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PROJECT

LIFECHAMPS: A Collective Intelligence Platform to Support Cancer Champions

GRANT AGREEMENT No.

875329

DELIVERABLE

D7.1 - Pilot evaluation framework and measures specifications

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ABBREVIATIONS LIST

Abbreviation	Meaning
APQ	Aging Perceptions Questionnaire
BWoSCC	Beatson West of Scotland Cancer Centre
CGA	Comprehensive Geriatric Assessment
CMSAS	Condensed Memorial Symptom Assessment Scale
CTSQ	Cancer Therapy Satisfaction Questionnaire
CWS	Cancer Worry Scale

EAP	Extensible Authentication Protocol
EC	European Commission
ECDC	European Centre for Disease Prevention and Control
ECG	Electrocardiogram
EHR	Electronic Health Record
ELOT	Hellenic Organization for Standardization
EQ VAS	EQ visual analogue scale
EQ-5D-5L	EuroQol Group EQ-5D-5L scale
EU	European Union
DPO	Data Protection Officer
FACT-G7	Functional Assessment of Cancer Therapy – General – 7 Item Version
FCRI	Fear of Cancer Recurrence Inventory
FRAIL scale	Fatigue, Resistance, Ambulation, Illnesses, & Loss of Weight
GDPR	General Data Protection Regulation
GROC	Global Rating of Change Scale
HADS	Hospital Anxiety and Depression Scale
HR	Heart Rate
HRQoL	Health Related Quality of Life
IADL	Instrumental Activities of Daily Living
ITIL	Information Technology Infrastructure Library
ITSM	Information Technology Service Management
LASA	Linear Analog Scale Assessment
MNA®-SF	Mini Nutritional Assessment Short Form
mMOS-SS	modified Medical Outcomes Study Social Support Survey

MST	Malnutrition Screening Tool
MTBQ	Multimorbidity Treatment Burden Questionnaire
PEOU	Perceived Ease of Use
PU	Perceived Usefulness
PIS	Participant Information Sheet
PREM	Patient Reported Experience Measure
PROM	Patient Reported Outcome Measure
PSN-L	Patient Satisfaction with Navigation-Interpersonal Scale
PUC	Pilot Use Case
QALY	Quality Adjusted Life Year
QoL	Quality of Life
SEPI	Sun Exposure and Protection Index
SIS	Swedish Institute of Standards
SPPB	Short Physical Performance Battery
SSTP	Secure Socket Tunnelling Protocol
TAM	Technology Acceptance Model
TFI	Tilburg Frailty Indicator
VES-13	Vulnerable Elders Survey
VPN	Virtual Private Network
ZBI	Zarit Burden Interview

1 EXECUTIVE SUMMARY

Deliverable 7.1 provides a thorough description of the planning for the pilot methodology and evaluation of the LifeChamps solution. The planned pilot studies will provide the required data for the development of the Big Data models, assess the user acceptability of the LifeChamps solution, and examine the feasibility and cost-effectiveness of using the solution by both cancer survivors and healthcare professionals.

For the purposes of training and testing the algorithms of the solution, a preliminary data collection study will be conducted for 6 months in parallel with the development of the Big Data models. During this study, patients in UK and Greece will be asked to report PROMs and use a set of sensors (including an activity tracker and a set of ambient location sensors) . HULAFE and APC will provide retrospective data in this phase.

In another study, user acceptance of the platform will be evaluated in two phases by a limited number of participants between M19 and M24. The first phase will include a mock-up version of the envisaged LifeChamps mobile application for the patients and the dashboard for the healthcare professionals. They will be asked to provide feedback on the content provided by the mobile app and dashboard, the design features and the perceived usability. During the second phase, an initial version of the LifeChamps integrated solution will be ready and made available to limited number of patients and healthcare professionals to evaluate its acceptability both in terms of usability and content. The gathered feedback will be used to optimise the LifeChamps solution for the real-life pilots.

By M25 a stable version of the LifeChamps integrated solution will be developed. A feasibility study will be conducted under real-life environment in all four pilot study sites. Both cancer survivors and healthcare professionals will be invited to participate in the real-life study. Patients will be asked to use the LifeChamps mobile application and provide Patient Reported Outcome Measures (PROMS), Patient Reported Experience Measures (PREMS) as well as data collected by sensors. Healthcare professionals will be requested to interact with the LifeChamps dashboard to gain access to enhanced information regarding the status of their patients. The feasibility study will utilise an interrupted time-series design and will take place over a 7-month period. The data collected will be used to evaluate the feasibility and effect of LifeChamps solution to the QoL of cancer survivors as well as the cost-effectiveness of its usage.

A detailed pilot planning is included at the end of this deliverable where the exact planned conduction periods of each pilot study is presented across the duration of the project.

2 INTRODUCTION

LifeChamps is a H2020 collaborative research project involving 14 partners across 10 countries, including SMEs, clinics, research centres and universities. The LifeChamps project aims to disrupt techniques for Big Data modelling, analysis, and aggregation under a novel context-aware Data intensive and large-scale analytics framework towards delivering multidimensional Quality of Life (QOL) solutions for breast, prostate and skin cancer survivors. Using an AI-based data analytics engine, this project will address key geriatric symptoms and conditions in older adult's post cancer treatment.

To achieve this objective, LifeChamps project will integrate ground-breaking technologies in the areas of Big Data and Artificial Intelligence towards delivering a smart, personalized and secure platform that will monitor health outcomes, support and advice patients with the goal of improving their QoL. The LifeChamps solution will empower the patients by providing support and information to guide and support them in improving their QoL while at the same time will enrich the information available to the healthcare professionals supporting them on providing the best care to their patients.

The LifeChamps solution will be evaluated in four multi-national pilot use case scenarios aimed at demonstrating its applicability and feasibility. This will be achieved by performing three parallel studies: i) a preliminary data collection experiment to train the analytics engine and the development of the AI protocol. The preliminary datasets will enable the testing of the draft algorithms to check their predictive functionality as part of pilot use-case scenarios, which will make use of real patient-reported data, sensor data and clinical data; ii) a small-scale end-user study for assessing the usability and acceptability of older cancer patient mobile application and healthcare professionals' dashboard. Through this patient-centred approach, LifeChamps solution can be improved via consecutive sprints, considering the received feedback; and iii) a feasibility study under real-life environment will be conducted making use of the LifeChamps solution by cancer survivors and healthcare professionals. This study will attempt to validate the output of the Big Data models through ground truth collection of PROMs and PREMs, assess the effect of introducing the LifeChamps solution to the patients' everyday life and estimate its cost-effectiveness.

The deliverable is divided into the following parts presenting a detailed plan for conducting each study:
Chapter 3 – Training Data collection and AI development protocol
Chapter 4 – Small-scale user acceptance evaluation framework
Chapter 5 – Real-life evaluation framework
Chapter 6 – Pilot planning

3 TRAINING DATA COLLECTION & AI DEVELOPMENT PROTOCOL

3.1 METHODOLOGY CONSIDERATIONS

In Task 7.3, preliminary datasets will be generated for training purposes of the developing frailty-predicting algorithms before the algorithms are incorporated within the LifeChamps platform for subsequent testing in Task 7.4.

The preliminary datasets will enable a dry run of the draft algorithms to check their predictive functionality as part of simulated 'experimental' scenarios, which will make use of real patient-reported data, sensor data and clinical data.

The nature of this experimental exercise will allow for the use of diverse methods for data collection, either prospective or retrospective, depending on the availability of such data at the pilot sites. The combination of prospective and retrospective (archival) data will provide opportunities for the algorithms to run with data of diverse quantity and quality, cross-sectional and longitudinal.

WP7 pilot partners will be contributing data to Task 7.3 as outlined in Table 1 below.

Pilot site	Prospective			Retrospective/archival		
	PROM PREM data	**Sensor data**	**EHR / Clinical data**	**PROM PREM data**	**Sensor data**	**EHR / Clinical data**
UofG	Yes	No	No	No	No	No
AUTH	Yes	Yes	Yes	No	No	No
HULAFE	No	No	No	No	No	Yes
APC	No	No	No	Yes	No	No

TABLE 1. CONTRIBUTION OF DATA FOR PRELIMINARY ANALYSIS BY TYPE OF DATA AND PILOT PARTNER

3.2 DATASETS DESCRIPTION

3.2.1 RETROSPECTIVE LONGITUDINAL E-PROMS/E-PREMS (APC)

The APC team will, through its collaboration with another research group in Region Stockholm and Karolinska Institutet, provide retrospective PROM/PREM and symptom scoring data for breast cancer patients that have received neo-adjuvant chemotherapy treatment and prostate cancer patients receiving curative radiotherapy. These patients have used a mobile application to score their symptom burden during a predefined period of 2-3 months as well as the EORTC QLQ-30 questionnaires before and after the intervention period (with the mobile application).

Inclusion criteria for these patient cohort were: patients with breast cancer receiving neo adjuvant chemotherapy, men or women, 18 years or older and patients diagnosed with prostate cancer, scheduled to receive curative radiotherapy for at least five weeks. Primary outcomes of the research study were: Outcomes concerning HRQoL, symptom

distress, perception of individual care, sense of coherence and health literacy – collected through validated questionnaires.

