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INTEGR@ TENCIÓN II

Evaluation Metrics Library

Measuring the impact of Information and Communication Technology-based Assistive Technologies (ICT-based AT)

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Evaluation Metrics Library: Measuring the impact of Information and Communication Technology-based Assistive Technologies (ICT-based AT)

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INDEX

Opening

Foreword

> **Technology alone is not enough. We also have to put our hearts in.**
>
> JANE GOODALL

With an ageing world population and an increase in non-communicable diseases, according to the WHO, more than 2 billion people will need at least 1 assistive product by 2030, and many older people will need 2 or more. Today, only 1 in 10 people in need have access to assistive products.

A prominent consideration is the accessibility of assistive technology solutions for older adults or people with dependency. In other words, that people, depending on their specific needs and their life context, can find the most appropriate assistive technology.

> **Any sufficiently advanced technology is equivalent to magic.**
>
> ARTHUR C. CLARKE

The United Nations Convention on the Rights of Persons with Disabilities recognises assistive technologies as an enabler of human rights.

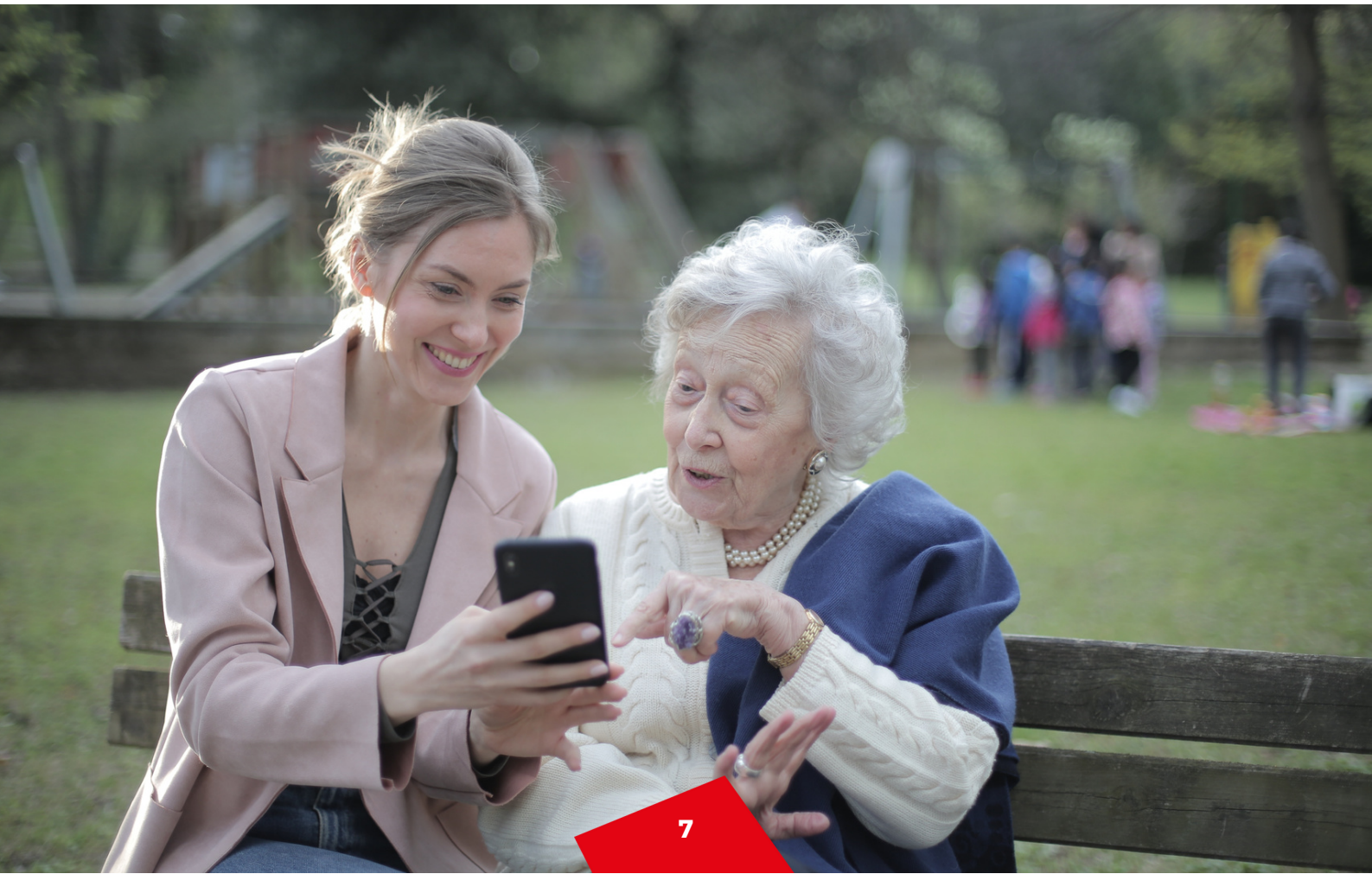
The Integr@tención ecosystem cannot remain impassive in the face of this reality, where it is equally relevant, or even more so when considering the territorial context. The cross-border territory of Castilla y León (Spain) and Northern Portugal is in a borderline population situation, currently viewed as a "demographic desert". It is characterised by a predominance of rural and isolated areas, with high ageing, increasing depopulation and strong inequalities in access to essential services. Social health care in these areas is a great challenge, exacerbated by the current loss and shortage of professional talent. Technological innovation is, without a doubt, an important facilitator of social health care in these areas.
The Integr@tención II project focuses on innovative technologies from the perspective of the needs of the end user, to help the elderly, dependent, disabled or chronically ill, to find assistive technology solutions adapted to their real expectations and the conditions of their environment, making the technological offer accessible to the demand (future users).

