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ACTIVAGE PROJECT

ACTivating InnoVative IoT smart living environments for AGEing well

Consolidated List of KPIs and Coordinated Methodology for Evaluation

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Abstract

This document introduces the methodology for evaluating the impact of the ACTIVAGE LSP by using a set of key performance indicators (KPIs). The **GLocal Evaluation Framework** tailored to implement specific guidelines to assess the impact in the form of KPIs about AHA-IoT based services is included. The GLocal Evaluation Framework describes an iterative process in order to promote their replicability and scaling up.

The GLocal Evaluation Framework is based on a ***bottom up*** approach providing Deployment Sites (DS) with guidelines and instruments to collect qualitative and quantitative Local Key Performance Indicators (KPIs), in order to generate an overall critical mass of evidence. "GLocal" concept refers to the capability of the framework to represent local specificities but, at the same time, to create trans-DS reference KPI and protocols supporting a global impact assessment.

In particular, the GLocal Evidence generation process is based on two main steps:

1. Local evidence generation protocol
2. Identification of Global and GLocal indicators

GLocal Evaluation Framework provides some reference instruments supporting the implementation of the GLocal Evidence Generation protocol:

1. AHA – IOT Service and Local Ecosystem Modelling (AHAIOTES) Questionnaire
2. Key Performance Indicators Table
3. GLocal Software infrastructure

Statement of originality

This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

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1 About This Document

This document introduces the methodology for evaluating the impact of the ACTIVAGE project by using a set of key performance indicators (KPIs). The **GLocal Evaluation Framework** tailored to implement specific guidelines to assess the impact in the form of KPIs about AHA-IoT based services is included. The GLocal Evaluation Framework describes an iterative process in order to promote their replicability and scaling up.

One of the main goals in ACTIVAGE is to create the EVIDENCE and to be the reference DRIVER of a virtuous circle of the AHA-IoT market growth. According to this goal, a tailored reference evaluation framework is the pivotal tool to support an effective, structured and homogenous impact assessment of ACTIVAGE services implemented at Deployment Site (DS) level.

The overall goal and distinguish challenge related to the ACTIVAGE Evaluation Framework is to provide a structured methodology and reference tools tailored to support the quantification and qualification of impact EVIDENCE and the identification of SUCCESS FACTORS of the ACTIVAGE AHA IoT ecosystems. Such a set of results will constitute the value-based reference for decision makers to support the definition of SCALING UP and REPLICATION strategies of IoT solutions for Active and Healthy Ageing.

This challenge perfectly aligns the ACTIVAGE project to the five steps of the *Scaling-up Strategy in Active and Healthy Ageing promoted by European Innovation* Partnership (EIP-AHA 2015a). This strategy is based on two main elements: "*what* to scale up and *how* to scale up" to overcome "*siloed"* approaches to innovation. Accordingly, ACTIVAGE will first create impact **EVIDENCE** ("*what*") and, secondly, will provide concrete outcomes and identify success factors to lead the scaling up process ("*how*"). Such a strategic link and synergic vision with European Innovation Partnership Scaling-Up Strategy will be actively promoted and pursued through methods and results sharing, in collaboration with EIP working groups and Reference Sites Coordinators.

In order to analyse the success factors and to provide decision makers with reference structured evidence and value based framework, ACTIVAGE evaluation framework activities will be focused to identify and analyse specific **Key Performance Indicators (KPI**), organizational features, business process, ecosystem framework and deployment strategies with proved impact factors evidence. Main target audience of such analysis are regional, national and European decision makers.

This analysis of Local and Global indicators and features to form the evaluation framework, is not based on EX-ANTE design, but on distinctive features of the ACTIVAGE strategy called ***GLocal***: a **BOTTOM UP** approach and an **ITERATIVE** process to discover "hidden" and not explicit KPI, success factors and enabling ecosystem features that will guide the update of the ACTIVAGE GLocal Evaluation framework. This iterative approach, which will be represented in further versions of this deliverable, will be addressed mainly in collaboration with Deployment Sites and WP9, WP2, WP7 and WP8 partners.

1.1 Interaction with the overall strategy of the project

The setting of a common Reference Evaluation Framework implementing the GLocal approach, able to complement Global and Local reference features and identify requirement is strongly intertwined with the overall ACTIVAGE project's strategy and work packages objectives.

The GLocal approach, together with WP2, provides the Co-creation framework helping in identifying needs, preferences and perceptions of ACTIVAGE users on acceptability, trust, confidentiality, privacy, data protection and safety through the definition of indicators of: usability of the solution, user experience, and willingness to buy above threshold.

It also supports the creation of the ACTIVAGE IoT Ecosystem Suite (AIOTES) providing the tool to produce evidence in terms of number of local technical platforms integrated by ACTIVAGE and number of connected infrastructures (WP3-WP5).

Additionally, the GLocal approach, based on the information provided by DSs (WP9), provides DSs with "guidelines" to produce evidence on their strategy. Thus, it strengths the setting-up of the Large Scale Pilot(s).

The whole ACTIVAGE project aims to set the basis for replicability and scalability of its results; namely the ecosystem enlargement. The GLocal methodology, through its ***iterative*** approach, will refine step by step the Evaluation framework thus providing a more and more suited framework to identify scalability enabling factors (WP7).

As WP8 aims to maximize impact assessment (T8.1), the GLocal evaluation methodology strongly supports this objective, by providing each DS with proper reference and tools to generate data, perform impact assessment and collect evidence from different prospective (WP9, T9.3).

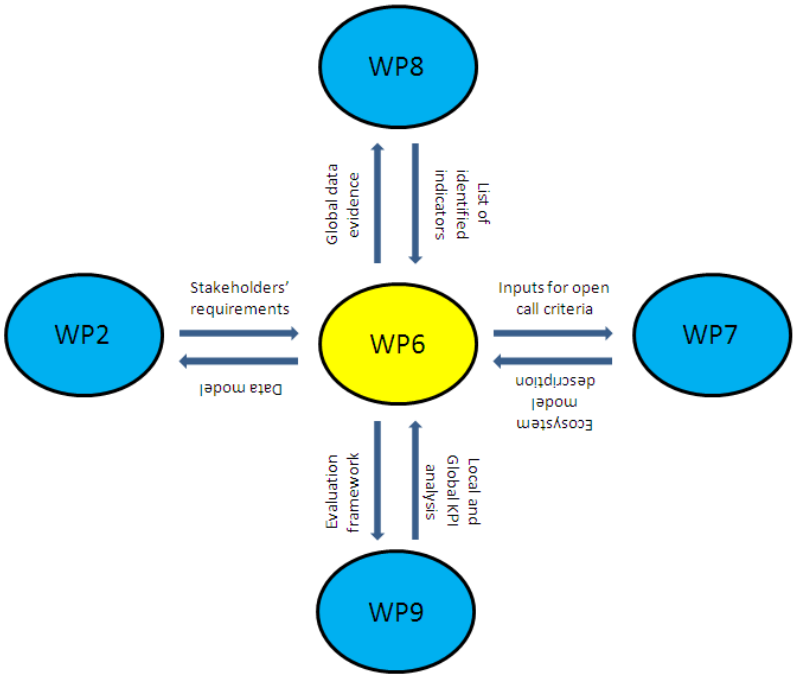


Figure 1 : WP6 strategic interactions with different project's WPs

1.2 Deliverable context

Project item	Relationship
Objectives	O3 (GLocal evaluation framework): D6.1 provides this framework in its first version.
Exploitable results	Apart from being itself an exploitable knowledge asset, D6.1 lays the cornerstone for

	– other important exploitable knowledge assets, especially the ACTIVAGE White Book, and – increasing the exploitation opportunities for both the ACTIVAGE IoT Ecosystem Suite and the LSP applications and services through being used in evaluating these technologies.
Work plan	D6.1 is the result of work in Task 6.1, which is the first active task in WP6. Other Tasks in WP6 will use this result to – add concrete evaluation procedures and tools (T6.2), – refine and extend the framework along the three axes QoL & Independence (T6.4), Service Sustainability (T6.5), and Innovation and Growth (T6.6), – apply its interim and final versions (to be created in the course of the above activities) in practice (T6.3), and – create the ACTIVAGE White Book (T6.7) Relationships to other WPs are explained in the specific Section 1.1 above. In particular it has a strong link with T.9.3, where each DS will apply the GLocal evaluation framework to analyse and integrate the impact assessment at DS level.
Milestones	D6.1 is part of the goals set for MS1, the BUILD milestone.
Deliverables	D6.1 and its iterative updates are / will be used, in particular, as input in the creation of D6.2 (evaluation tools & processes), D6.3..D6.5 (evaluation reports & the While Book), D8.1..D8.3 (impact strategy definition & assessment), and D9.2..D9.4 (KPI evolution and impact assessment at the deployment sites).
Risks	D6.1 contributes to gaining control of – Rk2 (extract & communicate benefits), by initiating evaluations whose results will help to overcome possible difficulties – Rk3 (user privacy) & Rk4 (acceptance) & Rk20 (harms to users), by preparing for continuous risk evaluation – Rk11 (evaluation data collection), by early preparation, and – Rk19 (KPI relevance), by early preparation.

1.3 The rationale behind the structure

The document qualifies the current state of the art of evaluating methods and best practices in the AHA and IoT domains (***Section 2***), afterwards the GLocal evaluation framework is discussed at conceptual level in order to properly position goals and strategies in the project context (***Sections 3.1-3.2***); then the framework is described at methodological and procedural level (***Section 3.3-3.5***). The last section reports Global Key Performance Indicators (KPIs) derived from Local KPIs identified by every Deployment Site. This first set of Local and Global KPIs is detailed in Appendix B.

1.4 Version-specific notes

Although no further versions of this deliverable are planned officially, WP6 will keep on to improve the GLocal framework (see in the above table the relationship to T6.2 & T6.4..T6.6), also based on lessons learned from the first and second interim evaluations in M15 and M24. Therefore, at least two updates of this deliverable will follow in M18 and M27.

2 The reference context

2.1 European Innovation Partnership on AHA

The overall goal and distinguish challenge related to the ACTIVAGE Evaluation framework is to provide **EVIDENCE** of success factors and service organization strategic features to enable ***SCALING UP*** and ***REPLICATION*** of IoT solutions for Active and Healthy Ageing.

This challenge perfectly aligns the ACTIVAGE project to the Scaling-up Strategy in Active and Healthy Ageing (AHA) promoted by European Innovation Partnership (EIP-AHA 2015b).

The study of the EIP-AHA strategy has pointed out that it is based on two main steps here briefly summarized: "***what*** *to scale up and* ***how*** *to scale up"* to overcome "siloed" approaches to innovation. So, the first step is to create impact EVIDENCE and the second one is to provide strategy and methods to lead the scaling up process.

Based on the **EVIDENCE** concept, referring to "*a body of facts or information that establishes the existence of something as fact",* the EIP- AHA strategy articulates the WHAT element according to 3 main steps:

1. Building a database of good practices, describing the practice, its methodology and processes in terms of target population timing, objectives etc.
2. Assessment of viability of good practices for scaling-up, comparing frameworks rather than classic evidence, such as that coming from randomised control trials. It is possible to compare systems on a larger scale and thus identify each system's characteristics and indicators of efficiency (an impact analysis of common values and outcomes is an important step in identifying good practices which are viable for replication).
3. Classification of good practices for replication according to feasibility (namely, knowledge, reaction time, stewardship, political agenda, costs and affordability, acceptability and monitoring capability), and contextual factors, such as demographic, social and economic conditions, cultural factors, and other non-healthcare determinants that impact on population health.