3.2.2 PROSPECTIVE E-PROMS/E-PREMS AND SENSOR DATA (AUTH)

AUTH will recruit older adults who have been diagnosed with breast or prostate cancer and have completed their initial treatment. Furthermore, inclusion and exclusion criteria as defined in Table 7 will be applied. Eligible participants will be recruited given the pool of cancer survivors that participated within Task 2.2 activities and if the enrolment is not sufficient, AUTH will address its cooperating cancer patient organisations. Participants deemed eligible after the screening process will be informed about the study and upon consent, they will be asked to provide sensor data via a wristband and/or ambient home sensors and complete a set of PROMs on a monthly basis.

An ethics application will be submitted to the Research Ethics and Deontology Committee of AUTH.

3.2.3 RETROSPECTIVE EHR DATA (HULAFE)

HULAFE will contribute retrospective Electronic Health Records (EHR) data for model development and synthetic data to test the data flow of the platform (data ingestion, data transfer and data storage).

Currently, data lake from HULAFE has up to 20 million records coming from several information systems involving clinical activity and assists areas such as emergency care settings, outpatient, hospitalization, clinical reports, surgical unit, intensive care unit and hospital at home unit. Also, information regarding imaging activity, laboratory tests, clinical trials activity, use of resources and economic management is available. Above this layer, a system was built to exploit structured and semi-structured information (Figure 1). HULAFE data warehouse consists of a total of 27 datamarts including a total of 761 tables occupying 787,282 megabytes. Data mart structure is hierarchical, so that datamarts containing demographic and morbidity data of patients according to different classifiers implemented, centralize this information to avoid any discrepancies between basic patient information that can be displayed in different studies and projects. Moreover, the Department has an additional source of information containing 6 million of unstructured data collected during the last 6 years reflecting a data storing rate of 1 million records per year.

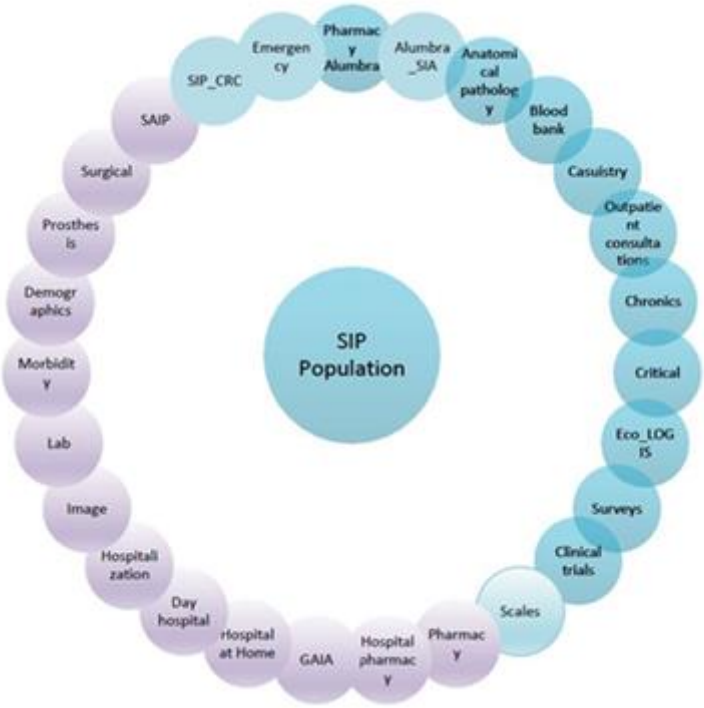

FIGURE 1. HULAFE DATA LAKE

3.2.4 PROSPECTIVE E-PROMS/E-PREMS (UOFG)

A prospective, observational, repeated-measures study design will be employed.

Study participants will be older members of the public with a diagnosis of breast or prostate cancer. Eligibility criteria will be as follows: members of the public, men and women based in the UK, aged ≥50, diagnosed with breast or prostate cancer, and living beyond cancer treatment. Eligible members of the public will also be required to speak, write and communicate in English, and have access to telephone and/or email and/or an internet-enabled electronic device (i.e computer, laptop, tablet or smartphone).

Members of the public that were previously involved in Task 2.2 of WP2 will be recruited. From this existing pool of participants, up to 10 people will be invited to participate.

Upon written consent, participants will be asked to complete a set of PROMs on consecutive timepoints and at monthly intervals. The PROMs and data collection timepoints will match those selected for use in the pilot (PUC4).

An ethics application will be submitted to the MVLS Ethics Committee at UofG, directly linked to the previous ethics application from Task 2.2.

3.3 DATA COLLECTION/EXTRACTION PROCESSES

All research activities will take place in accordance to the World Medical Association Declaration of Helsinki, 9th revision (2013). The partners will sign the required contracts

with regard to data transfer, sharing and processing will in accordance with Regulation (EU) 2016/679 GDPR.

3.3.1 RETROSPECTIVE LONGITUDINAL E-PROMS/E-PREMS (APC)

Retrospective data have been collected in a previous completed research study, conducted by the research group of Ann Langius-Eklöf at Karolinska Institutet (KI) and data collection was made within Region Stockholm. Pseudonymised datasets including data from HRQoL questionnaires and symptom burden are kept securely on password protected servers at KI. The sample size is approximately 130-140 patients randomised in two groups: mobile intervention group and standard care group. The data have been collected over 30 weeks at three time points: at baseline, end of treatment and three months after the end of treatment.

3.3.2 PROSPECTIVE E-PROMS/E-PREMS AND SENSOR DATA (AUTH)

Demographics and clinical data will be collected from the participants, if not already available. Research data (e-PROMS) will be electronically collected, using an established online survey tool (EUSurvey - Welcome (europa.eu)) and through web APIs provided by the sensor providers. Research data will include the core PROMs which will be collected during the real-life pilots by all four pilot sites, namely EQ-5D-5L, FACT-G7 and TFI. All data will be constantly pseudonymised during the collection process and will be anonymised as soon as possible to be ready for transfer.

3.3.3 RETROSPECTIVE EHR DATA (HULAFE)

La Fe Health Department has developed a Real-World Data analysis platform led based on SAS® Software Analytics infrastructure allowing the addition of capacities (streaming data, imaging, genomics data, etc) keeping all data in a relational model easy to be connected. The data feeding the platform is composed by the aggregation of 25 datamarts and comprises 250 millions of rows, 65 tables, 2.530 columns resulting in a total size of 640Gb. Data updates are scheduled on a daily, weekly, or monthly basis, depending on the datamart.

The data contemplated in this task will be collected retrospectively in the Electronic Health Record and the corresponding information modules on the use of resources of the Department of Health. HULAFE will use the SAS® Enterprise Guide tool to prepare and extract all the data. This tool has a graphical interface to integrate and explore different variables or different groups of these variables directly through all the information systems available in the Valencia La Fe Health Department. At the same time, this software allows us to generate different workflows that can be managed simultaneously, to extract all the information necessary to create data extraction databases.

3.3.4 PROSPECTIVE E-PROMS/E-PREMS (UOFG)

Upon written consent, participants will be requested to complete a set of PROMs at seven consecutive timepoints, equally spaced at monthly intervals. The PROMs will be selected to measure the PRO variables targeted as part of PUC4 and the subsequent pilot.

This longitudinal dataset will provide sufficient data for initial training of the draft algorithms. Participants' demographic and clinical variables will be linked to the dataset from Task 2.2 via the participants' study ID. No new demographic or clinical data will be collected.

Research data will be electronically collected, using an established online survey tool (https://www.onlinesurveys.ac.uk/) according to UofG policy. Research data will be downloaded in the form of Excel files. These files will be password-protected, and they will be stored on secure password-protected UofG servers. At this stage, the research data will be pseudonymised to enable matching research data to the participant's corresponding demographic/clinical variables (already collected as part of Task 2.2). Once demographic/clinical variables have been entered, study IDs will be deleted from the Excel file, which will de-identify and fully anonymise the data, ready for transfer.

3.4 DATA TRANSFER

All extracted/collected data will be transferred from 'data-releasing' partners to 'data-receiving' partners for analysis purposes. Individual data transfer processes will be enabled via tripartite or quadripartite data transfer/processing agreements (as applicable) between the data-releasing pilot partner (i.e. APC, AUTH, HULAFE, UofG) and the three data-receiving project partners (i.e. AUTH, ALTRAN, UPV). These agreements will be in place before any data transfer occurs. The agreement process will be initiated separately by each data-releasing pilot partner and be in line with regulations at each pilot site.

Fully anonymised data will be transferred in all cases. All files containing data will be password-protected and stored securely at each pilot site according to local institutional policy. Data transfer will be enabled via secure transfer systems at each pilot partner, in line with GDPR regulations.

Data releasing partners are as follows.