people in need have access to assistive products

In line with the detected need, the Global Alliance of Assistive Technology Organizations (GAATO) has identified a set of challenges that underline the need to measure the results and impact of the use of assistive products or assistive technology solutions. These challenges include:
i. measuring the results and impact of assistive technology at individual, community, local, national and global levels;
ii. the development of tools for the collection, storage and use of data;
iii. ensuring results relate to the systems and their implementation; and
iv. evaluation of good practices and policies.

This document - "Evaluation Metrics Library: Measuring the impact of Information and Communication Technology-based Assistive Technologies (ICT-based AT)" - tries to respond to these identified challenges and is intended as a reference guide in the field of evaluating the impact of the use of innovative assistive products.

Integr@tención Team



About this Library

This Evaluation Metrics Library (EML) was developed as part of the deliverables for “Integr@tención II” (POCTEP; 0796_INTEGRATENCION _II_6_E), a European-funded project (INTERREG V A ESPAÑA PORTUGAL (POCTEP) aimed at building upon the achievements of the previous Integr@tención initiative (cf., Box 1).

Integr@tención II focuses on the offer of Information and Communication Technology-based Assistive Technology (ICT-based AT) solutions from the perspective of the end user’s needs. This is accomplished through the creation of a Unified Access Point (UAP), a new service integrated into the Integr@tención Impact Hub. The Unified Access Point serves as a specialised centre designed to help older adults to find ICT-based AT solutions tailored to their actual needs and environment.

Its goal is to make the technological offerings easily accessible to future users.

"Integr@tención II focuses on the offer of Information and Communication Technology-based Assistive Technology (ICT-based AT) solutions from the perspective of the end user’s needs."

ICT-based assistive products and related services encompass a diverse range of digital tools, software applications, and hardware devices to support individuals in overcoming functional limitations and enhance their social participation, by improving accessibility, independence, and quality of life. Therefore, such ICT-based assistive products and services can be greatly relevant in addressing the challenges of ageing in place (Biermann et al., 2018, World Health Organization, 2018).