According to the EIP –AHA strategy, the "HOW element" is measured according to 2 main steps:

1. Facilitating a partnership for scaling-up through the establishment of networking activities (Action Groups, Reference Sites but, regionally, EUREGHA, ERRIN, AER, ENSA and CORAL too) such as thematic workshops, seminars, conferences, surveys, informal meetings and study visits.
2. Implementation: key success factors and lessons learned, firstly choosing type of scaling-up, dissemination and advocacy activities, ways to organize the process, assessing costs and mobilising resources and monitoring and evaluation actions.

2.1.1 ACTIVAGE for scaling up and replication of AHA-IoT services

At this regard, ACTIVAGE gets the unique opportunity to design and validate a **real Use Case** showing how the overall EIP strategy could be implemented by providing decision makers with practical validated case studies analysed in terms of deployment strategy, success and enabling factors, so that larger intake of AHA-IoT services can be supported.

In accordance with the EIP scaling up strategy, ACTIVAGE project embodies the following steps:

1. EVIDENCE PHASE- WHAT to replicate

   The objective of this phase is to define and validate "*how to raise and measure the impact EVIDENCE of a service*".

   WP6, through the GLocal Evaluation framework, leads the implementation of this phase through a multilayer iterative Evidence Creation process enabling data generation and business process know how for impact assessment and exploitation strategy (WP8, WP9).

2. REPLICATION PHASE- HOW to replicate

   The objective of this phase is to define and validate methods and tools to support the "*replication of services with evident and proved impact".*

   The focus on "replication" will drive the work conducted during the evidence phase to address specific data and indicators able to describe replication potential and features of specific AHA-IoT service. Therefore outcomes of "replication phase "activity will also validate effectiveness of instruments generated during the Evidence phase.

   The replication process will be implemented and validated within the WP7 (Ecosystem enlargement).

2.2 Best Practices in AHA services Impact Evaluation Frameworks

Relying on the experience of ACTIVAGE partners, a first analysis of the most common and used frameworks for impact evaluation of AHA services has been performed, to set the basis of the GLocal evaluation framework.

In order to select the most relevant frameworks we have taken into account several requirements:

– Socioeconomic benefit should be one of the domains included in the framework
– Technology assessment approach should be also considered
– It should have demonstrated applicability for AHA domain

In the following sub-sections, we briefly introduced the three selected frameworks: MAST model, MAFEIP and OPEA.

2.2.1 The Model for the Assessment of Telemedicine (MAST)

Developed by Kidholm et al. (2012) in Europe, it is currently proposed as a methodology for evaluation in the Active & Healthy Ageing domain.

The aim of this model is to provide a structure for assessment of effectiveness and contribution to quality of care of telemedicine applications that can be used as a basis for decision-making.

MAST consists of a base followed by six domains of assessment as it is described: (1) in which the health problem and characteristics of the application are described, (2) safety; (3) clinical effectiveness; (4) patient perspectives; (5) economic aspects; (6) organizational aspects; and (7) socio-cultural, ethical and legal aspects. After assessment of these domains, a transferability assessment should take place, considering aspects such as cross-border, scalability and generalizability. In the following figure, a summary of MAST elements is shown.

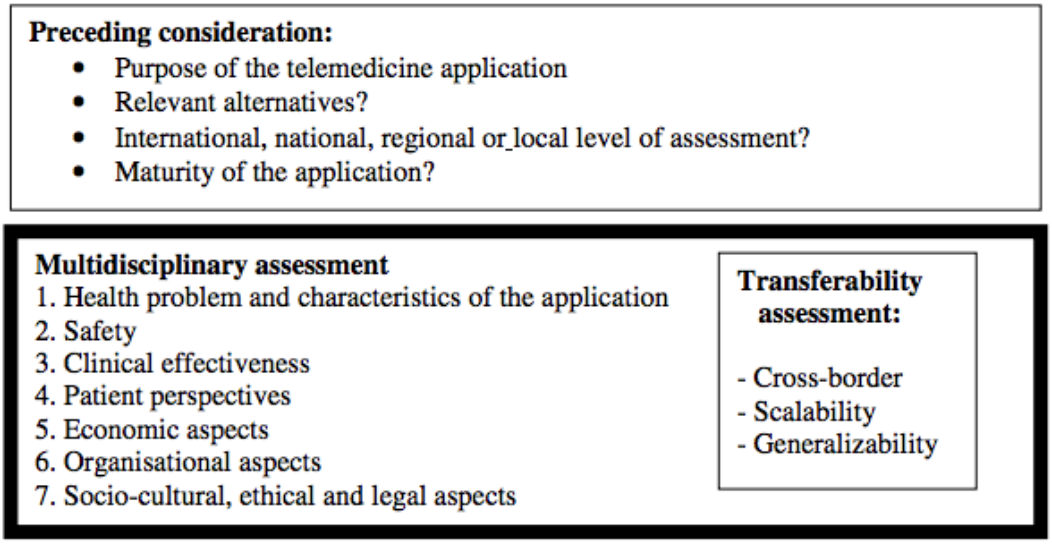


Figure 2 MAST model elements

MAST model provides a Toolkit with checklists for each of the 7 domains describing outcome measures that should be included in new empirical studies, as well as issues related to transferability, methods for data collection and examples of outcomes measures from previous studies.

The main topics proposed to be included in the evaluation domains are:

- Safety
  - Clinical safety (patients and staff)
  - Technical safety (technical reliability)
- Clinical effectiveness
  - Effects on mortality
  - Effects on morbidity
  - Effects on health related quality of life (HRQL)
    - Generic measures of quality of life
    - Disease specific measures of quality of life
  - Behavioural outcomes (e.g. exercise)
  - Utilization of health services (e.g. number of readmissions)
- Patient perspectives
  - Satisfaction and acceptance
  - Understanding of information
  - Confidence (in the treatment)
  - Ability to use the application
  - Access
  - Empowerment, self-efficacy
- Economic aspects
  - Economic evaluation (societal perspective)
    - Amount of resources used when delivering the assessed telemedicine application and its comparators in the health care sector and other sectors.
    - Unit costs or prices for each resource used

        - Related changes in use of health care resources
        - Clinical effectiveness of the telemedicine application and comparators (to be used in the cost-effectiveness analysis)
    - Business case (institutional level)
        - Expenditures per year (including expenditures related to the resource use described in the cost estimation above)
        - Revenue per year:
            - Activity (number of patients or services)
            - Reimbursement (e.g. DRG-rate) per service or patient
- Organizational aspects
    - Process
        - Workflow
        - Staff, training and resources
        - Interaction and communication
    - Structure:
        - Spread of technology, centralization or decentralization
        - Economy (see domain on economic aspects)
    - Culture: Attitude and culture
    - Management
- Socio-cultural, ethical and legal aspects
    - Socio-cultural considerations
        - Changes in the patient's role in major life areas (e.g. social life, working life)
        - Patients' relatives and others' understanding of the telemedicine application
        - Societal, political context and changes. Will the application influence the general model for the delivery of healthcare services if deployed?
        - Changes in responsibility. Are the patients and/or relatives capable of handling the responsibility?
        - Gender issues. Has the service any consequences on the position of gender?
    - Ethical considerations
        - Overall questions: Does the application challenge religious, cultural or moral beliefs?
        - Potential ethical problems, e.g. giving the responsibility to the patients
        - Autonomy: Is the patient's autonomy challenged or increased?
        - Equity among different groups in society
    - Legal considerations
        - Clinical accreditation
        - Information governance
        - Professional liability
        - Patient control – consent, access

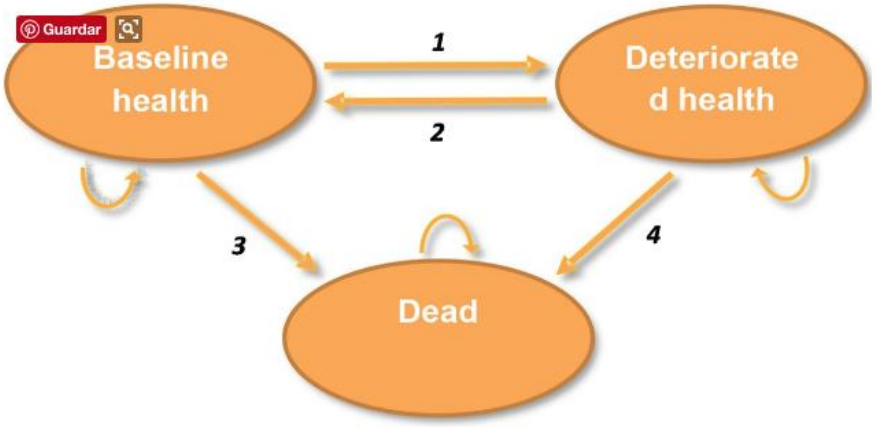
The main strengths of the model are that it is multidisciplinary and comprehensive and it is based on scientific studies and criteria for quality. With regard to the main weaknesses, the model can be time consuming for new empirical studies and it is only relevant in assessment of matured telemedicine applications. If the application is still being developed and still needs to be improved, other kinds of assessments should be carried out, e.g. in formative studies.

2.2.2 Monitoring and Assessment Framework for the European Innovation Partnership on Active and Healthy Ageing (MAFEIP)

Developed in the context of the European Innovation Partnership on Active and Healthy Ageing, MAFEIP model (A. Fabienne, C. Boehler, M. Lluch, and R. Sabes-Figuera 2014) aims to accumulate evidence on the impact of the activities carried out within the Partnership in terms of quality-adjusted life expectancy and health and care resource use within and across its six thematic Action Groups; and second, to provide decision relevant outcomes that are of value to developers, investors and implementers of innovation in the Active and Healthy Ageing arena across Europe.

It is a public and web-based tool that builds on top of Decision Analytic Modelling techniques and it is based on a three state Markov Model ('baseline health', 'deteriorated health' and 'death'). “Each health state is defined by an amount of resource use and quality of life (utility). This represents the average resource use and quality of life of a patient in that health state.” (MAFEIP User Guide)

The model relies on collecting data on health-related quality of life (HRQoL), health and care resource utilization and cost, as well as probabilities to move from one health state of the model to another



1= Probability to move from baseline health to deteriorated health
2= Probability to move from deteriorated health to baseline health
3= Probability to move from baseline health to dead state
4= Probability to move from deteriorated health to dead state

Boehler et al. (2015). Development of a web-based tool for the assessment of health and economic outcomes of the European Innovation Partnership on Active and Healthy Ageing (EIP on AHA). *BMC Medical Informatics and Decision Making*; 15(Suppl 3):S4, DOI: 10.1186/1472-6947-15-S3-S4 Open Access

Figure 3 MAFEIP model structure

The tool provides “estimates on the Incremental Cost Effectiveness Ratio (ICER = ΔC/ΔE) or the Incremental Net Monetary Benefit (INMB = ΔE ∗ λ - ΔC) of one intervention compared to another, where λ denotes the willingness to pay threshold for an additional unit of health gain” (MAFEIP User Guide).