APC

In collaboration with KIs Compliance & Data Office a quadripartite data transfer/processing agreement between the data controller (KI) and the data-receiving/data processing project partners (i.e. ALTRAN, AUTH, UPV) will be arranged. Pseudonymised data will be securely transferred to data-receiving/processing partners, which will store and handle the data according to the agreement.

AUTH

In collaboration with AUTH DPO a processing and transfer agreement between the partners (i.e. ALTRAN, AUTH, UPV) will be signed. Pseudonymised data will be securely transferred to data-receiving/processing partners, which will store and handle the data according to the agreement.

HULAFE

Once the type of relationship between the partners (HULAFE, AUTH, ALTRAN and UPV) has been established for the transfer of data, the corresponding contract will be signed where each of the parties is responsible.

The data used in the project will have been pseudonymised from origin and data will be securely transferred with authorization by virtual private encrypted network (SSTP, EAP or similar) to the above-mentioned partners, which will store and handle the data according to the agreement. Each partner will establish the appropriate technical and organisational security measures to prevent unauthorised access, loss, theft or modification of the information processed, thus protecting the confidentiality, integrity, availability and resilience of the systems and of the information being processed.

UOFG

the process for a quadripartite data transfer/processing agreement between UofG and the data-receiving project partners (i.e. ALTRAN, AUTH, UPV) in collaboration with UofG Legal and in line with UofG policy. The secure UofG Transfer system to transfer password-protected Excel files of fully anonymised research data to the data-receiving project partners will be used.

Data-receiving project partners will securely store all password-protected files according to local policy outlined below. Only members of the local research team will have access to this data.

ALTRAN

Physical servers are kept on a restricted access room with biometric control. Only Altran administration authorized users, with granted biometric access are allowed to access this room.

The logical access will be granted to a subset of the team (the ones directly involved on the models' creation) dedicated to the LifeChamps project, through a virtual machine. Such accesses are controlled by AD permissions and require Altran's VPN usage.

Strict policies and rules regarding identification, request, authorization, and authorization controls are in place, using Information Technology Infrastructure Library (ITIL) best practices via Information Technology Service Management (ITSM) tool.

Project Manager requests via authenticated ITSM tool, appropriate access rights to the consultants, requests are then validated by customer service and implemented by sys admin.

All risks are mitigated using the industry best practices. Altran is ISO27001 certified and following strict policies regarding security and observing also GDPR. Annual audits are carried out, PenTest and vulnerabilities are part of the on-going activities. Risk assessment and reports and treatment plans are included in annual objectives.

AUTH

The data will be received and deposited safely in accordance with the data transfer and processing agreement's security provisions signed with the partners. The server on which the data will be deposited and processed is in the Lab of Medical Physics, School of Medicine, building 8, 3rd floor, AUTH, Greece. The access to the server is protected both physically and logically. The logical access will be granted to a subset of the team (the ones directly involved on the models' creation) working on the LifeChamps project, through a virtual machine.

The Lab of Medical Physics server implements hardware and software measures that insure data accessibility and integrity. No copy or back-up of the data will be required or permitted.

UPV

The data will be deposited in an institutional team, with physical and logical access control, with the following measures. The servers linked to the provision of services are located at the Universitat Politècnica de València, 8G building, B access, first floor, servers room number 1.037.

Restriction of access to the room, only allowed to authorized personnel with a card in an electronic lock.

Access to the server is restricted to UPV users specifically belonging to the research group linked to the LifeChamps project. Specifically, the server will have a virtual machine that can only be accessed by users who participate in the project and have a real need to access the data.

Access policies and access control lists are implemented by IP (Internet Protocol) limitation, restricted by VPN (Virtual Private Network), and active directory user.

The person in charge of the project requests in writing to the administrator of the research group the inclusion of a new researcher in the project data repository.

The server has several hard drives that manage the availability of data and its integrity, it is not necessary to make backup copies as such.

3.5 DATA MANAGEMENT

Upon the pre-processing stage, 'data-receiving' partners will scan and monitor the available multi-modal data for possible inconsistencies. These inconsistencies are relevant to incorrectly formatted, duplicate or incomplete data. In the former two cases changes will be made to correct the format based on the harmonised standards across all datasets and duplicates will be removed. On the occasion of missing data, there will be an initial computational assessment whether the missing values are Missing completely at random (MCAR), Missing at random (MAR), Missing not at random (MNAR)(1). Depending on this assessment, we will exploit different multiple imputations methods (e.g., full information direct maximum likelihood), do sensitivity analyses and/or apply modelling approaches (e.g., Random Tree Forests) that can handle properly missing data.

3.6 DATA ANALYSIS

During an exercise that took place in WP4, several clinical questions have been identified and filtered for each pilot site. These questions were relevant to each pilot's site focus.

- AUTH: Understanding and predicting Treatment Tolerance,
- APC: Multiple assessment of psychological and lifestyle factors,
- HULAFE: Reduce mental burden and improve QOL for patients,
- UofG: Predict the effects of the interaction between late/persisting treatment-related symptoms and multimorbidity/polypharmacy.

The exercise entailed a framework for the data sources (e.g, EHR, sensors, PROMs), the predictor variables (e.g., weight, sleep duration) and the output (e.g., classify patients as at high, moderate or low risk for frailty) that all the different analytical models in LifeChamps will need. Throughout the data analysis pipeline, 'data-receiving' partners will carry out several pre-processing steps to materialise these complex multi-modal analytical models.

For example, the initial data from sensors will be refined, further, with statistical, spectral and supervised learning analyses to identify and extract possible patterns (e.g., activities of daily living) inside their signals. Sensor, EHR and PROM data will be all analysed together through exploratory algorithms (e.g., pairwise markov random fields, bayesian networks)(2) to identify possible interactions and dependencies among their trajectories, mapping the frailty and QOL domains of elderly prostate, breast and melanoma cancer patients across all the data collection process. Extracted features from sensors data, that can be considered as proxies/digital biomarkers for clinically relevant variables (i.e., patterns from a patient's movement, combining data from a smartwatch and room motion sensors, could be an indicator of the anxiety levels or the fatigue of this person), will be validated in comparison to the related data from PROMs. All the data that will be collected, either in their original modality or through feature extraction, will be assessed for their importance during training and tuning the hyper parameters of the final models for the clinical needs of each pilot site.

Some of these analyses (e.g., pre-processing analyses, final analytical models) will provide input for data driven recommendation to the patient's mobile app, creating a digital frailty index, making timely risk analysis and patient stratification on the clinicians' dashboard. The patients' progress and evolution will be analysed qualitatively and quantitatively using Process Mining techniques, and the clinicians will be able to monitor their patterns as well as their possible anomalies, as a possible sign of a patient's QoL deterioration.

Additionally, the collected retrospective and prospective data obtained during the preliminary data collection in all four sites will be statistically analysed to provide insights about the research questions prioritised by the research partners and the scopes of the feasibility study under T7.4. Initially, descriptive statistics and plots will be performed to identify the characteristics of the data such as outliers, trends, seasonality and general measures of tendency and variability. Also, the analysis will include traditional comparisons between pre and post measurements such as repeated measures ANOVA or logistic regression, where applicable.

3.7 TIMELINES

An indicative time plan of activities is shown below in Figure 2.

	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Start of task 7.3	○																			
Preparation for data generation																				
Dataset extraction or collection																				
Data transfer/processing agreements																				
Data transfer & management																				
Dataset analysis																				

FIGURE 2. TIMELINE OF PRELIMINARY DATA COLLECTION

4 SMALL-SCALE USER ACCEPTANCE EVALUATION FRAMEWORK

This chapter aims to present a comprehensive framework for assessing the usability and acceptability of end-user application and dashboard. From consortium partners' perspectives, such evaluation aims to acquire feedback from end-users during the solution-testing phase. Through this approach, the partners can improve the LifeChamps solution via consecutive sprints, taking into account the received feedback.

4.1 EVALUATION METHODOLOGY

The performance of the LifeChamps solution will be evaluated in in-lab conditions by the end-users. The evaluation plan will focus on the specification of an integrated evaluation framework reaching the intention to use, the quality of the end-user mobile application and dashboard, and the overall impact on the QoL of end-users by setting measurable evaluation criteria and creating an evaluation procedure. The evaluation is also going to include the evaluation of the standard ''Patient involvement standard''. For the purpose of defining how to evaluate the standard a literature review was conducted and a critical analysis of instruments was identified as well as an extensive report including instruments of measuring and evaluating person centred care(3,4). These instruments are going to be used in order to evaluate the patient involvement standard in terms of enabling person centred care and the results are going to be communicated to the Swedish Institute of Standards (SIS) and ELOT (Hellenic Organization for Standardization).

The general goal for usability tests is to identify which interface facilitates the user's ability and motivation to navigate in the application or dashboard. The design, information flow, and architecture will also be analysed based on the collection of both objective and subjective measures.

A popular model for evaluating user satisfaction and user acceptance is the Technology Acceptance Model (TAM) (5). TAM (Figure 3) was developed to explain two critical factors influencing user decisions in accepting technology: perceived usefulness (PU) and perceived ease of use (PEOU). PU is the degree to which the potential user believes that the technology will enhance his/her performance on a given task, and PEOU refers to the degree to which the potential user expects the target system to be easy to use. Besides that, a user's belief about a system can be influenced by other factors referred to as external variables in Figure 3.

