 2	Missed	Missed	New Entry
engshdemo	Week 3	Missed	Missed	New Entry
engshdemo	Week 4	Missed	Missed	New Entry
engshdemo	Week 7	Missed	Missed	New Entry

Showing 1 to 10 of 36 entries

D

Patient ID: 22 | Last screen completed on: 27-05-2021 | Start new survey

Over the past [weeks/months], did you miss any doses?

Nausea / Concerns: The benefits of my medicine(s) outweigh the risks (such as side effects)

Social Support: My support network helps me cope with my illness and medicine

Confidence: I am confident I can always take my treatment for my illness as prescribed

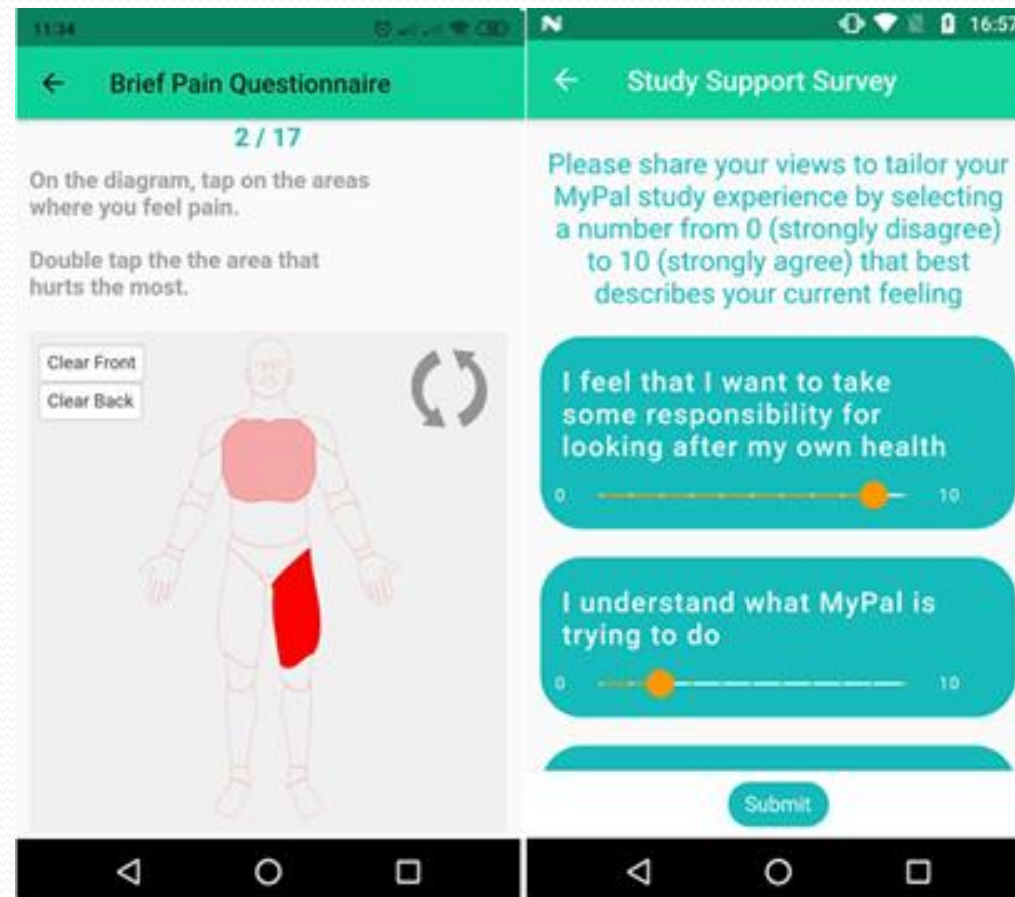
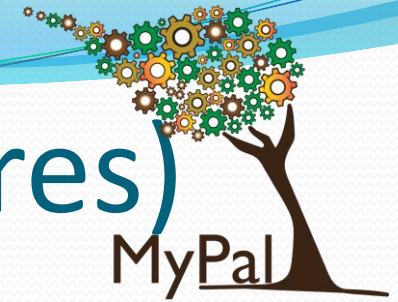
Control / Curability: How much do you think your medicine(s) can help your illness?

Illness Consequences: How much does your illness affect your day to day life overall?

Emotional Distress: How much does your illness affect you emotionally? (e.g. does it make you angry, worried, upset or depressed?)

A: The aggregated dashboard, B: The individual dashboard, C: Notifications, D: The discussion tool

Mobile app for Adults (questionnaires)





Mobile app for children



Conversational Agent



MyPal

- Collected voice recordings
- Manually transcribed voice recordings to text
- Anonymized text documents
- Translated Greek conversations to English
- Trained an English language model
- Implemented a mobile application for the conversational agent
- Implemented an API to connect the language model with the mobile application of the CA