This allows, in real time, estimation of the lifetime incremental quality adjusted life years (QALYs) and incremental cost of an intervention versus its respective standard care alternative. It can be adjusted background mortalities and the willingness to pay for additional health outcomes to the respective jurisdiction and the information provided by the tool can be used for an early and iterative assessment of innovations' cost-effectiveness in a particular health and care setting.

Regarding the main issues or weaknesses encountered when applying the methodology, it may result difficult to collect the necessary data to populate the tool and also it could be difficult to estimate an intervention in 3 states, so it could be considered difficult to be used by health and social care institutions. On the other hand, its main strengths are that it is flexible to represent all kind of interventions and it has the institutional support from the EC.

2.2.3 Open Platform Ecosystem Assessment Framework (OPEA)

Developed in the context of CIP-ICT-PSP project ReAAL (ReAAL Project 2016), the main objective of the framework is to collect evidence about the impact of adopting an open platform in the development of AAL services on a large scale, specifically addressing the socioeconomic benefits.

The framework consists of three parts, which have been developed iteratively:

1. **OPEA conceptual model.**

   It originates from a general model for telemedicine assessment (the MAST model, see section 2.2.1), but it was thoroughly revised to make it applicable to the AAL domain, and the context of open platforms. Compared to the MAST model, the technical and economic domains are more elaborated. The model covers the following domains: Assistance problem & characteristics of the application and platform, Technical aspects, User perceptions, Outcomes, Economic aspects, Organizational aspects, Contextual aspects, Showcases. The conceptual model was further operationalized using DeLone and McLean's Information Systems Success Model (ISS) (DeLone, McLean 2003), which is a model that draws causal relationships between the integral quality of an information system, its use and its experienced benefits. The ISS model provided with a set of concepts that were translated to relevant indicators for the evaluation of the open platform.

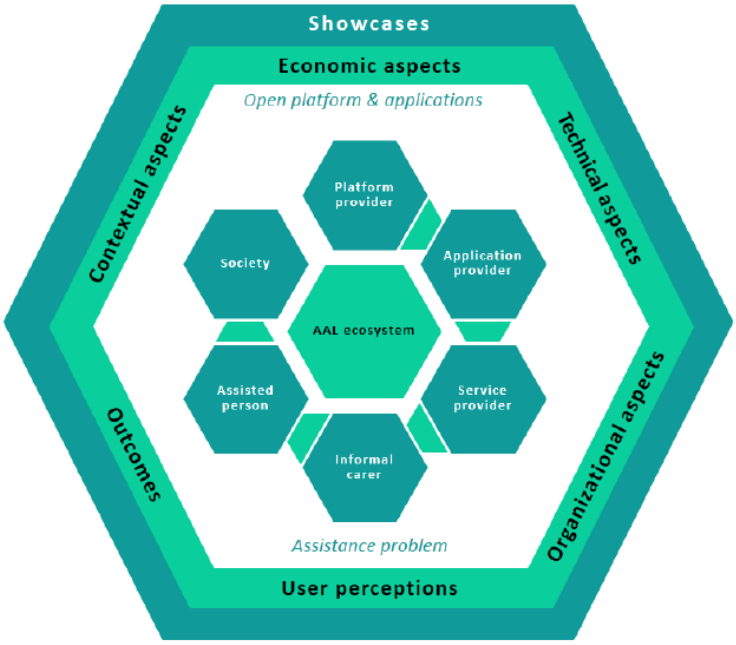


Figure 4 OPEA Conceptual model

2. **OPEA indicator model**

   It is a three-dimensional model that assisted in the construction of relevant indicators. The first axis depicts the value network of the AAL platform provider, AAL application provider, Health Service or Social Service provider, the informal carers, assisted persons and

society. All stakeholders are relevant for the evaluation of the open platform ecosystem-in-use, and they have their own value objectives for deploying AAL services on an open platform. The second axis marks the assessment domains of the evaluation: assistance problem and characteristics of the open platform & applications, technical aspects, user perceptions, outcomes, economic aspects, organizational aspects, and contextual aspects. The third axis relates to the three levels of assessing the AAL ecosystem: the platform, application, and service level.

The value objectives of axis 1, the domains of axis 2 and the levels of axis 3 are joined in a list of indicators that are used in the evaluation design.

3. OPEA evaluation design

The evaluation relies on quantitative evidence as well as qualitative insight into the development, deployment and operational processes

The evaluation strategy takes a double approach: the evaluation of pilots and the evaluation of showcases that demonstrate the value of open platforms. Each pilot is involved in one or more showcases.

The pilot evaluation consists of two phases:

– Phase 1 evaluates the adaptation of services to the open platform and testing;
– Phase 2 evaluates deployment and operation.

The data collected in the pilot and showcase evaluation is combined and complemented in the final step of the evaluation: the impact evaluation. This final step is meant to validate overall results (findings about the value of open platforms), and draw scenarios about the impact for the AAL market beyond the scope of the project. In this step we specifically look at network externalities.

Both the pilot, showcase and impact evaluation use multi method designs with qualitative and quantitative data. The following data collection tools are used: questionnaires, focus group interviews, individual interviews, templates, and blogs. Other materials (reports) can be added as a source, for example test reports or operation reports. The showcase evaluation is designed as a technical demonstration and value assessment from the perspective of different stakeholders. The impact evaluation uses all previously collected data, and adds to this dedicated focus groups of the consortium, questionnaires to stakeholders outside the consortium and discussions with experts.

Regarding the main strengths, OPEA is specifically tailored to assess socio-economic benefit of open platforms in the AHA domain and it addresses the whole ecosystem around the AHA solutions. On the other hand, its comprehensiveness makes it very resource demanding, as it includes an extensive list of indicators that generates a cumbersome execution of the evaluation framework.

2.2.4 Conclusions of the analysis

In the following tables a summary comparison of the three frameworks is presented.

Table 1: Mapping assessment frameworks and evaluation domains

	Patient perspectives	Clinical effectiveness	Economic aspects	Organisational aspects	Socio-cultural, ethical and legal aspects	Safety	Technical aspects
MAST	X	X	X	X	X	X	
MAFEIP		X	X	X			
OPEA	X	X	X	X	X	(incorporated in techni	X

Table 2: Assessment frameworks comparison

	Refers to specific domain?	Refers to specific target population?	Refers to Triple Win?[1]	Main strengths	Main weaknesses
MAST	Telemedicine	No	No	• Strong scientific background and validity • Multidisciplinary	• Time consuming • Suited for mature interventions
MAFEIP	No	No	Yes	• Flexibility • Institutional support	• Difficult to collect all necessary data
OPEA	AHA	No	Yes	• Tailored for socio-economic benefit of open platforms • Consider whole ecosystem	• Resource demanding

The work for defining the GLOCAL methodology to be used within ACTIVAGE project will take into account the lessons learned from the analysis done, incorporating the main strengths of the models reviewed, starting from the assessment domains defined by MAST and using the Triple Win strategy for indicators classification, integrating as much as possible existing tools and methods for KPI definition and measurement.

[1] EIP-AHA triple win strategy refers to (1) more healthy life years, (2) a sustainable health system, and (3) innovation and growth

2.3 IoT ecosystem domain

ACTIVAGE project is built upon two Business Ecosystems: the *Active and Heathy Ageing Ecosystem* and *the IoT Technology Ecosystem* (see deliverable D8.1 Impact Attainment Strategy, section 3.2 a)

An *IoT ecosystem* is a global business ecosystem not constrained to any geographical boundaries, where members share the common goal of consolidation and growth of IoT technologies market worldwide through standardization, interoperability, and technological innovation (D8.1 section 3.2 b).

Other deliverables in WP3, WP4 and WP5 provide detailed information about the IoT ecosystem and their relationship with the AHA communities, that is, to conceptualize, measure and validate the effect and then the value that an IoT approach has in the AHA domain.

In the context of D6.1, the goal is to understand the main elements of an IoT solution, transform them into *Indicators and Value* for the AHA domain and converge *Indicators* and *Values* into a reference evaluation framework for the IoT-AHA ecosystem that ACTIVAGE aims to create.

Further versions of this document will provide concrete elements and definitions. In this first iteration of D6.1, the main aspects and preliminary considerations are provided.

2.3.1 IoT architecture

For the sake of simplicity and taking into account the context of WP6, the main elements of a technological architecture for IoT systems can be roughly grouped into *devices, edge, and cloud* (Scully 2016)**.** These categories define where the computation is performed. At device level, sensors are used to collect data, whether they are measurements from the end-users' body (such as body temperature, oxygen in blood, heart rate), end-users' activities (such as number of steps walked, or entering a room in a house), end-users' environment (such as air quality, or amount of light). Devices may perform some elemental signal processing, but at this level the processing is limited.

Once the data is collected from sensors, it is typically sent through either a personal area network, or a local area network to the local gateway. Gateways, typically smartphones, set top boxes or personal computers, coordinate the data from all sensors as well as the control of any actuator in the edge space. This level is called edge computing, where the data is processed, stored and contextualised typically for self-use of the user as at this level interfaces show the user their historic data, as well as key interventions to improve their quality of life.

Edge computing is limited to the data gathered around the gateway, this fact may limit the capabilities of the solutions and services offered to the user. Afterwards, gateways connect to the Internet, where they interact with cloud services. These services are used to extend the features of the services, by for example enabling gateways to collect relevant data or by compiling data collected from many gateways, and many more devices, in order to extract population wise information.

This architecture is a gross simplification, as in some particular cases it is not followed. For example there are devices that do not require gateways to send information to the cloud services; gateways may connect to other gateways; and services and solutions may be served directly from cloud servers.

IoT is a complex field that stresses connectivity of devices in order to allow data to reach wherever it is needed. The revolution lies on a series of factors, from the cost reduction of hardware, increase of semiconductor speed and capabilities and connectivity improvements at all network levels. Yet there are some legacy designs, like traditional devices and client-server paradigm, that need to be incorporated in to the concept, thus new software artefacts

need to be created to incorporate these solutions and make it easier to interconnect the different layers; this is where the need for platforms arise.

IoT platforms enable applications to abstract common tasks and reuse features for an easier and cheaper development, testing, configuration, deployment, and administration of the whole system, in addition to enabling interconnection and interoperability between any device, software module, and even services.

2.3.2 IoT Value for AHA

IoT offers a set of concrete values for AHA systems that need to be measured, analysed and evaluated throughout the ACTIVAGE project (Research Nester 2017). A preliminary and not exhaustive list of values is provided below:

Service Transparency: The capability of a service to be offered, regardless of the technological infrastructure.

Service Personalization: The capability of adapting the service (or a set of services) to the particularities of each user.

Security and Privacy: The assurance that the system is safe, secure and that personal data is not distributed where it should not.

Technology Usability and acceptance: The feature of users being to overcome the technological barrier and take profit of the extra help to improve their lives.

Use Case Reusability: The capability of implementing the same use cases and business cases in other regions.

Data reusability and share-ability: The capability of making same data produced by a person for one or more services in his/her own benefit, to be used on services towards other persons and to be used by organizations for many goals, like measuring service's quality, managing and improving care processes, as these data have been preserved in their privacy and security conditions.

Service dynamism and interoperability: The capability of creating new services by composing other services.

Service Optimization: The capability of scaling both the internal resources to offer a concrete service as well as the number of services, to offer the perfect balance of results and costs.

Service costs and scalability: The capability of the service to restrict to a budget, and or maintain a discrete running costs even when operating with many more users.

Application specialization: The capability of providing specialised applications that otherwise would not be cost effective.