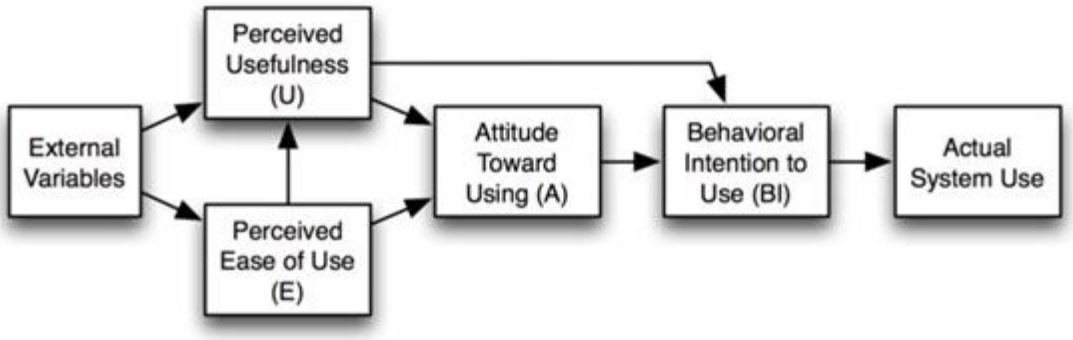

FIGURE 3. TECHNOLOGY ACCEPTANCE MODEL (TAM)

More recently, a Senior Technology Acceptance Model (STAM) was proposed as an extension of the previous TAM by adding age-related variables, health, and ability characteristics (6). Furthermore, personal characteristics (i.e., health deficiencies, gerontechnology self-efficacy, and anxiety) and environmental facilitating support (i.e., assistance and guidance) have been shown to add more value for predicting gerontechnology usage (6).

Besides TAM and STAM models, the usability test is also used to assess the ease of use of end-user interfaces. For instance, Lin suggests that by combining multiple usability measurement methods (e.g., qualitative and quantitative data) achieve more diversified results one can better summarize the relations between user perceptions of technology acceptance and usability testing attributes (such as effectiveness, efficiency, learnability, and memorability) (7).

Following the three pieces of evidence described above (5–7), we will develop an evaluation methodology for the LifeChamps app and dashboard that guides usability testers and helps them to obtain useful data and to produce high-quality usability information. In the next section, we present quantitative and qualitative usability attributes to be measured.

In addition, APC and AUTH is going to use and evaluate the ''Patient involvement standard'' SS-EN 17398:2020 which connects to the LifeChamps Task 8.3: Contribution to standards. For the purpose of defining the methodology to be followed to evaluate the standard a literature review was conducted and identified validated instruments to measure person-centred care. Questionnaires are going to be distributed to both healthcare professionals and patients to evaluate the standards.

4.2 ATTRIBUTES/VARIABLES SELECTION PROCESS

The four main quantitative attributes (efficiency, effectiveness, learnability, memorability) that should be used to measure the usability degree of each user are described in Table 2.

Attribute	Description	Type of measure

Efficiency	The degree of how fast users can accomplish a task	Task completion time (s) for an experienced user
Effectiveness	The accuracy and completeness with which users achieve specified goals	Task completion ratio (%) for an experienced user
Learnability	The degree to which users can easily finish a task when using an application for the first time	Task completion time (s) and task completion ratio (%) for the first time
Memorability	The level of ease with which users can recall how to use an application after not using it for some time	The time duration (s) to work successfully after avoid using an app for some days

TABLE 2. ATTRIBUTES/VARIABLES FOR EVALUATION

PU in TAM is connected with the efficiency and effectiveness of usability attributes, and PEU can be relevantly explicated by learnability and memorability (7). Table 3 provides the list of measures of TAM and corresponding usability attributes.

Attribute	Description	Usability attributes
Perceived Usefulness	The degree to which the potential user believes that the technology will enhance his/her performance on a given task	• Effectiveness • Efficiency
Perceived Ease of Use	The degree to which the potential user expects the target system to be easy to use	• Learnability • Memorability

TABLE 3. RELATIONSHIP BETWEEN USABILITY AND TAM

4.3 PROCEDURE

The evaluation process will consider the specificities of LifeChamps end-users (older cancer survivors and clinical staff). In this way, the project consortium will inform the purpose of the usability tests and asked to sign a consent form for their participation. Then, the end-users receive a brief instruction on the experiments that will be conducted. Instructions, consent forms, and tasks will be clear and quickly understandable to all participants.

The usability tests will be divided into two stages. First, participants will perform tasks without any instruction about usability until complete in order to evaluate the learnability and effectiveness of the application and dashboards. Then, participants will receive instructions about usability, and they practice all tasks intending to assess efficiency.

A later discussion will be carried out to practice and co-design with end-users. This activity is meant to critique the existing design and consider the several perspectives and needs of users. The end-users will be divided into Miro teams(8), depending on the number of participants (5 or more would work in groups; too many in the same group, some don't participate). Every comment will then be collaboratively placed using the Miro tool into different categories. For example:

- to be assessed in the app: onboarding, home screen, profile/settings, mental wellbeing, education, motivational messages, records;
- for the clinical dashboards, the sections/screens are: list of patients, patient-general overview, patient-specific record, medical log.

At the end of the test, each participant fills out a TAM questionnaire and has a brief interview with an observer to clarify the intention of each marked scenario.

The questionnaires will be developed to measure the different variables or attributes described in Section 4.2. Each variable will be measured through several questions with a Likert-type scale. Indicative questions to be included in the LifeChamps user acceptance evaluation questionnaires are presented in Table 4. Questionnaires will also include fields for collecting general information of end-users such as age, geographical situation, education, gender, health status, and others. The questionnaires will be composed of:

- Questions measuring "perceived ease of use";
- Questions measuring "perceived usefulness";
- Questions measuring "subjective norms";

Users will qualify each statement on questionnaires based on a 7-point differential rating scale recommended by the literature, from -3 (totally disagree) to 3 (totally agree).

	-3 Totally disagree	-2 Disagree	-1 Slightly disagree	0 Neither agree or disagree	1 Slightly agree	2 Agree	3 Totally agree
Q1. The LifeChamps App may be useful to understand my own health:							
Q2. The LifeChamps App is easy to use:							
Q3. I would recommend the LifeChamps App to others:							
Q4. I do not have concerns about the security of information:							
Q5. I can use the LifeChamps App without anybody's direction:							

Q6. I would use the LifeChamps App if I received appropriate training:							

TABLE 4. EXAMPLE QUESTIONS OF THE LIFECHAMPS USER ACCEPTANCE QUESTIONNAIRES

4.4 DATA ANALYSIS

The collected raw data obtained for this study will be analysed, interpreted, and discussed. We are planning to use descriptive statistics applied to the quantitative data. It involves presenting, summarizing, and organizing the data to a clear and understandable form of the expected result. In specific, we are going to implement three major types of descriptive statistics measures:

- Measures of frequency;
- Measures of central tendency;
- Measures of dispersion or variation.

4.5 TIMELINE

The methodology for the usability tests and user acceptance evaluation will be implemented through two different phases, described in the timeline (Table 5) suggestion below:

1. Preparation of usability tests – Phase I
2. Workshop for usability tests – Phase I
3. Data analysis - Phase I
4. Preparation of usability tests – Phase II
5. Workshop for usability tests – Phase II
6. Data analysis - Phase II
7. Analysis of the user acceptance (D7.5)

	M18	M19	M20	M21	M22	M23	M24	…	M33	M34
Task 1										
Task 2										
Task 3										
Task 4										
Task 5										
Task 6										
Task 7										

TABLE 5. TIMELINE OF USER ACCEPTANCE EVALUATION

4.6 LIMITATIONS

Before the implementation, we need to point out some risks and limitations incurred by the chosen methodology. The lack of internal resources, the limited number of participants, and the limited time for interventions should be considered severe risks. Thus, active communication campaigns and motivational activities will have to be foreseen to limit non-answers and dropouts. The project consortium should therefore give particular attention to the potential adaptations of the methodology.

5 REAL-LIFE EVALUATION FRAMEWORK

This chapter aims to present a comprehensive framework for validating the LifeChamps solution outputs via the collection of data from the mobile application, clinical evaluation and sensors. The pilots will utilise a time-series study design to maximise the data collected while controlling for confounding variables. Through this approach, the partners can finalise the LifeChamps solution with reliable input via almost continuous data collection, PROMS, PREMS and anchors serving as ground truth.

5.1 METHODOLOGY CONSIDERATIONS

The LifeChamps real-life pilot incorporates an artificial intelligence and behavioural science-based health recommender system to provide personalized recommendations to adhere to healthier lifestyle habits, coach in nutrition and physical activity, and guide regarding social inclusion among other elements to increase quality of life. The feasibility study will be conducted to assess the solution and verify its outputs. The planning includes the Real-Life pilot which will use the intermediate stable version of the platform.