Integr@tención II builds upon the achievements of the previous Integr@tención project. The Integr@tención project, "Plataforma transfronteriza para el escalado de soluciones innovadoras en la atención socio-sanitaria” [Cross-border platform for the scaling of innovative solutions in social and health care", aimed to promote the scaling up of processes, products and services for independent living, resulting from R&D&I activities, to ensure that, through the adoption of innovative solutions, older adults with dependency, disability or chronic illness can be cared for at home even until the end of their lives. The Integr@tención project was funded by the INTERREG V A Spain Portugal Programme (POCTEP) (see: https://www.intras.es/proyectos-relacionados/integrtencion; http://2019-2021.integratencion.eu/).

Box 1. Integr@tención project.

About this Library

Presently, there are several standard measures for evaluating the success of ICT-based assistive products and services. However, there is currently no established methodological framework or catalogue of instruments specifically designed to assess their usability and effectiveness. Understanding why, when, and how to evaluate the processes and results of using these solutions by older adults and/or by persons with disabilities is essential for overcoming implementation barriers (e.g., low acceptance) and fostering the development of future technological solutions.

Assessing the effectiveness and impact of ICT-based AT in older adults and/or people with disabilities, their families, and society presents unique challenges. To address these challenges, it is essential to have a reliable and diverse set of metrics that comprehensively capture the various dimensions of impact.

This EML aims to fulfil that need by providing a comprehensive collection of metrics. The metrics library encompasses key aspects such as quality of life, functional and cognitive status, social connectedness, and physical health. The goal is to promote rigorous evaluation practices in the field, while facilitating evidence-based decision-making, to foster advances and promote the adoption of effective ICT-based assistive products and related services.

Harnessing the power of assessment to promote positive change in the lives of older people and people with disabilities through the effective use of assistive technologies is crucial.
EML is a resource curated to provide researchers, evaluators, practitioners, policy decision-makers and other stakeholders with a reliable and diverse set of metrics to evaluate both already available and new ICT-based AT. The standardised metrics offered by this library serve as a common framework and language for evaluation, facilitating knowledge sharing, and evidence-based decision-making.

"EML is a resource curated to provide researchers, evaluators, practitioners, policy decision-makers and other stakeholders with a reliable and diverse set of metrics to evaluate both already available and new ICT-based Assistive Technologies."

As the field of ICT-based AT continues to evolve, so too must this library, incorporating new metrics and best practices to stay at the forefront of evaluation in the realm of ICT-based AT.

Index of terms

AT: Assistive technology

EML: Evaluation Metrics Library

EU: European Union

GAATO: Global Alliance of Assistive Technology Organizations

ICT: Information and Communication Technology

ICT-based AT: Information and Communication-based Assistive Technologies

SDGs: Sustainable Development Goals

PwD: People with dementia

RCTs: Randomised controlled trials

UAP: Unified Access Point

UN: United Nations

WHO: World Health Organization

1. Introduction

1.1. An ageing society

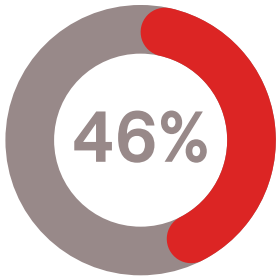
Population ageing has been acknowledged as one of the four major global demographic "megatrends" alongside population growth, migration, and urbanisation (United Nations, 2019). It has enduring and significant implications for sustainable development. The share of individuals aged 65 to 79 in the European Union's total population is expected to increase from 15% in 2022 to 17% in 2100, while the share of people aged 80 years or more is predicted to more than double from 6.1% in 2022 to 15.3 % in 2100 (Eurostat, 2023). However, while people are living longer, not all years are lived in good health (Marasinghe et al., 2022). Increased longevity is often accompanied by multimorbidities and a high risk of declining physical and mental capabilities. These factors can limit the ability of older individuals to take care of themselves and actively participate in society (World Health Organization, 2022).

In 2020, women in the EU-27 lived, on average, 10.9 years with activity limitation out of their 21 years of life expectancy at the age of 65. For men, the corresponding figures were 7.9 years with activity limitation out of their 17.4 years of life expectancy at 65.

Overall, the average number of years of healthy life lost to poor health has risen from 8.62 in 1995 to 9.72 in 2017 and is expected to increase in most countries (Cao et al., 2020).