Open ecosystems: Marketplaces where hardware, software, and services can be offered, compared, demonstrated, and consumed.

Data availability and processing: The capability of using the collected, derived and even neglected data to improve the service and the quality of life of their users.

Connectivity improvements: the technological advancements that foster the capability of sharing data and services faster, more pervasive, with better availability, at reduced costs.

2.3.3 IoT Indicators

The whole IoT concept is built upon the premise of collecting data and sharing such data with other entities (Soldatos et al. 2014). In effect IoT builds the perfect system to collect indicators directly from the users and deployment sites. These key indicators stemming from IoT, or that can be collected through IoT can be classified by the source of the information:

– User data: like step counter or health data, it can be used to proof the user acceptance or the quality of life improvement. Typically gathered in the gateway or cloud (where the cloud allows for specific user data querying). From an evaluation perspective this data may be interesting but requires delicate balancing with data protection protocols and mechanisms.
– Aggregated data: data generated by the systems using multiple users' data and generating aggregated forms of it. This type of data is typically gathered at Cloud level, since it is aggregated there and provided by Deployment Sites. In some cases not all the user data is sent and aggregated in the cloud, thus this data may not convey the full story of the user experience, or other evaluation dimension we try to measure.
– User metadata: Data, which may or may not be currently collected, around the user's usage of the system, for example frequency of application usage. Metadata generated by the user by just interacting with the system is very interesting as it will provide a formal expression of the user engagement (as well as other measurable dimensions). Deployment sites may not store this data, or they may need to adapt their system so this type of data is transmitted.
– System metadata: data that is generated by the system itself such as frequency of connections, frequency of errors, time between failures, time to recover, number of required human interventions. This data might be useful to evaluate the quality of the service, or to contextualize other measurements (e.g. : users are not engaged, but this may be due to the system being down and not because they do not care).

These data indicators (together with others) will be useful to measure dimensions, such as System quality, User engagement / acceptance, Effectiveness / ROI, etc.

Other indicators, related to technical and functional performances of IoT solutions usually collected, are:

– Installation requested time
– Battery duration
– Number of maintenance intervention per year
– Number of failure per year.

In the next months, interaction with WP3-4-5 and WP9 will help to derive the list of Indicators that are going to be used in the evaluation activities.

2.3.4 ACTIVAGE AHA-IOT Ecosystem

The AHA-IoT ecosystem is envisaged by ACTIVAGE as a "hybrid" TECHNOLOGY – BUSINESS ECOSYSTEM which should be built around the technological assets designed and developed in ACTIVAGE, leveraging the evidence of value creation and experiences from the large scale piloting activities.

The main actors involved in this ecosystem can be classified in three categories: 1) technology developers, manufactures and vendors; 2) the customers of technology suppliers, and 3) service providers. All of them and their interest and expectations from this new AHA-IoT ecosystem are relevant in order to define appropriate KPIs enabled to measure the real impact and to guarantee its sustainability.

Details about AHA-IoT ecosystem can be found in deliverable D8.1 Impact Attainment Strategy, section 3.2).

The analysis and description of local ecosystem related to each DS would contribute to identify other organizational, business process, regulatory, financial, relevant educational features indicators as well as for the iterative approach of GLocal evaluation framework definition.

3 GLocal Evaluation Framework

3.1 ACTIVAGE Impact Attainment Strategy

The ACTIVAGE project follows its relevant objective: towards demonstrate and create evidence about digitally-enabled solutions and services for Active and Healthy Ageing, triggering the creation of the new AHA-IoT ecosystem and defined its sustainability.

This objective may be only available if a solid and multi-dimensional strategy is defined in order to maximize the impact of the ACTIVAGE project. The deliverable D.8.1 Impact Attainment Strategy (IAS), defines a complete strategy, analysing the key expected impacts of the ACTIVAGE project, phases when the impacts may be measured and strategic actions suggested for each WP in order to achieve each impact.

ACTIVAGE IAS is more than an impact strategy, it also identifies a set of KPIs that are shared with the GLocal Evaluation framework in order to check their feasibility and effectiveness at DS level. These KPIs allow measuring the real impact of the ACTIVAGE in each moment, refining any required correction actions.

Therefore, IAS and GLocal Evaluation framework will maintain a relevant bidirectional feedback across the project. We can distinguish two different parts:

– **From IAS to GLocal Evaluation Framework:** IAS and GLocal Evaluation Framework share IAS KPIs that may be involved in the GLocal Impact assessment. The figure 5 shows the roles and relationships between IAS and the GLocal Evaluation Framework.

– **From GLocal Evaluation Framework to IAS:** The GLocal evaluation framework provides DS with guidelines to measure the real impact, identifying strengths and weakness of the ACTIVAGE project and the DS, and feeding the IAS with information and data about the ACTIVAGE expected impact accomplishment. According to this evidence and knowledge, IAS will define and refine strategic actions in order to maximize the measured impact.

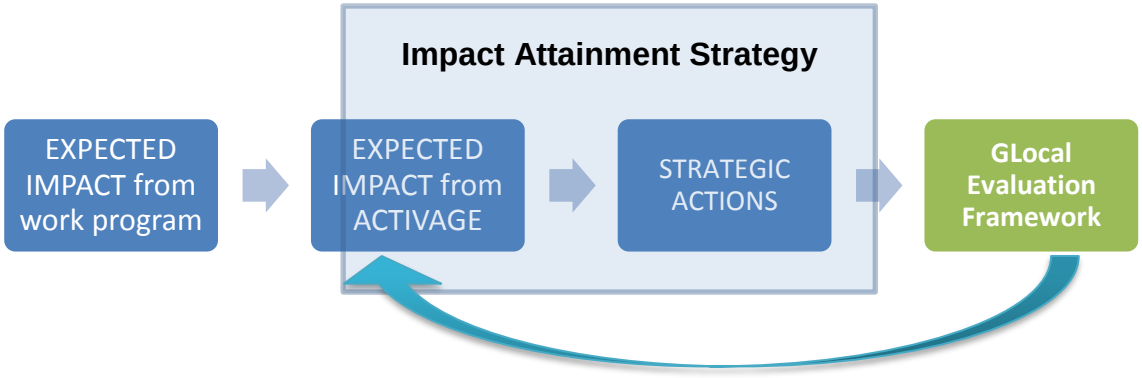


Figure 5: Relation between IAS and GLocal Evaluation Framework

Additionally, the GLocal Evaluation Framework may support the next **Strategic Actions** (S.x.x) defined in the IAS (for details see D8.1):

S.1.1 Define, together with relevant stakeholders, Global and Local KPIs related to such improvements and include them in the Evidence Generation and Impact Assessment Strategies.

S.3.3. Develop different studies to measure the user satisfaction of the ACTIVAGE solutions for older adults and caregivers focused on the improvement of quality of life, safety and wellness, and healthy and active ageing promotion.

S.3.4/S.5.1/S.8.1 Develop a continuum evaluation of users' acceptance, satisfaction and benefits, able to identify corrective activities to redefine the solutions.

S.5.1. Evaluate the maturity and accessibility of the AHA services based on IoT for European population.

S.5.2. Create evidence and make effective dissemination about the real benefits of the AHA services based on IoT for older adults and their carers & families.

S.7.3. Assess the impact of the AHA-IoT ecosystems based on KPI and create the evidence and key messages.

S.7.4. Validate the evidence creation with IoT and AHA communities.

3.2 GLocal Framework Objectives

The GLocal evaluation framework aims to provide a clear reference instrument to collect data and to support the impact assessment at DS level in order to generate an overall critical mass of evidence and quantified KPI.

As a consequence, the GLocal approach is tailored to optimize exploitation results, to implement a process enabling federation of results between the different DSs and to provide a reference evaluation framework for AHA-IoT Large Scale Pilot at European scale.

More in detail, the GLocal methodology aims to reach the following conceptual and procedural results:

– To constitute a reference coherent evaluation framework to support impact assessment conducted at DS and at whole project
– To promote the reliability of data evidence thanks to the use of IoT solutions
– To share a common glossary for service description and assessment outcomes representation
– To deliver guidelines and instruments supporting the scaling up and replication process of AHA-IoT services.

These objectives will be pursued trough a strategy based on the following key activities

– Avoiding to start from scratch, but building on top of previous large pilot evaluation experiences and reference assessment methods.
– To exploit reference tools, such as ontologies and glossaries, to harmonize and have a consistent and homogenous approach to the identification and definition of AHA-IoT services and KPIs.
– To follow a bottom up approach to effectively represent local ecosystems
– To implement tailored Data quality check and Data Management policy.
– To adopt an iterative protocol.

3.3 The "GLocal" Approach

The ACTIVAGE GLocal Evaluation Framework is based on a clear definition of the "***GLocal"*** concept: GLocal does not mean partially local and partially global; nor in the middle between Global and Local approach, but simultaneously **FULLY GLOBAL** and **FULLY LOCAL:** GLocal

approach is tailored to preserve all the specificities that make local evaluation methodologies in line with their objectives, but, at the same time, creating trans-DS reference KPI and protocols to be able to merge and compare each DS outcomes toward a global impact and evaluation assessment.

In order to achieve this result, the ACTIVAGE project defined a GLocal Evidence Generation protocol, which is described in the following sections, enabling the coherence of these two dimensions and supporting the scaling up process from local to global dimension.

Tangible outputs are foreseen from these activities, in particular:

– GLocal methodology
– GLocal solution
– GLocal results and data usable by partners or by others actors.

3.4 GLocal Evidence Generation Protocol

It is of paramount importance that each DS follows a specific procedure to generate evaluation data and to assess impact through a set of harmonized tools and methodologies. To achieve such a goal WP6 will implement a specific “evidence Generation Protocol” to be adopted at DS level. The general goal of the process is to provide guidelines and tools for studying how health policies impact is evaluated, how evidence is built, which are the indicators, targets and assessment tools used, if any.

Because of the relevance of a community-based approach, also emphasized by the Sustainable Development Goals Agenda (United Nations 2016), a ***bottom-up approach*** is deployed in order to create an authentic and reliable baseline at local level that can provide a structured input to an overall project impact assessment.

The local detailed analysis of enabling factors and evaluation data is considered crucial for building a shared understanding of the DS context and which are the contingency actions that enable the promotion of the AHA-IoT framework.

Previous experiences show that in absence of such data and analysis there is a relevant complexity to compare different results and to provide a clear reference-understanding framework to the key stakeholders.

In order to support scaling-up and replication strategy of AHA-IoT, local ecosystems modelling and impact assessment it is important but it is not enough as previous experience and on-going initiatives have demonstrated; there is a need of a Global approach to identify and implement replication model and strategies.

Financial, procurement, service organization, user engagement policies, stakeholder education, capillarity of the services are crucial aspects to be taken into account.

To reach this objective, the GLocal Evaluation protocol structures Evidence and Replication information based on proper integration of local and global dimension.

3.4.1 Local Evidence Generation process

An iterative data generation process is implemented at Deployment Site level. The overall process is based on three main phases that aim at determining:

1) Local ecosystem features
2) How the evidence is generated
3) Evaluation Framework Updating

1. LOCAL ECOSYSTEM FEATURES

a. AHA Service and Local Ecosystem Modelling
b. Local Key Performance Indicators and targets definition (Local KPI)
c. Data source and data gathering mechanism definition and validation.