A time series study design will be used for the real-life pilot study to allow for extended data collection before and after the period during which an intervention is introduced, as in the general diagram below.

O1 O2 O3 O4... X O5 O6 O7 O8...

The extended data collection strengthens researchers' ability to attribute change in outcomes from before (data collection time-points O1-O4) to after (data collection points O5-O8) an intervention (X) is introduced.

A time series design is ideal for feasibility trials before a pilot trial is conducted. It is the strongest quasi-experimental approach for evaluating longitudinal effects of interventions(9–11). It visually displays the dynamics of response to an intervention by showing whether an effect is immediate or delayed, abrupt or gradual and whether or not an effect persists or is temporary. This design allows the minimisation of the effect of confounding factors due to between-subjects differences, such as age, gender, and level of education by having all participants serve as self-controls.

The real–life pilot will take place on M26 over a 7-month period, divided in three stages. The recruitment will take place over two months. The first stage will have a duration of 2 months, where only the endpoints of the study will be collected by the participants on a monthly basis, totalling three time points. During the second stage of the study the participants will install sensors in their home to monitor daily activities and a smartwatch to monitor basic vitals and physical activity for a period of 3 months. Additionally, they will be asked to fill questionnaires (PROMs/PREMs) related to their physical and psychological status via the mobile app of the LifeChamps solution. The sensors and the questionnaires are described below. Healthcare professionals that will participate in the pilots will be introduced in the study at this point and will have access to the LifeChamps dashboard. The healthcare professionals that will participate can either be the attending doctor of the participating patients or not. The third stage of the study will be identical to the first, where only the endpoints will be collected.

<table>
<tr><th>Before</th><th>During</th><th>After</th></tr>
<tr><td rowspan="3">T1 T2 T3
(endpoint PROMs/PREMs)</td><td>X1X2X3X4
(monthly assessment PROMs)</td><td rowspan="3">T4 T5 T6
(endpoint PROMs/PREMs)</td></tr>
<tr><td>X1 X2 X3 X4....X87 X88 X89 X90
(daily sensor data)</td></tr>
<tr><td>X1X2X3X4
(monthly EHR data extraction)
(monthly clinical team review)</td></tr>
<tr><td>Duration: 2 months</td><td>Duration: 3 months</td><td>Duration: 2 months</td></tr>
</table>

TABLE 6. INTERRUPTED TIME SERIES STUDY DESIGN

In line with current recommendations for sample sizes feasibility/pilot studies(12) it is planned to recruit a total of up to 200 patients and 40 healthcare professionals across all pilot sites. Each pilot site will recruit up to 10 healthcare professionals, AUTH and APC will recruit up to 40 patients each, while HULAFE and UofG will recruit up to 60 patients each. In addition, HULAFE will also recruit up to 60 patients to serve as a control group.

Feasibility study research questions

1. Is patient recruitment possible in terms of numbers and rates within the recruitment period?
2. Is participant retention in the study possible in terms of numbers and rates?
3. What are the quality and utility of the Patient Reported Outcome Measures (PROMs), sensor data, and electronic health record (EHR) data?
4. Is data integration within the trial digital platform possible?
5. Can predictive modelling data be generated?
6. Can predictive modelling data be (reliably) provided to clinicians via the dashboard app?
7. What are the views/experiences of study participants (patients and clinicians) using the trial digital platform?

Clinical research questions

1. Is there any signal of response in the scores of end-point PROMs and/or Patient Reported Experience Measures (PREMs) from before to after using the LifeChamps solution?
2. Is there any signal of economic impact from the use of the LifeChamps solution?

5.2 PARTICIPANT SELECTION PROCESSES

Inclusion and Exclusion criteria to be used across all partners follow.

Inclusion Criteria	AUTH	APC	HULAFE	UofG
Cancer type	Breast or prostate cancer	Melanoma	Breast or prostate cancer	Breast or prostate cancer
Stage of cancer and diagnosis timeframe	-Diagnosed with early stage (I-III) cancer (breast, prostate) and living beyond initial cancer treatment (curative/incurable) -Diagnosed with advanced or metastatic disease with life expectancy >12 months - at least 1 month after a) local treatment with curative intent (surgery, radiotherapy) or b) initiation of systemic treatment (hormone treatment, CDK4/6 or new generation antiandrogens) -Absence of diagnosed secondary malignancy	Within 12 months from diagnosis and initial treatment Diagnosed with malignant melanoma (stage I-III) within 12 months previously. Has finished primary and secondary treatment and is now cancer free.	Locally advanced prostate cancer (Stage III) or breast cancer in treatment with curative intent. Diagnosed within 3 years prior to study participation	-Diagnosed with metastatic breast cancer or prostate cancer on androgen with a prognosis of ≥18 months from the point of recruitment. -Diagnosed at least 6 months prior to participation in the trial. -About to finish or has finished primary treatment for the respective cancer type, i.e. surgery and/or chemotherapy and/or radiotherapy.
Age	≥60	≥60	≥65	≥70
Functional and cognitive status	Deemed by a member of the multidisciplinary team as physically and psychologically fit to participate in the study Able to read, write and understand the respective local language A baseline score of above 2 on the Mini-Cog			
Technological skills and smartphone availability	Able to bring and use own Android version 10 (or above) device during the study. Domestic 24/7 internet access via wi-fi and/or 4G mobile data (will be provided if unavailable)			

TABLE 7. INLCUSION CRITERIA OF REAL-LIFE PILOTS

Exclusion Criteria	AUTH	APC	HULAFE	UofG
Stage of cancer and diagnosis timeframe	-currently receiving chemotherapy	-Terminal stage of cancer - prognosis of <18 months from	-Terminal stage of cancer - prognosis of ≤18 months from	-Terminal stage of cancer, prognosis of <6 months as

	-terminal cancer stage on palliative care -prostate cancer: low risk disease treated with active surveillance -survival prognosis of <18 months from the time of recruitment -Patients with previous or concomitant invasive malignancy are not eligible; the exceptions are patients with the following malignancies (previous or concomitant) who are eligible if adequately treated: -Basal or squamous cell carcinoma of the skin -In situ non-breast carcinoma without invasion -Contra- or ipsilateral in situ breast carcinoma Non-breast invasive malignancy diagnosed at least 5 years ago and without recurrence: -Stage I papillary thyroid cancer -Stage Ia carcinoma of the cervix -Stage Ia or b endometrioid endometrial cancer -Borderline or stage I ovarian cancer -Major diagnosed mental or cognitive disorder affecting ability to participate in the study -Unwilling to provide written informed consent	the point of recruitment -Major diagnosed mental or cognitive disorder affecting ability to participate in the study -Unwilling to provide written informed consent	the point of recruitment -Presence of metastasis -Major diagnosed mental or cognitive disorder affecting ability to participate in the study -Unwilling to provide written informed consent	determined by the clinical team. -Current diagnosis of major mental or cognitive disorder affecting ability to participate in the trial. -Unable to provide written informed consent.

TABLE 8. EXCLUSION CRITERIA OF REAL-LIFE PILOTS

The selection and recruitment processes adopted by each pilot site follow.

AUTH

Patients aged 60 and above, diagnosed with early-stage breast or prostate cancer will be identified at the Department of Medical Oncology at G. Genimatas General Hospital, "Alma Zois" a non-profit association of women who had experienced breast cancer based in Thessaloniki, Greece and collaborating private clinics. The patients will be presented with the opportunity to participate in the study and screened based on the inclusion and exclusion criteria. In case they can be included in the study, they will be provided with the information sheet and the consent form, informed that their refusal to participate will not change in any case their current treatment and provided with explanations to any inquiry they may have. Healthcare professionals will be recruited by the two oncologists of the AUTH team. They will be asked to participate and provided with the information sheet and consent form should they express interest.

HULAFE

Considering the Pilot Use Case 3 inclusion/exclusion criteria, patients suitable to participate in the study will be identified by the Principal Investigator or the delegated nurse(s), doctor(s) or researcher(s). If needed, patients will be identified by consulting the HULAFE's information systems. Also, the recruitment of professionals will be done by the study investigators by analyzing the information provided by the managers of the Healthcare Department. Identification will involve reviewing the identifiable personal information of patients, service users or any other person by the clinical teams. The data will be handled with appropriate confidentiality and technical security, as required by Organic Law on Personal Data Protection 15/1999.

All participants will be given a copy of the full Informed Consent Form comprising the Information Sheet and the Certificate of Consent to be signed in case they choose to participate. It will also clearly state that all the services participants receive at the Institutions will continue and nothing will change in case they choose not to participate. Participants may be allowed to change their mind later and stop participating even if they agreed earlier. Inclusion/exclusion criteria and recruitment methods will be refined considering the outputs from WP7 and will need to be reviewed and approved by the Ethical Committee of the Medical Research Institute of Hospital La Fe.

UofG

Patients aged 70 years and above with breast cancer, or prostate cancer will be identified from clinician outpatient caseload lists at the Beatson West of Scotland Cancer Centre (BWoSCC), and attached clinics, within NHS Greater Glasgow and Clyde.