2. EVIDENCE GENERATION

a. Service deployment – pilot phase
b. Data collection and data quality check across all deployment and execution phases.
c. Local KPI measurement
d. Identification of key success factors
e. Analysis of correlation among success factors, local ecosystem and perceived benefits.
f. Overall Evaluation and Impact analysis performed at DS level
g. Input generation for Overall project Evaluation and Impact assessment analysis.

3. EVALUATION FRAMEWORK UPDATING

a. Corrective actions analysis and promotion:
b. AHA Service Model template updating (focus on "hidden" enabling factors and barriers)
c. Evaluation Framework and KPI table updating

3.4.2 How to extract global indicators and guidelines?

In order to support extraction of Global Indicators and to implement specific guidelines, the GLocal protocol foresees two main steps:

1. Identification of a short list of mandatory GLOBAL KPI to be taken into account from each Deployment Site.
2. Classification of specific groups Local KPI Second Step intertwined to a specific ***"big research question***" in a dedicated "Box". We define as a "big research question" a precise inquiry related to a specific large issue.

Building a list of Global KPI and Big research question Boxes will follow the following steps:

1. Selection of the set of common Local KPI providing a short list of Global KPI.

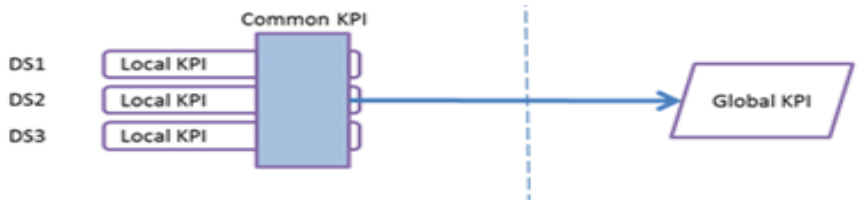


Figure 6: Global KPI selection process

2. All the other Local KPIs are redistributed in 8 boxes, representing 8 Big Research Questions.

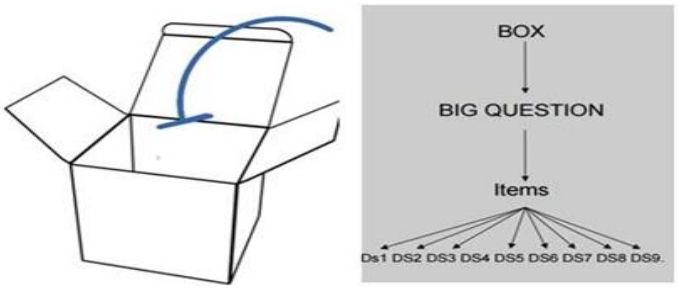


Figure 7: Box and Big Question

Why "Boxes"?

In the different DS of ACTIVAGE project, IoT solutions are related to different AHA issues such as: connected health, health-promotion, prevention, training, medical follow-up post-hospitalization, autonomy, active ageing.

The literature proves at least that no IoT added-value should be taken for granted (Bower et al.) and that all those items shall be checked and that any supposed added-value provided by IoT should be proven within the project and before building any exploitation plan or business plan. Therefore it is particular relevant to empower a proper AHA – IoT evaluation framework.

Considering this, a huge amount of medical Local Performance Indicators, QoL KPIs, Organizational Local KPIs, economical local KPIs, sustainability local KPIs, acceptability KPIs, innovation local KPIs, Education local KPIs shall be measured within ACTIVAGE.

Consequently, the GLocal evaluation framework will take into account items such as:

IoT expected impact categories

- Health benefit
- Autonomy
- Quality of life
- Quality of life at work
- Prevention
- Health promotion
- Social life
- Gains of time
- Money saving
- Organization of care
- Sustainable living at home
- Co-Design and Users engagement

Facing this variety and multidimensional dimension of Local KPI and in order to, simultaneously, taking them into account, respect their specificity and allow a global approach, we proposed 8 boxes (Big Research Questions) in which Local PIs are agglomerated when possible, classified by themes, DS, item.

Each DS and/or each Use Case (UC) shall put its indicators in the proposed boxes. One box corresponds to one Big Research question.

Starting from the preliminary Local KPIs from DSs, the following Research Question have been identified:

List of Big Questions:	N°
• How does my solution impact well-being and QoL of end-users?	1
• Does my solution provide a clinical benefit?	2
• How does my solution impact the organization of care?	3
• Does my solution allow money savings, gains of time? What costs/benefit ratio?	4
• Is my solution acceptable? Unacceptable?	5
• To which extend my solution is sustainable?	6
• Do my solution imply ethical, legal, social or cultural issues? How? Why?	7
• Is my solution reliable in real settings?	8

Figure 8: Big Questions

Big questions are compliant to the items and subjects of current reference evaluation frameworks, like MAST (Kristian et al. 2012) and MAFEIP (Fabienne, Boehler, Lluch, and Sabes-Figuera 2014):

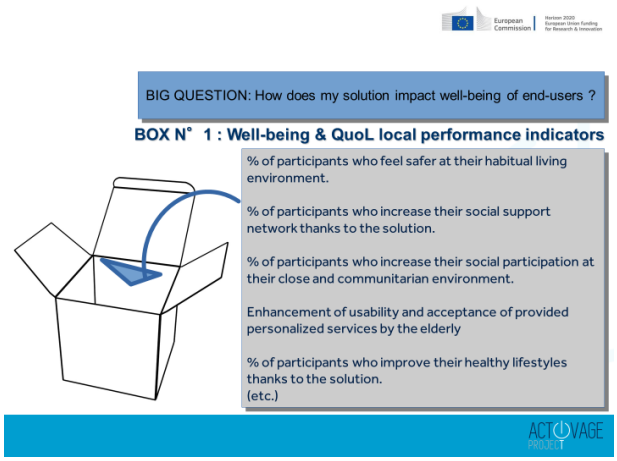


Figure 9: Box and Big Question, an Example

Through a process of iteration, boxes can be defined and iteratively fed with new data uploaded by each partner. This approach will allow to generate a set of **GLocal Key Performance Indicators** enabling to see at a glance how an item is measured or a big question is managed throughout the different DSs and, consequently, in those different European ecosystems. With such a "Boxes approach", it is possible to see at a glance how an item is measured throughout the different DS within its specific ecosystem. This will provide:

– ACTIVAGE partners with a robust tool to compare and in case aggregate results.
– IAS strategy with a set of KPIs able to cover all the Global IAS KPIs (details can be found in deliverable D8.1 Impact Attainment Strategy)
– decision makers willing to define a scaling up or replication strategy with a set of evidence and tools to assess the impact of the specific strategy adapted to local ecosystems taking into account the specificities of the local context.

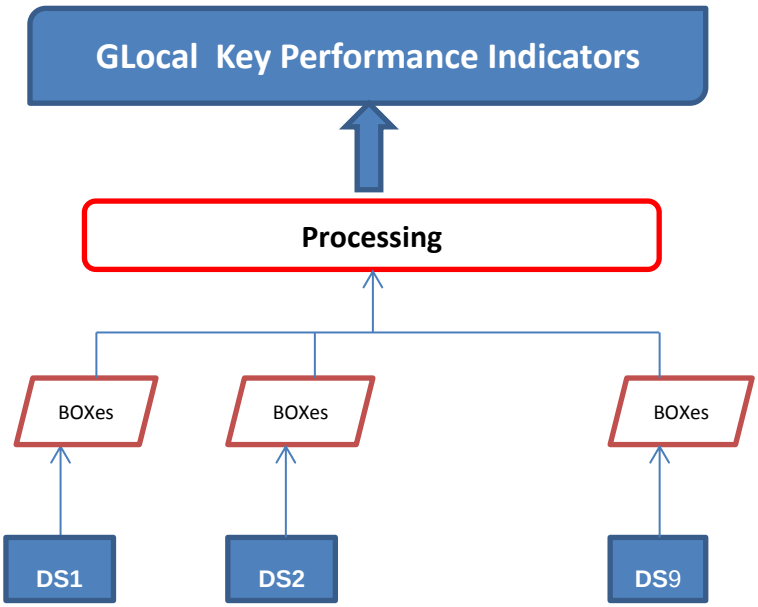


Figure 10: GLocal KPIs extraction

3.5 GLocal instruments

GLocal Evaluation Framework provides some reference instruments supporting the implementation of the GLocal Evidence Generation protocol:

- AHA – IOT Service and Local Ecosystem Modelling (AHAIOTES) Questionnaire
- Key Performance Indicators Table
- GLocal Software infrastructure

3.5.1 AHA – IOT Service and local ecosystem modelling

The **"***AHA-IoT service and local EcosyStem modelling*" (AHAIOTES) is a list of questions aiming to extract local ecosystem features and key factors enabling high intake of the service and promoting its replication and scaling up.

The questionnaire is aligned with some reference models aiming to facilitate the scaling-up of good practices by recognizing their maturity requirements. We specifically refer to the SCIROCCO Maturity model (Scirocco Project 2016) that has been defined under the B3 Action Group of the EIP-AHA strategy.

SCIROCCO is a validated self-assessment tool that evaluates healthcare systems across 12 different "dimensions":

1) Breadth of ambition.
2) Capacity building.
3) Citizen empowerment.
4) Evaluation methods.
5) Finances & funding.
6) Information & e-Health services.
7) Innovation management.
8) Population approach.
9) Readiness to change.
10) Removal on inhibitors.
11) Standardization & simplification.
12) Structure and governance

Every dimension defines a set of established multidimensional indicators of maturity that allow developing an unbiased assessment of the maturity of the healthcare system.

This assessment shows a spider graphic of the current status of the evaluated healthcare system, identifying key point such as weakness and strengths, identify gaps and improving areas, benchmarking with other systems.

According to the SCIROCCO approach, the AHAIOTES questionnaire aims at helping decision makers to identify:

– the context requirements of a good practice that is considered for adoption,
– the level of maturity required for the health and social care system to adopt a particular practice,
– the actions that more progressive regions have taken in order to be successful,
– lessons learned from these pioneers to overcome barriers and accelerate results,
– the process of information sharing on lessons learned to help other aspiring regions to speed up their own adoption.

The questionnaire includes, among other things, analysis of the AHA-IoT service features, users and policy makers engagement, matching with regional policies, attitude to measure services' performance, availability of a software platform able to pool the collected data (see the Annex 1 for details).

Such local analysis is useful in order to compare results that facilitate the identification of common features thus enabling a scaling-up and replication process.

This analysis will be updated at the end of the pilot phase according to an iterative data evidence generation process.

3.5.2 Key Performance Indicators Table

The second instrument provided by the GLocal framework is a template to collect key performance indicators, data source and target. The aim of the model is to endow DSs with an instrument allowing them to evaluate the impact and having a concrete picture of where they are and where they can arrive setting targets and data sources.

The local KPI template follows the Triple Win Strategy (EIP-AHA 2015c). As such, according to their domain, KPI are divided in the following sections: ***Quality of Life***, ***Sustainability*** and ***Innovation & Growth***. DSs have to provide indicators for each section, including data source and associated target. It is also foreseen that each indicator answers to one or more big questions that cover the Triple Wins sections as reported in Figure 9.

Indicator	Data source	Target	Big question N°	USE CASES	UC#1	UC#2	UC#3	UC#4
impact on QoI			1,2,5					
Sustainability			3,4,5,6,7					
innovation and growth			3,6,8					

Figure 11: KPIs Table template

Use Cases are reported and indicators considered by DSs are referred just to the set of use cases belonging.

The template is not a rigid tool, but it is flexible. In fact, DSs have the possibility to iteratively update indicators until reaching a final version.

This is considered as a valuable structure in order to clearly identify and understand the vital indicators as well as the **vision** for the future.

3.5.3 GLocal Software infrastructure

Evaluation Data concerning every GLOBAL and GLOCAL KPI per sites will be collected in a global data-repository called "***ACTIVAGE Evidence Open Data Base"*** that will be implemented and exploited by ACTIVAGE project.

According to the DoA, this repository represents the backend component of the **GLocal Software platform** that have three different user interfaces (views): 1) the LSP-Dashboard; 2) the ACTIVAGE Public Evidence Website; 3) and the AHA-Advisor[2].

- The "**LSP Dashboard**" is a user interface to be accessed by partners of the project in charge of managing and coordinating the DSs.
- The "**ACTIVAGE Public Evidence website"** is a user interface to be accessed openly by any person or professional interested in accessing the underlying ACTIVAGE Evidence Open Data Base, by accessing pre-defined reports or making queries that allow creating composition of underlying data, and project data analytics
- The "AHA-ADVISOR" will provide a reference web-based ICT multi modal platform providing, to people interested to know about IT solution for aging well, with broad range of services and benefits in the domain of Smart Living and self-monitoring devices for aging well.

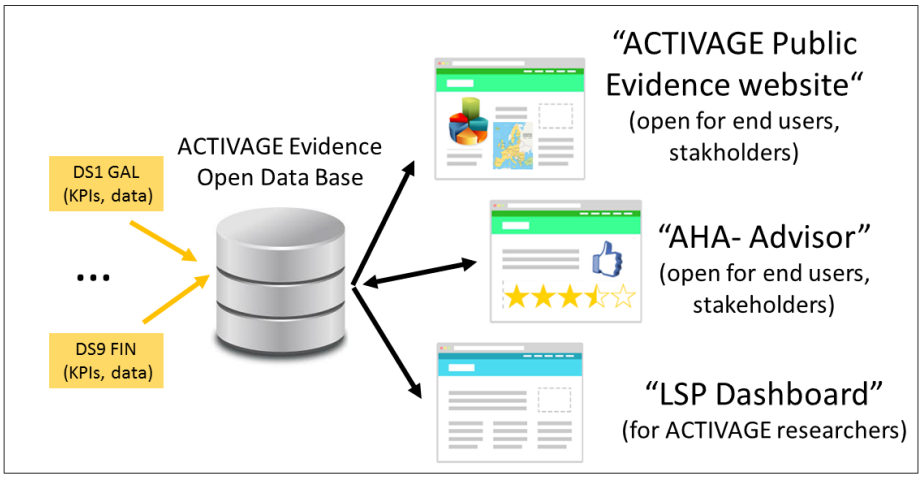


Figure 12: The ACTIVAGE Evidence Open Data Base and its user interfaces

The GLocal platform is an essential tool supporting the ACTIVAGE assessment framework that provides a set of high value-added services such as:

[2] Active and Healthy Ageing Advisor (AHA-Advisor), inspired by "Trip-Advisor" tool for travel, restaurants and leisure.

- Data collection service: this service will allow a fast and effective data collection taking into account different assessment methodologies and the reference KPIs.
- Modular user profiling service: a model will be designed to formalise the profile of the user, taking into account the evolution in terms of user wishes and competences. Upgradability and adaptability are ensured using ontology-based models such as GUMO that permits the merge or the composition of several related concepts. This service will rely on these models for managing user profiles.
- Intelligent Monitoring Service: this service will be based on data analysis and data aggregation techniques that allow easy interpretation of evaluation data coming from different pilot sites.

GLocal platform development will follow an iterative approach. Details about the platform will be found in deliverable D6.2. In order to build a first version of the tool, in addition to the elements defined in this deliverable, those that have been defined in D1.4 will be considered too, as shown in the next figure.

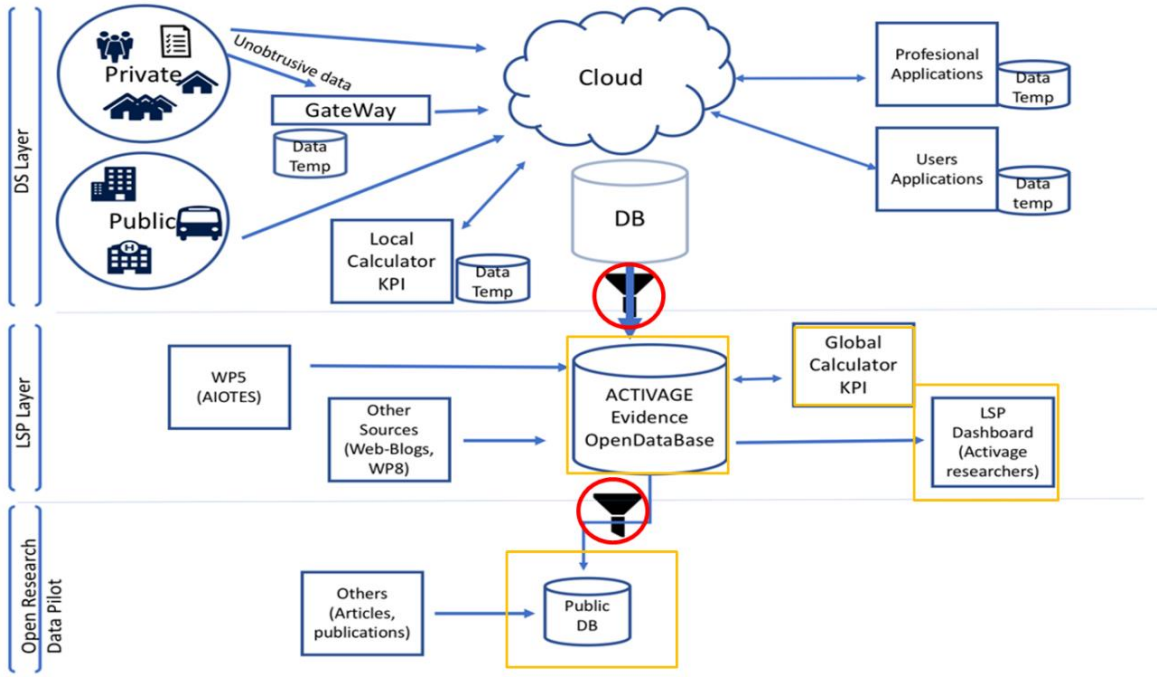


Figure 13: The ACTIVAGE data Life Cycle Management Model

As highlighted in the figure, WP6 will define the filters to derive and transfer information from DS to the LSP level, that is the rules and properties that allow to create GLocal and Global KPIs, as well as the filter to transfer information to be used at Public level through the Public DB.

In parallel to this, the views and access to the different stakeholders will be defined in the next versions of the tool, while the first version will focus on the data model and on the calculation of the different categories of KPIs.

4 Global Key Performance Indicators

According to the GLocal Evidence generation protocol (see Section 5.4), every DS filled its first version of Local KPI Table (see the Annex 2 for details) .

Starting from this preliminary result, a short list of **Global mandatory indicators** has been identified: these are common to every DS both in terms of type of indicator and Data Source.

Then, Global KPI Table could be updated according to the iterative evidence generation protocol.

Table 3: Global KPI v1.0

Indicator	Data source
Impact on QoL	
Users QoL	HRQOL, EQ-5D-5LAQoL-7D
Social Interaction	Iterative questionnaires/interview and IoT tool feedback : Communication Social relationship Social interaction home visits frequency Activities attended Using IoT tool to measure
Safety Perception	Self assessment questionnaire
Daily Physical activity	Barthel, Activities of Daily Living Inventory
Number of Hospitalization and re-hospitalization	Visits being monitored in comparison to the control group.
Sustainability	
Number of Hospitalization and re-hospitalization	Visits being monitored in comparison to the control group.
Number of participants to the service	User Experience Questionnaire
Improved efficiency of service providers	User Experience Questionnaire/Administrative and economic official data
Costs reduction	Administrative and economic official data
Innovation and growth	
New IoT based AHA Services	Number of services
Number of services with a performance evaluation system	Number of services

5 Conclusion

Evaluating the impact that a service could have in a specific scenario is fundamental. As such, an assessment framework must have all the elements able to produce the EVIDENCE. The GLocal Evaluation framework has this aim. This first deliverable's version would have the expectation to be a first brick towards the iterative building of the final framework. As such, a first description of the framework has been provided in order to offer a picture of the goal and the direction that GLocal Evaluation Framework is going to undertake.

In our view the bottom-up approach as well as the alignment to the scaling-up strategy are the added values highlighting local features, but maintaining and boosting a global perspective.

During the project lifespan, through the piloting phase, lessons learnt will help us in improving the framework, in updating local KPIs, in refining and enriching Global short list of KPIs and finally in elaborating a concrete set of GLocal KPIs and features that would be scaled-up in different contexts and that will support the Impact Attainment Strategy developed in WP8.

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Appendix A AHAIOTES questionnaire template (v1.0)

A.1 AHAIOTES QUESTIONNAIRE V1.0

The AHAIOTES questionnaire is part of the GLocal Evaluation protocol. It aims to help you to describe and model your AHA – IOT service and local ecosystem.

The service modelling consists of the analysis of different service components and dimension as hereafter:

AHA-IOT Service

Which is the specific demand the service has to address?

Which are the objectives of the service?

Which is the target user group? (for details please go to the "Local ecosystem modelling" section a))

Which are the other stakeholders and their role? Is there a Case Manager?

Which is the service workflow?

What is the maturity level of the service:

a. Improvement of a service that is already complaint with regional health program: Whist is the deployed improvement? (please go to the "Modelling of the context" section C)
b. It is a disruptive innovative service: Is it supported by a political demand?

What are technological requirements? (connectivity, adoption of standards..)

USERS ENGAGEMENT

How does it work the users engagement?

Who is in charge for user engagement?

What is the percentage of contacted users that join the service?

Number of training sessions towards end users/ other stakeholders

Who is the trainer?

Average time to deploy the service

PERFORMANCE INDICATORS AND DATA COLLECTION

What data is your local healthcare or social system already collecting?

What further data will be collected?

How can new data collection processes fit with existing processes? (please refer to the KPI Table)

What impact assessment tool do you plan to use (MAFEIP, MAST….)

HOW will be data collected?

a. Paper-based modalities
b. Software tool

Who will get what information?

Who will elaborate information?

Who will see information?

How do you will implement quality check data entry to guarantee “good” data?

OUTCOMES TOWARDS DECISION MAKERS

Who are local Decisions Makers for your service: healthcare professionals, policy makers? Are technology providers involved?

Which Expected Outcomes measurement should be used to inform our decision-making and priorities?

SUSTAINABILITY MODEL (second iteration)

Which are the Service start-up costs (investment costs)?

Average time necessary to deploy the service (to complete the start-up phase) ?

Service business and payment model: is the service exempt by the State? Should users face out of pocket payments? Could the service be defined universally accessible?

Which is the foreseen time to return on investment (timeframe for investment)?

Is the service able to promote local economy?

Is the service able to innovate itself? Is it receptive to user requests?

Are universities or private sector companies involved in the innovation process?