A member of the research team will attend patient clinics to identify potential participants from casenotes, confirm eligibility and signpost those eligible patients to the clinical team (e.g, Oncologist, Clinical Nurse Specialist) by inserting a participant information sheet (PIS) into their case notes. The researcher will notify the member of the clinical team of the potential eligibility of the patient, the clinician will first approach

the patient during their appointment and introduce the study, if interested, they will provide the PIS. All patients provided with a PIS, and the outcome (e.g., reason for exclusion) will be entered into a recruitment log. The researcher will follow up any initial questions at the clinic and will telephone the patient at least 24 hours later, giving them time to consider participation and subsequently confirm participation, or not.

If the patient is not present in the clinic (remote telecare consultations due to Covid-19), the patient will be sent an invitation letter by the research/clinical team, along with a PIS for their perusal. The researcher will then follow up potential participants via telephone to answer any questions and subsequently confirm participation, or not.

All agreeable, eligible potential participants will be asked to provide written informed consent. All declining patients will be thanked for their time and reassured that their decision will have no impact on their current or future treatment and care.

APC

For Pilot Use Case 2, melanoma survivors aged ≥60, that have completed primary treatment within the last 12 months before the pilot's start date, will be identified by our clinical partners within primary and secondary care in Region Stockholm. Clinicians (primary care physicians, nurses, Dermatologists, Oncologists, Surgeons, Radioncologists) can inform the melanoma survivor about our study during the first follow up meeting or even right after the primary treatment and address his/her eligibility. We will also disseminate online advertisements for the study and recruit participants through our project partners (eg. KI) or the Swedish melanoma patient association (Melanomföreningen) and direct them to an online recruitment form within Region Stockholm. In the case of poor recruitment, online advertisement will be done as well via public channels such as newspapers, directing eligible participants to the online contact form. Participants will get written information regarding our pilot, web material and of course contact information to the researchers. Researchers will then make a follow-up call to confirm interest in study participation. During the contact, the melanoma survivor will have to provide their written consent or decline participation and of course, ask for a second contact before his/her final decision. All declining melanoma survivors will be thanked for their time and reassured that their decision will have no impact on their current or future treatment and care. All consenting participants will be reassured that they can withdraw at any time that they desire from the study.

Participation process

Patients

Patients that have been screened for the inclusion and exclusion criteria, informed about the study, have accepted to participate and have given their consent by singing the consent form can enter the study's first stage.

STAGE ONE

The participants will be asked to provide demographic information, fill out the end-point PROMs and the anchor point. They will be asked to provide PROMs and anchor

point information two more times with 4 weeks in between. In total the end-points and the anchor point will be measured 3 times during the first stage of the study.

STAGE TWO

After the first 2 months the participants will enter the second stage of the study which will last for 3 months. They will be instructed to download the mobile app of the LifeChamps solution and to install the home sensors at their home. The sensors will be the MYSPHERA LOCs and a smart weight scale . They will be given the Fitbit Charge 4 wristband and will be instructed to wear it while being passively monitored by the MYSPHERA LOCs system as much as possible. The participants' involvement with the LifeChamps solution will be mostly through the mobile app which will provide them with useful information to support / guide them in improving their QoL, remind them to provide PROMs and PREMs and use the weight scale provided to them in specific time intervals (weekly or monthly).

STAGE THREE

After the second stage of the study, the participants will be asked to return the hardware that was provided to them and will enter stage three. During this stage they will be only asked to provide the PROMs and the anchor point information three more times with 4 weeks in between. After the 2 months of stage three the participants will be thanked for their participation. The results of the study will be available to them as soon as they are ready should they choose to request them.

Health professionals

Healthcare professionals that will participate in the pilots will have access to the LifeChamps dashboard which will provide pseudonymised information regarding the patients' physical activity and patients PROMs and PREMs. They will not be able to view real time processed information, such as risk of frailty, QoL, risk of dependency and psychological condition, from the LIFECHAMPS analytics engine. They will be shown the anonymised outputs of the engine and asked their opinions on whether such information would have helped better manage their patients' treatment.

5.3 DATA COLLECTION PROCESSES

The following chapter describes the methods of data collection and which PROMS, PREMS and sensor data will be collected. During the study, data regarding the recruitment rate and participant retention will be recorded to address the primary research questions.

PROMS/PREMS

The following PROMS and PREMS for QoL and Frailty will be collected during the pilot studies across all pilot sites. The PROMS and PREMS will be collected using the most feasible method and according to the ECDC guidelines due to the pandemic. The methods of collection will include, live collection, online, over the telephone or via the mobile app depending on the stage of the study and the status of the COVID-19 pandemic.

Common measurements that will be collected across all four pilot sites:

Measurement during screening for inclusion and exclusion criteria

Cognitive function

Mini-Cog

The mini-COG is a good screening tool for cognitive function and impairment. The mini-COG which consists of three-word recall and a clock-drawing test and can be completed within 5 minutes. A score of less than 3/5 indicates the need to refer the patient for full cognitive assessment.

Measurement of endpoints

Anchor Points

In order to early identify changes in subdomains of well-being we recommend the use of anchor points, specifically the use of the Global Rating of Change Scale (GROC) questionnaire adapted to each specific domain.

- Total HRQOL Change,
- Physical wellbeing,
- Social/family well-being,
- Emotional well-being,
- Functional well-being.

Suggested format of questions

Compared to how you were a) before the start of the trial or b) previous clinical visit (Rating 1 to 7):

1. How are you doing overall?
2. How are your physical activities?
3. How are social activities?
4. How is your mood?
5. How are your work-related activities (including household work)?

Answers:

1: Very much Improved, 2: Much Improved, 3: Minimally Improved, 4: No change, 5: Minimally Worse, 6: Much Worse, 7: Very much Worse

The GROC questionnaire can be completed over the phone every 4 weeks.

Quality of Life

EQ-5D-5L

The EQ-5D-5L essentially consists of 2 pages: the EQ-5D descriptive system and the EQ visual analogue scale (EQ VAS). The descriptive system comprises five dimensions: mobility, self-care, usual activities, pain/discomfort and anxiety/depression. Each dimension has 5 levels: no problems, slight problems, moderate problems, severe problems and extreme problems. The patient is asked to indicate his/her health state by ticking the box next to the most appropriate statement in each of the five dimensions. This decision results in a 1-digit number that expresses the level selected for that dimension. The digits for the five dimensions can be combined into a 5-digit number that describes the patient's health state. The EQ VAS records the patient's self-rated health on a vertical visual analogue scale, where the endpoints are labelled 'The best health you can imagine' and 'The worst health you can imagine'. The VAS can be used as a quantitative measure of health outcome that reflect the patient's own judgement.

FACT-G7

The Functional Assessment of Cancer Therapy – General – 7 Item Version (FACT-G7) is a shortened, 7-item version of the FACT-G designed to capture the most relevant issues quickly and effectively to cancer patients in a valid and reliable manner. The FACT-G7 can be used to rapidly assess top-rated symptoms and concerns for a broad spectrum of advanced cancers in clinical practice and research, as well as for quality reporting in cancer chemotherapy and radiation.

Frailty

Tilburg Frailty Indicator (TFI)

TFI has robust evidence of reliability and validity among 38 frailty assessment instruments, including the FI and the Phenotype of frailty. The Tilburg frailty indicator has been validated recently and has been found to be a prognostic factor for disability and increased utilization of health resources.

or

G8 covers several domains of frailty, including age, medication, mental problems, nutrition and mobility. According to the guidelines patients with a G8 score below 14 should undergo a comprehensive geriatric assessment (CGA) as this score is associated with 3-year mortality.

PROMS to be collected during the second stage of the study

Anxiety and Depression

HADS

Hospital Anxiety and Depression Scale (HADS) is commonly used by doctors to determine the levels of anxiety and depression that a person is experiencing. The questionnaire comprises seven questions for anxiety and seven questions for depression and takes 2–5min to complete.

Late cancer treatment effects

ESAS-r

The ESAS-r is a tool that was developed to assist in the initial assessment of nine symptoms, at a point in time, that are common in palliative care patients: pain, tiredness, drowsiness, nausea, lack of appetite, depression, anxiety, shortness of breath, and wellbeing. There is also a blank scale for patient-specific symptoms.

Adherence to medication

MARS-5 – Medical adherence Report Scale

The MARS-5 is a 5-item questionnaire which describes nonadherent behaviours and is measured in a 5-level Likert scale.

PREMS

Quality of Care

CTSQ – Cancer Therapy Satisfaction Questionnaire

The CTSQ is a 5-point Likert questionnaire aimed to assess patient satisfaction with and preference for chemo, hormonal, and biological therapies. It consists of 16 items with a recall period of last four weeks.

Patient centredness/empowerment in care services

DES-10 – Decisional Engagement Scale

The DES-10 is a patient-reported measure of engagement in decision making of cancer patients. It assesses patients' awareness of diagnosis, level of involvement, level of information seeking, level of empowerment and planning.