A.2 Local Ecosystem Modelling

Local Ecosystem Modelling

a. Target Stakeholders

End Users: age/sex/needs/social context/economic resources/personal attitude towards technology and sharing of data

Healthcare providers: age/sex/needs/reimbursement schemes/digital literacy and personal attitude towards technology and sharing of data

b. Political Level

Are there any strategic plans supporting healthcare services’ innovation adoption?

Where is the focus of public investment on healthcare (e.g., emergency department, early diagnosis of rare diseases, chronic care, hospitals, and / or integrated care)?

Services Performance Measurement: which types of data are currently measured, if any?

Previous experience in service's scaling up:

- Not
- Yes. If yes, which is the enabling factor and which is the most critical one

c. Service Baseline

How many users have been involved?

Have been the users involved for a trial or for the engagement in a routine service?

Why the baseline service is not running yet? Which has been the most critical factor?

Which are the lessons learnt?

Please insert your Name and professional background

_____-

Name

_____-

Professional Background

_____-

Organization

Appendix B Local and Global KPI Tables v1.0

Indicator	Data source
Impact on QoL	
Users QoL	HRQOL, EQ-5D-5LAQoL-7D
Social Interaction	Iterative questionnaires/interview and IoT tool feedback : Communication Social relationship Social interaction home visits frequency Activities attended Using IoT tool to measure
Safety Perception	Self assessment questionnaire
Daily Physical activity	Barthel, Activities of Daily Living Inventory
Number of Hospitalization and re-hospitalization	Visits being monitored in comparison to the control group.
Sustainability	
Number of Hospitalization and re-hospitalization	Visits being monitored in comparison to the control group.
Number of participants to the service	User Experience Questionnaire
Improved efficiency of service providers	User Experience Questionnaire/Administrative and economic official data
Costs reduction	Administrative and economic official data
Innovation and growth	
New IoT based AHA Services	Number of services
Number of services with a performance evaluation system	Number of services

Indicator	Data source	Target
Impact on QoL		
Reducing adverse events related to comorbidities	Data comparison through SOLE network and EHR (Emilia Romagna eHealth infrastructure	35% reduction
More active participation in the care process	Social Interaction (Kane Scale)	25% increase
Improved interaction paradigms	User Experience Questionnaire (ADL + IADL)	-40%
Improvement physical well-being	MSQOL-54	15%
Sustainability		
Reduction of hospital admission and days spent in hospital	Administrative Data: Hospital Discharge Data (SDO)	20,00%
Reducing frequent visits to the Emergency Department	Administrative Data: Emergency Admission Data (PS)	30,00%
Reduction of re-hospitali-sation rate	Administrative Data: Hospital Discharge Data (SDO), Home Care (ADI), Severe Acquired Disability (GRADA)	40,00%
Users' relatives: decrease in days off work	CarerQol-7D Informal Care Questionnaire (still under discussion)	after +5 years: 25% 2 days per months
Monitoring and reducing consumption of assistive devices for post-stroke patients (observation from the beginning of the pilot)	Administrative Data: Assistive Device	
Innovation and Growth		
Number of Open Source components made available	Count publications on open source platforms like GitHub etc.	at least 5 (still under discussion)
Creation of a market place for apps addressing ageing well need and older people requirements	Record date of market place creation / count number of apps available	target date / target number of apps
enable new services linked to IoT and increase the number of services provided by social assistance cooperatives	User Experience Questionnaire (ADL + IADL)	Up to 30%
Increasing the size o the spin-off ICUBO: 50% new employees	Verify new employee contracts	

USE CASES	1. Daily activity monitoring	2. Integrated care	3. Monitoring assisted persons outside home	4. Emergency trigger	5. Exercise promotion	6. Cognitive Stimulation	7. Prevention of social isolation	8. Safety, comfort and safety at Home	9. Support for mobility
	Yes	Yes			Yes		Yes		

EMILIA-ROMAGNA

Indicator	Data source	Target	USE CASES	1. Daily activity monitoring	2. Integrated care	3. Monitoring assisted persons outside home	4. Emergency trigger	5. Exercise promotion	6. Cognitive Stimulation	7. Prevention of social isolation	8. Safety, comfort and safety at Home	9. Support for mobility
impact on QoI												
KPI4 2a: Gains on the Rate of rehabilitation	Savings created in the use of rehabilitation compared to previous costs. Questionnaire of how often and what price has the client previously been receiving rehabilitation	20% efficiency in rehabilitation		Yes	Yes			Yes				
KPI 3a: Reduction on PainRelief continuous medication while keeping the pain away	Pain relief measuring device	10% reduction in continuous medication need										
Sustainability												
KPI 1a: Assisted living total satisfaction of Patient and professionals	Patient satisfacton survey (likert), group interviews for random selected groups of professionals and end users	30% increase in the total satisfaction of customers and professionals										
KPI 1b: Assisted Living cost per patient reduction	Reduced costs, information from the municipalities. Reduced number of home care visits	15% reduction in assisted living costs										
innovation and growth												
KPI 1c: Amount of new findings through the use of IOT	New applications and innovations in the use of the IoT equipment in testbeds	5 new applications or business potentials										
KPI 2c: IOT use in monitoring the progress of rehabilitation rate	Data collection of rehabilitation exercises, quantities of use, quantities of consultation, nature of consultation	30% improvement in the rehabilitation rate										

FINLAND CLUSTER

Indicator	Measurement tool	Target	USE CASES	1. Daily activity monitoring	2. Integrated care	3. Monitoring assisted person outside home	4. Emergency trigger	5. Exercise promotion	6. Cognitive stimulation	7. Prevention of social isolation	8. Safety, comfort and safety at Home	9. Support for mobility
Impact on QoL												
Improve the quality of life of the users (Initial and final)	EUROQOL-5D	10% improvement		Yes	Yes		Yes		Yes	Yes		
Evaluate the improvement of the burden for the caregiver	Zarit Questionnaire	10% improvement		Yes	Yes		Yes		Yes	Yes		
Satisfaction survey about the service (Daily activity monitoring) (Annexe 4): installation, monitoring, personal attention ... (monthly)	An ad hoc survey will be designed in which the user must value the service through a Likert scale (1, unsatisfactory to 5, very satisfied)	Average of 3 or more		Yes	Yes		Yes		Yes	Yes		
Innovation and growth												
Evaluate preferences and perceptions of ACTIVAGE users on acceptability, trust, confidentiality, privacy, data protection and safety (Initial and final)	User Experience Questionnaire (UEQ)	10% improvement		Yes	Yes		Yes		Yes	Yes		
Creation of business case for use of IoT solutions for healthy ageing	Evaluation of project	show that viable		Yes	Yes		Yes		Yes	Yes		
Service sustainability												
% of voluntary dropouts decisions due to dissatisfaction with the service/total dropouts decisions	Analysis of data collected	<20%		Yes	Yes		Yes		Yes	Yes		
Reduction of number of access to the Hospital emergency services of patients with anticoagulated atrial fibrillation (ACAF): tele-monitored versus NOT tele-monitored	Analysis of data collected from Clinical Systems (EHR/HIS)	10%		Yes	Yes							
Reduction of number of access to the PAC (Point of continuous attention) emergency services for patients with anticoagulated atrial fibrillation (ACAF): tele-monitored versus NOT tele-monitored	Analysis of data collected from Clinical Systems (EHR/HIS)	10%		Yes	Yes							
Reduction of number of Face-to-face visits to Primary care visits of patients with anticoagulated atrial fibrillation (ACAF): tele-monitored versus NOT tele-monitored	Analysis of data collected from Clinical Systems (EHR/HIS)	10%		Yes	Yes							

GALIZIA

Reduction of number Home visits from Primary care professionals visits to patients with anticoagulated atrial fibrillation (ACAF): tele-monitored versus NOT tele-monitored	Analysis of data collected from Clinical Systems (EHR/HIS)	10%	Yes	Yes				
Reduction of hospital admission and days spent in hospital for patients with anticoagulated atrial fibrillation (ACAF): tele-monitored versus NOT tele-monitored	Analysis of data collected from Clinical Systems (EHR/HIS)	20%, 20%	Yes	Yes				
Increase in the number of accesses of professionals to the HCE of the patient with ACAF: tele-monitored versus NOT tele-monitored	Analysis of data collected from Clinical Systems (EHR/HIS)	50%	Yes	Yes				
Average time (in seconds) of response of operator to a call, once it has entered the ARC	Analysis of data collected				Yes			
Average time (in minutes) from a call to the ARC to the mobilization of the specialized resource (firefighters, security forces, ambulances, health services, etc.).	Analysis of data collected				Yes			
Average time (in minutes) from a call to the ARC to the mobilization of other resources (family, friends, neighbours, etc.).	Analysis of data collected				Yes			
Average time (in minutes) arrival of the mobile unit to the home (if applicable).	Analysis of data collected				Yes			
Improve various cognitive areas (orientation, memory, clock drawing, and verbal fluency).	7 Minute Screen	Improvement between before and after the deployment of trials					Yes	
Decrease social isolation	UCLA Loneliness Scale , a 20-item scale designed to measure one's subjective feelings of	Improvement between before and after the deployment of trials						Yes

GALIZIA

continued

Indicator	Measurement tool	Target
Impact on QoL		
health improvements in the elderly that are actively ageing , independent living via IoT supported services	HRQOL or EQ-5D (version validated in Greek)	
independent living of elderly via IoT supported services promoting AHA	User Experience Questionnaire (ADL + IADL)	
clinical indicators of proper chronic disease management via IoT telehealth services (Use Case 2- UC2)	HBA1C levels (For Central Greece UC2 pilot - Patients >65years old with Diabetes Mellitus and comorbidity)	at least 1.9%
Disease specific HRQOL for Use Case 2- UC2 patients	Disease specific HRQOL (PAID scale validated in Greek (For Central Greece UC2 pilot - Patients >65years old with Diabetes Mellitus and comorbidity)	
informal caregivers of elderly expected to experience a decrease in care burden and feel comfortable living of their elderly at home, via IoT services	self assessment questionnaire	
elderly patients acceptance and satisfaction of IoT telehealth services (UC 2)	self assessment questionnaire	
Decrease social isolation	Using IoT tool to measure: Communication Social relationship Social interaction home visits frequency Activities attended	Increase in 30% of UC2 variables and criteria (yes)
increase the patient empowerment	• Focus Groups • User Experience Questionnaire (UEQ)	20%
Sustainability		
Reduce of elderly patients visits to their attending physicians, due to use of IoT telehealth services (UC2)	number of patients' visits to their attending physicians	At least 10%
Enhancement of usability and acceptance of provided personalized services by the elderly	using Heino &Van Leen Scales (http://www.hfes-europe.org/accept/accept.htm)	80.00%
Share of main users wanting to continue using service	Nr. of implemented technologies/services offered	50 = at least
Cost Utility Analysis, based on HRQOL/cost of services (for UC2)	cost per quality-adjusted life-year (QALY) gained	< 3 X the GDP per capita in Greece
Innovation and growth		
Enable new IoT based services and increase the number of services provided to elderly people	Number of IoT supported users	50% increase
"Creation of business case for use of IoT solutions for healthy ageing"	Bussiness plan	Business plan of viable scenario

USE CASES	1. Daily activity monitoring	2. Integrated care	3. Monitoring assisted persons outside home	4. Emergency trigger	5. Exercise promotion	6. Cognitive Stimulation	7. Prevention of social isolation	8. Safety, comfort and safety at Home	9. Support for mobility
	yes	yes	yes						Yes for Attica and Thessaloniki pilot sites

GREEK CLUSTER

UC9
MOBILITY

Indicator	Measurement tool	Target
Stimulate and motivate the senior to remain physically fit (physical decline)- at least 65%.	Objectively through their data collection	At least 30%
Health improvements in the elderly that are actively ageing (i.e. travelling, walking, biking, etc.)	Objectively through their data collection	At least 30%
Enhanced revenue creation for participating stakeholders (estimated through	elderly WTP/WTH of services – subjective and their use of connected services – objective)/ Well being / QoL	At least 30%
Enhancement of usability and acceptance of provided personalized services by the elderly	using Heino &Van Leen Scales (http://www.hfes-europe.org/accept/accept.htm)	80.00%
Share of main users wanting to continue using service	Nr. of implemented technologies/services offered	50% at least
Reduction of travelling risk	Simulation	15%
Perceived improved comfort/decreased anxiety of driving	User rating from user surveys (BEFORE/AFTER). Baseline scenario is required	30%
Usefulness of enhanced knowledge of travel information (Real time traffic, parking info)	Nr of trips modified based on users logs	20%
Mobility services adapted for AHA	Nr of new viable C-ITS services	100%

Indicator	Data source	Target
Impact on QoL		
Facilitated and increased Daily Life Activity autonomy for older people living at home	Iterative questionnaires SMAF inspired tool	Perceived improvement (based on patients' declaration through semi-directive interviews)
Improve the quality of life of the users	HRQOL (SF 36)	0.5/1 increase
Social interaction intensification, decrease social isolation	questionnaires/interview and IoT tool feedback : Communication Social relationship Social interaction home visits frequency Activities attended	write here
Less and shorter stay in institution/hospital, Reduction of re-hospitalisation rate	Comparison with previous trends - access to IT regional healthcare systems	Perceived improvement (based on patients' declaration through semi-directive interviews) 10% reduction in nursing home stay Perceived improvement (based on medical care givers declaration)
Sustainability		
increased number of equipement and equiped persons	based on IMA and FFD numbers	>25% increase
improved coordination between services to organize" going back home"	questionnaire / interviews of familly / careers / users/ social services	<30% unsatisfaction and conflicts reduce preparation time
Innovation and growth		
Acceptability of the evolutive IoT Pack (real usage in the long term)	Iterative questionnaires, number of use after 3-6-12 months	>75% satisfaction,number of use increased of 30%
Enable new IoT based services and increase the number of services provided to elderly people	number of services	up to 30% compared to running Autonom@dom web platform
Reduction of incorrect alerts signals (false positive and fasle negative)	number collected from IMA teleassisatnce service	50% reduction
simplified personalization and shorter installation time and reduce maintenance	Using FFD statistics : number of intervention/ home / time/ intervention	>25% decrease

USE CASES	1. Daily activity monitoring	2. Integrated care	3. Monitoring assisted persons outside home	4. Emergency trigger	5. Exercise promotion	6. Cognitive Stimulation	7. Prevention of social isolation	8. Safety, comfort and safety at Home	9. Support for mobility
	Yes			Yes	Yes	Yes	Yes		

GRENOBLE

Indicator	Data source	Target
Impact on QoL		
Improvement in physical wellbeing of particpants	self assessment questionnaire (in line with EQ-5D)	80% of participants see improvement
Improved sense of safety in the home	self assessment questionnaire	80% increase
Decrease social isolation	Using IoT tool to measure: Communication Social relationship Social interaction home visits frequency Activities attended	20% increase of social activities and interactions
Increased physical activity in participants	data collected throughout project. (EQ-5D)	50% increase
Sustainability		
Decrease in referrals to telecare service	particpants vs control group	50% decrease
Number of visits to primary care facilities	figures for people being monitored vs average	30% decrease
Number of particpants engaging positively with technology	Number who complete, satisfaction questionnaire	80%
Demonstrable savings to Health and Social care system	Analysis of data collected vs posssible outcomes prior to project	30% cost reduction
Increased access of community and social facilities & services	compare particpants with pre trial figures	increase of 50%
Innovation and growth		
Creation of business case for use of IoT solutions for healthy ageing	Evaluation of project	show that viable

USE CASES	1. Daily activity monitoring	2. Integrated care	3. Monitoring assisted persons outside home	4. Emergency trigger	5. Exercise promotion	6. Cognitive Stimulation	7. Prevention of social isolation	8. Safety, comfort and safety at Home	9. Support for mobility
	Yes			Yes			Yes		

LEEDS

Indicator	Data source	Target	USE CASES	1. Daily activity monitoring	2. Integrated care	3. Monitoring assisted persons outside home	4. Emergency trigger	5. Exercise promotion	6. Cognitive Stimulation	7. Prevention of social isolation	8. Safety, comfort and safety at Home	9. Support for mobility
Impact on QoL												
Improve the quality of life of the users	HRQOL or EQ-5D-5L	30,00%										
Reduce the fear of fall	FES - I (or short FES-I) https://www.researchgate.net/publication/5815865_The_Short_FES-I_A_shortened_version_of_the_Falls_Efficacy_Scale-International_to_assess_fear_of_falling	Reduction of 0,5. Short FES-1 score ranges from 7 (no concern about falling) to 28 (severe concern about falling)						Yes	Yes	Yes		
Increase the overall physical activity in elderly population.	Total time by week performing moderate and intense aerobic activity. (WHO)	Reaching the WHO guidelines in 80% of the users										
Improve postural performances of users	Equimetrix evaluation tool and Tinetti scale	Increas of the average of items 5 to 8										
Maintain stable cognitive performances	Mild Cognitive Impairment Questionnaire/ MiniQ/ Mini mental	50% of user does not have a decrease in cognitive performances										
Decrease social isolation	Using IoT tool to measure: Communication Social relationship Social interaction home visits frequency Activities attended	Increase in 80% of social activities and interactions										
Increase the patient empowerment	• Focus Groups • User Experience Questionnaire (UEQ)	30%										
Improve follow up of patients ' evolution	Usage statistics	Monthly increases 1%										
Reduce the number of hospital visit	Visits being monitored in comparison to the control group.	10,00%										
Innovation and growth												
Add new social benefits for the site.	Periodical focus Groups on perception of social benefits	40%										
Increase number of implemented technologies (systems and devices).	Number of solution implanted	>10										

Sustainability		
Reduce care expenses	Cost x person	-2,00%
Improve user loyalty with private assurances	Decrease in Insurance Policies cancelled	10%
Improve user satisfaction with the offered services	• User questionnaire • UTAUT questionnaire (perceived usefulness)	50%
Improve usability and acceptance rate of technology among elderly population	User questionnaire based on: • System Usability Scale Likert acceptance scale (Van Der Laan) • Heino &Van Leen Scales • TAUM survey (End-user perspective).	40%
Improve the efficiency in the service delivery	Quality control Questionnaire	20%
Improve TEA´s operational process.	Results of 62 items Questionnaire J Dolla and G Torkzadehb	15%
Improve the timing pay off of the benefits	Return On Investment	5% per year
Potential for care process improvement and cost gains .	Decrease of operative cost per hour and increase in number of hours attended in social care	5%

MADRID

Indicator	Data source	Target
Impact on QoL		
Average life expectancy	municipal statistics	increase
Quality of Life in the older adult and informal caregiver	WHO-QoL	increase in 20%
Perceived Stress in the elderly person	Perceived Stress Test	Maintain or decrease
Perceived Quality of Care by the elderly person	Specific Questionnaire	The user should perceive a higher quality of care
Activities of Daily Living for the older adult	Barthel	Increase in 10%
Prevention effectivenes: % early detection of fragility or cognitive impairment processes	Specific Questionnaire	>5%
Facilitated and increased Daily Life Activity autonomy for older people living at home: number of daily /weekly outdoor activities undertaken	User Experience Questionnaire	Increase >50%
% of participants who feel safer at their habitual living environment (both indoors and outdoors case of use)	User Experience Questionnaire	75%
Sustainability		
% of main users wanting to continue using service	User Experience Questionnaire	>50%
Acceptance of the Technology	UT-AUT methodology	Acceptable solution
Number of hours invested by the informal caregiver, attending gender issues.	Number of hours invested in a week	Decrease in 10%
Cost of assisted old adult: Budget of municipal assistance services for elder people/ elder people assisted (€/persona)	City data	Not to increase more than 5%
% elder adult population currently assisted by municipal services over elder adult population with potential to be assisted	City data	Increase the current share
Burden for the caregiver, assessment of gender issues.	Zarit Questionnaire	Decrease in 10%

USE CASES	1. Daily activity monitoring	2. Integrated care	3. Monitoring assisted persons outside home	4. Emergency trigger	5. Exercise promotion	6. Cognitive Stimulation	7. Prevention of social isolation	8. Safety, comfort and safety at Home	9. Support for mobility
	Yes		Yes						

VALENCIA

Public authorities costs savings: number of visits to health or social services (hospital, emergencies, primary care, local social services center) per year. It can also be quantified in €	User Experience Questionnaire and data from Social and Health Services	Increase in comparison to previous year. The difference can be quantified in €
To attend more people at the most cost-efficiency service		To attend more people at the city with moderate increase of budget as a rationale for scalability of the solution as a municipal service
Perceived ease of use and usefulness from stakeholders (users, caregivers, providers, public Administration)	At DoW	High level
(%) Weight Basic Social Services budget/municipal budget on current expenditure	municipal statistics	Maintaining even more services are provided to more people are assisted
Efficiency measurement for public resources: Cost of social services for elderly people/ Nº users	Cost of social services for elderly people/ Nº users	Maintaining or decreasing
Elderly people assisted by Municipal Social Services per 1000 inhab.	municipal statistics	Increase
(%) Weight Basic Social Services and home care budget/municipal budget on Basic Social Services	municipal statistics	Maintenance
Perceived Quality of Care by the elderly person	Specific Questionnaire	The user should perceive a higher Quality of Care

Indicator	Data source	Target
impact on QoI		
% of participants who feel more comfortable in their habitual living environment	self assessment questionnaire	at least 80%
% of participants who feel safer at their habitual living environment.	self assessment questionnaire	at least 75%
Sustainability		
Number of correct positive alerts (after coll of own phone)	self assessment questionnaire	true positives >90%
Number of selected rules	proof of logs	each apartment at least two active rules
% of participants who configure the rules themselves or with help of their relatives	self assessment questionnaire	at least 25%
# of rules that can be user-configured	self assessment questionnaire	at least 10 of the 15 rules
Number of apartments with full functionality of all rules	self assessment questionnaire	at least one apartment
Number of particpants engaging positively with technology	self assessment questionnaire	at least 75%
% of participants who are satisfied with the escalation chain (emergency trigger)	self assessment questionnaire	at least 90%
Creation of business case	evaluation of project	established business case
Innovation and growth		
Usability of the new system compared to the former system in Weiterstadt	self assessment questionnaire	at least the same as before

USE CASES	1. Daily activity monitoring	2. Integrated care	3. Monitoring assisted persons	4. Emergency trigger	5. Exercise promotion	6. Cognitive Stimulation	7. Prevention of social isolation	8. Safety, comfort and safety at Home	9. Support for mobility
				Yes				Yes	

WOQUAZ