Care process coordination

PSN-1 - Patient Satisfaction with Navigation-Interpersonal scale

The PSN-1 is a 9 item questionnaire aimed using a 5-level Likert scale to measure patient satisfaction with the interpersonal relationship with their navigator.

Perception of Aging

APQ – Aging Perceptions Questionnaire

The APQ is a 7-dimensional scale which each dimension comprising of 3 to 5 items. These dimensions are chronic and cyclical timeline, positive and negative consequences, positive and negative control, and emotional representations

List of additional PROMS and PREMS (or other) to be collected

PUC1 – AUTH

The additional PROMs and PREMs to be collected in PUC1 is under discussion with the AUTH clinicians and stakeholders.

PUC2 - APC

SEPI: sun exposure and protection index
FCRI: Fear of cancer recurrence inventory or CWS : cancer worry scale

PUC3 – HULAFE

HULAFE will consider the following list of PROMS and scales to include in the pilot:

- Functional assessment:
  - Barthel Index
  - Lawton and Brody Instrumental Activities of Daily Living (IADL)
- Cognitive assessment:
  - Pfeiffer questionnaire
- Social assessment:
  - Gijon social-family scale
  - Zarit Burden Interview (ZBI) scale
- Nutritional assessment
  - Mini Nutritional Assessment Short Form (MNA®-SF)
- Frailty
  - Fatigue, Resistance, Ambulation, Illnesses, & Loss of Weight (FRAIL) scale
  - Short Physical Performance Battery4 (SPPB)
  - Vulnerable Elders Survey (VES-13)

PUC4 – UofG

PRO variables	PROM name	PROM number of items	PROM URL
Social support	mMOS-SS	8	https://www.sciencedirect.com/science/article/pii/S0895435612001163
Physical symptom burden	CMSAS	11	https://www.tandfonline.com/doi/pdf/10.1081/CNV-200026487?needAccess=true
Emotional symptom burden / mood	CMSAS	3	https://www.tandfonline.com/doi/pdf/10.1081/CNV-200026487?needAccess=true
Nutritional status / malnutrition	MST	2	https://pubmed.ncbi.nlm.nih.gov/10378201/
Multimorbidity treatment burden	MTBQ	10	https://www.bristol.ac.uk/primaryhealthcare/resources/mtbq/
Vulnerability (functional and health status)	VES-13	13	https://bmjopen.bmj.com/content/8/4/e019413
HRQoL	LASA	5	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2732111/

Cognition / perceived cognitive ability	No PROM as variable measured via the mini-Cog at baseline
Physical activity	No PROM as variable measured via sensors
Falls / concerns about falling	No PROM as variable measured via sensors
Polypharmacy	No PROM as variable measured via EHR data (polypharmacy defined as 2 or more concurrent medications)

TABLE 9. LIST OF ADDITIONAL PROMS

Sensors

The following sensors will be utilised in all four pilot sites for data collection and participant monitoring.

- Activity tracker wristband FitBit charge 4 collecting heart rate, heart rate variability, steps, activity tracking, sleep monitoring, breathing rate, skin temperature and SpO2
- Smart Scale measuring weight, body composition
- Home sensors tracking ambulation and functioning MySphera LOCsRasberry Pi kit for data collection and transfer to LIFECHAMPS server

Pilot specific Sensors (Add any additional sensors that you may use)

PUC1 - AUTH

AUTH will use only the common sensors during its pilot.

PUC2 – APC

APC will collect in addition UV index information through the combination of GPS information of the mobile phone and an online service providing the radiation based on geolocation.

PUC3 – HULAFE

HULAFE will use the common sensors: activity tracker, scale measuring weight and Rasberry Pi. Home sensors will be offered as an option for patients to be used during the pilot.

PUC4 - UofG

UofG will use only the common sensors during its pilot.

Electronic Health Record (EHR)

During the second stage of the study, information from the EHR of the participating patients will be loaded unto the LifeChamps analytics engine. This will only take place for EHRs of participants whose attending doctors are also participating in the study.

The information will be loaded via the LifeChamps dashboard which is to be used by the participating clinicians.

PUC1 – AUTH

Clinical data to be collected in PUC1 is under discussion with the AUTH clinicians and stakeholders.

PUC2 – APC

DIMENSION	***VARIABLES***
DEMOGRAPHICS	Weight
	Height
	BMI
	Age
CANCER TYPE AND PROGRESSION STATUS	Time treatment
	Tumor stage
	Clark scale
	Breslow depth
	SNB status
	Tumor location
	Family history of skin malignancy
COMORBIDITIES	ICD-10 diagnoses
	Planned health contacts
	Emergency health contacts

TABLE 10. APC EHR VARIABLES

PUC3 – HULAFE

HULAFE will consider the following EHR variables to be gathered during the pilot:

Dimension	***Variables***
DEMOGRAPHICS	Age
	Gender

MORBIDITY	Weist circumference
	Weight
	Height
	Body mass index
	Depression
	Anxiety
	Multimorbidity burden
	Alzheimer diagnosis
	Dementia diagnosis
	Urinary symptoms
	Urinary incontinence
	Bowel irritation
	Sexual dysfunction
	Incidents of falls
	Infection
	Cardiac incidents
	Fractures
	Charlson comorbidity index
CANCER TYPE AND PROGRESSION STATUS	Regional lymph node excision/irradiation - electronic health record
	Family history of melanoma
	Family medical history
LAB MEASURES	Lipid profile
	Fasting blood glucose
	Urine test (bacterial growth, culture and sensitivity)
	Blood sugar

	Calcium intake
	PSA records (incuding PSA kinetics= PSA velocity and PSA doubling time)
	PSA test
DRUGS	Number of medications
	Polypharmacy burden
	Adherence to medication
	Medication takens for other reasons
	Type of medication (Bisphosphonates, denosumab, raloxifene, calcitrol, teriparatide vitamin D supplements, tamoxifene, aromatase inhibitors, LHRH agonists, anti-androgens)
EPISODES	Hospitalization event
	Emergency event
	Primary Care event
	Outpatient event

TABLE 11. HULAFE EHR VARIABLES

PUC4 - UofG

UofG will collect the following information from the EHRs:

VARIABLE	MEASUREMENT PARAMETER
WEIGHT	Kilograms
HEIGHT	Centimetres
AGE	Years
CARDIOTOXICITY INCIDENTS	Name
TNM CANCER STAGING	At diagnosis, at study start, during study, end of study
PSA TEST (PATIENTS WITH PROSTATE CANCER ONLY)	At diagnosis, at study start, during study, end of study

ANTI-CANCER TREATMENT / PROTOCOL	Type, dose, administration, route, frequency
SUPPORTIVE CARE MEDICATIONS (E.G. BISPHOSPHONATES, DENOSUMAB, RALOXIFENE, CALCITRIOL, TERIPARATIDE, VITAMIN D SUPPLEMENTS, TAMOXIFEN, AROMATASE INHIBITORS, LHRH AGONISTS, ANTI-ANDROGENS)	Type, dose, administration, route, frequency
NON-CANCER RELATED MEDICATIONS	Type, dose, administration, route, frequency
COMORBID ILLNESSES	Name
FRAILTY SCORE BASED ON CLINICIAN'S ASSESSMENT (WHERE AVAILABLE)	At study start, during study, end of study
SCHEDULED FOLLOW-UP APPOINTMENTS WITH THE CLINICAL TEAM	Record new appointment
URGENT/UNSCHEDULED CLINIC VISITS	Record clinic visit event and outcome
HOSPITALISATION EVENT	Record hospital admission event and duration
EMERGENCY EVENT	Record visit to A&E event and outcome

TABLE 12. UOFG EHR VARIABLES

MOBILE APP

The mobile app will push the following datasets collected by the wearable and the weight scale into the LifeChamps platform via the Edge component:

Fitbit charge 4

User information:

- Lifechamps user ID
- Lifechamps user Role

Health Features (along with the timestamp of every data sample):

- Steps
- Distance
- Calories burned
- Active minutes
- Hourly activity
- Stationary time
- Total Sleep duration
- Light Sleep duration
- Deep Sleep duration
- REM sleep duration
- Sleep score
- SpO2
- Skin Temperature
- Heart Rate Variability (HRV)
- Breathing Rate

Fitness (along with the timestamp of every data sample):

- Floors climbed
- Workout duration

-

Withings Body+

User information :

- Lifechamps user ID
- Lifechamps user Role

Health Features (along with the timestamp of every data sample):

- Weight
- Muscle mass
- Bone mass
- Fat mass
- Fat free mass
- Fat ratio

Besides, for the specific use case of APC, the mobile app will also push UV index information to the LifeChamps platform gathered from https://www.openuv.io/ (along with the User information and corresponding timestamps).

Dashboard

The LifeChamps Dashboard will serve as monitoring and decision support tool in which no data collection will take place. However, the Dashboard will support EHR uploading.

The HCP will be able to upload EHR records of certain patient into the LIFECHAMPS system.

5.4 DATA ANALYSIS

Data analysis plan the LIFECHAMPS real-life pilot is divided in three major categories. Analysis of the data to measure the feasibility and possible effects of the platform which will lead to scientific publications is described first. Following is the data analysis which will take place in the LIFECHAMPS HPC and finally, the data analysis for the cost-effectiveness part of the study is described last.

STATISTICAL ANALYSES

The collected raw data obtained during the real-life pilot in all four sites will be analysed using the following steps in an effort to answer the primary and secondary research questions of the feasibility study as prioritised by the clinical partners. Initially, descriptive statistics and plots will be performed to identify the characteristics of the data such as outliers, trends, seasonality and general measures of tendency and variability. Also, the analysis will include traditional comparisons between pre and post measurements such as repeated measures ANOVA. Following this step, segmented regression analysis will be performed for the data collected before and after the second stage of the study. The last step of the analysis will be addressing potential methodological issues to increase the robustness and reliability of the results. Interrupted time series designs have several distinctive issues which can introduce bias in the study such as seasonality, time-varying confounders, over dispersion and autocorrelation(9,13). These methodological issues will be mitigated by applying the appropriate measures and processes.

DATA PIPELINE IN LIFECHAMPS HPC

The data pipeline that will be developed during the LifeChamps project consists of several interrelated modules. The collected sensor and PROM/PREM data will be sent to the LIFECHAMPS HPC infrastructure where it will be stored anonymously in the data lake. A part of this stream of data will be pre-processed on the Edge and the Cloud Analytics engine, to extract additional features and explore patterns inside the data. The additional features and knowledge that will be acquired from this process will be also directed to the HPC infrastructure to be stored with the rest of the data in the data lake.

A similar approach will be implemented on the EHR data, also. Pilot sites will send pseudonymised sets of their EHR data which will be collected and stored in the data lake, inside the HPC infrastructure. ALTRAN, UPV and AUTH partners will perform a series of pre-processing and exploratory analysis on this EHR data, together with the aforementioned sensors and PROM/PREM ones on the Cloud Analytics engine. The results of these analyses will be stored, again, at the data lake.

Finally, clinical modelling will take place on the Cloud Analytics engine with all the raw and pre-processed data from all the preparatory analytical tasks. The results of these clinical models will be stored at the data lake. These results will feed data driven patient

education recommendations at the mobile app and the clinical dashboard of the project's healthcare professionals.

COST-EFFECTIVENESS ANALYSIS

Four Cost-utility analysis will take place, one for each pilot, comparing reporting outcomes of incremental cost per QALY.

For the single group interrupted time-series feasibility studies, incremental costs per QALY will be compared based on the utilities scores before and after the intervention for the same group of patients. As for the controlled feasibility study in Spain the comparison in incremental costs per QALY will take place between intervention and control group where in the last one, no intervention will be applied.

QALYs:

The evaluation of the Quality of Life will be conducted with the EQ-5D-5L instrument. The value of each health state I.e., the adjustment in a range of 0-1 will be implemented with the Time-Trade off method (TTO) based on the standard value set of EuroQol group for each country. For the countries that lack a value set (Greece and maybe Sweden – ongoing validation) will be used either the cross-walk value sets or another country's value set. Life expectancy assessment will be based on the literature with or without the support of the MAFEIP tool.

Costs:

Interventions costs can be divided in 2 categories: Direct and Indirect costs.

Directs costs include Development costs which are the same for all pilots defined by project leader in collaboration with all partners and implementing costs that may differ for each pilot site. The second ones will include set-up costs (i.e., set up of sensors, educating the end-user on using the LifeChamps app), 'visit costs' (i.e., contact nurse/doctor other healthcare professional occupied for the intervention) and 'maintenance' costs (i.e. technical support in case of damage of the sensing tools).

Indirect costs' calculation will depend on the availability of data regarding sick leave, special insurance costs etc. For the pilot sites that those information are not available in the EHR , the medical consumption questionnaire of the Institute for Medical Technology Assessment (iMTA) will be performed .

For additional support for the cost-utility analysis may the MAFEIP tool be used.

5.5 TIMELINES

The methodology for the real-life pilot study will be implemented as described in the timeline (Table 13) suggestion below:

1. Preparation of study protocol
2. Submission of study protocol for ethical approval
3. Recruitment period
4. Control period
5. Usage of LifeChamps solution
6. Data analysis
7. Pilot trials in real-life environments (D7.4)

	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31	M32	M33	M34
Task 1	■	■	■													
Task 2				■												
Task 3						■	■	■								
Task 4						■	■	■	■	■	■	■	■	■		
Task 5								■	■	■	■	■				
Task 6													■	■	■	
Task 7																■

TABLE 13. TIMELINE OF REAL-LIFE PILOTS

6 PILOT PLANNING

The WP7 partners have conducted a comprehensive plan of the following steps of the pilots, considering the current COVID-19 pandemic, the input from other WPs and ethical applications' delays. The plan spans from M19 to M34 culminating in the submission of deliverables D7.4 – Pilot Trials in real-life environments, D7.5 User Acceptance evaluation, D7.6 Evidence of effectiveness on person and care outcomes and D7.7 Cost effectiveness study.

Small-scale end-user acceptance study will identify the components and features of the mobile app and dashboard that will best fit the end-users' needs and liking. Additionally, the design, information flow and architecture will be evaluated by the end-users. Phase 1 of the end-user acceptance study will be taking place in M19 and early M20. This study will be led by ALTRAN and will be repeated on M23-24 with phase 2 utilising the initial version of the LifeChamps solution.

Preliminary data collection will be led by UofG and is scheduled to begin on M19, and it is planned to take place until M26 with an optional extension to M30. This phase will provide the initial data to be fed to the LifeChamps engine and serve as training data for the algorithms to examine their functionality and evaluate the whole data flow of the engine. Such data will include either prospective or retrospective patient-reported, sensor and clinical data.

The real-life pilots aim to validate the LifeChamps solution outputs via the collection of data from the mobile application, clinical evaluation, and sensors. The pilots will take place simultaneously on the four pilot sites (UK, Sweden, Spain and Greece), utilising an interrupted time series study design. The participants will be enrolling for 7 months to the study divided in three stages of 2, 3 and 2 months, respectively. The first and last 2 months will serve as self-control while during the second stage of the study, the participants will be using the LifeChamps solution. Based on D6.1 the stable version of LifeChamps solution will be released on M26 the recruitment for the real-life pilots will begin on M24, allowing the first participants to use the LifeChamps solution on M26 after they have concluded the first stage of the study.

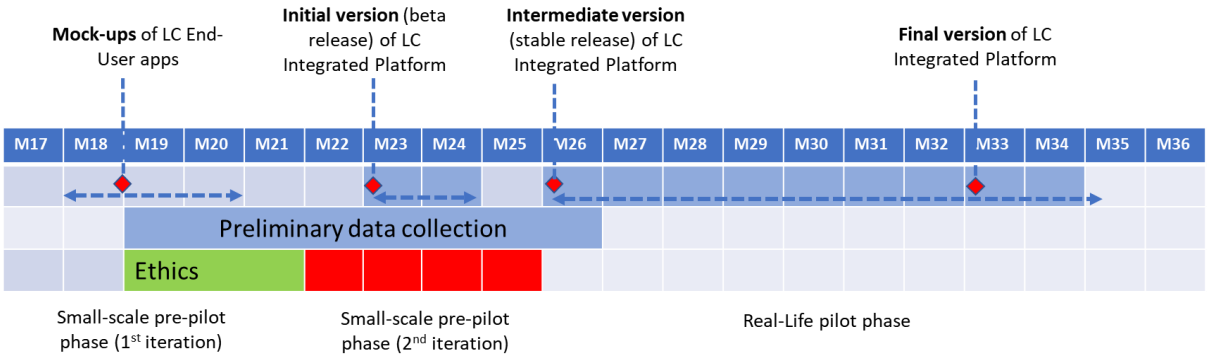

FIGURE 4. TIMELINE OF ALL PILOTS

7 CONCLUSIONS

This deliverable presented the framework of the development, assessment, and evaluation of the LifeChamps platform to be developed. This framework is based on three major processes, training data collection for the AI development, user acceptance evaluation and feasibility assessment via a real-life environment study. The training data collection includes the usage of retrospective EHR data from HULAFE and APC and the collection of PROM and sensor data from participants across all pilot partners which will be transferred to the technical partners responsible for the development of the platform. End-user acceptance evaluation will utilise co-creation methodologies to provide adequate feedback for the partners so that they can improve the quality, design and user satisfaction of the LifeChamps solution based on the end-users' input. Lastly, a feasibility study based on the interrupted time series design will be performed in real-life environment to validate the LifeChamps platform. The study will include measures to provide evidence to prove the applicability, usability and effectiveness of the LifeChamps platform in realistic conditions. Additionally, the study will include the assessment of the cost-effectiveness of the LifeChamps via the MAFEIP tool. The results of the real-life pilot trials will be reported in deliverables D7.4, the results of the user acceptance evaluation will be reported in deliverable D7.5, the results of the effectiveness in deliverable D7.6 and the results of the cost-effectiveness analysis in deliverable D7.7.

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