Presently, around 46% of older people have disabilities, and more than 250 million individuals aged 60 years and over experience moderate to severe disability (World Health Organization, 2023). Looking ahead, the global trend of ageing populations, along with higher disability rates among older people, are likely to lead to further increases in the population affected by disability. The accumulation of health risks across a lifespan of disease, injury and chronic illness are considered the major causes.

There is an urgent need to review and delve deeper into the interconnections between discourses on ageing and disability to better understand their parallels.



of older people have disabilities

World Health Organization, 2023

Globally, and despite regional variations, relatives and informal caregivers are the backbone of the care and support system for older adults. Most older adults in need of consistent care rely on support from relatives, concomitant or not with formal care (e.g., home care services). However, there is already a shortage of caregivers (Ribeiro et al., 2022), which is expected to escalate in the coming years, due to declining fertility rates, migration, urbanisation, and later retirement (Prince et al., 2008).

In countries where a Mediterranean family-based care model prevails, the involvement of formal care services for older people may be lower. Therefore, many countries face challenges in addressing the needs of an ageing society and meeting the substantial demand for care services for older individuals.

It is inevitable, therefore, that traditional perspectives regarding lifestyles in advanced age and the resources required to address the challenges of population ageing are being called into question (Fonseca, 2018). Residential care facilities for older adults are currently an essential response in situations of extreme frailty and vulnerability or when other alternatives are insufficient to meet their needs. However, entering these facilities often entails significant disruption to the person's previous life and almost always severs their connection to their community. Most older adults want to age in a familiar environment, preferably staying in their own homes and within their community (Bárrios et al., 2020). With this in mind, as people age, they require supportive environments to help them adapt to the changes and potential loss of capabilities (Fonseca, 2018).

Establishing and sustaining favourable contexts that facilitate ageing is crucial to promote the well-being of older individuals and enable them to maintain their autonomy, independence, and social relevance for as long as possible (Fonseca, 2018). The concept of "ageing in place" is implicitly embedded here, which can be defined as:

> **the ability of older individuals to live safely, independently, and comfortably in their own homes as they age and as their health-related and other needs change. Factors that influence whether an older individual can successfully age in place–that is, without need for long-term institutionalized care–include environmental characteristics of the "place" itself (e.g., home, neighborhood, community), such as its physical suitability, safety, and access to appropriate support services if needed, and personal characteristics or circumstances that support an individual's independence, such as economic stability, positive relationships with family and friends, a sense of self-efficacy, and ability to manage activities of daily living.**
>
> AMERICAN PSYCHOLOGICAL ASSOCIATION, 2023

When people remain in their homes and communities, the costs related to institutional care can be avoided. Therefore, staying at home is favoured by policy makers and health providers (Wiles et al., 2012). Ageing in place represents a contemporary concept that signifies a shift towards social policies that prioritise the desire of older adults to stay in their homes for as long as possible, within their familial and community environment, and with a sense of independence (Fonseca, 2018).

The Sustainable Development Goals (SDGs) of the 2030 Agenda make explicit references to persons with disability and older persons with regard to promoting and protecting their rights and dignity and facilitating their full participation in society, pledging that no one will be left behind (United Nations, 2022).

To overcome exclusion and enhance individuals' functional abilities, it is essential to foster the use of assistive products and increase accessibility by implementing universal design of product and environment adaptations.

"The Sustainable Development Goals (SDGs) of the 2030 Agenda make explicit references to persons with disability and older persons with regard to promoting and protecting their rights and dignity and facilitating their full participation in society"

Figure 1.
Excerpts from sustainable development goals with reference to older people or people with disabilities.

1.2. Assistive Technologies and ICT in an ageing society

In recent years, there has been a growing exploration of technological innovations to address the challenges associated with ageing. As highlighted in the WHO Global Report on Assistive Technology, everyone is likely to need assistive technology (AT) during their lifetime.

Assistive technology, an umbrella term, includes both low-tech and high-tech products aimed at maintaining or improving an individual's functioning and independence (World Health Organization, 2023). The rapid advances in the field of Information and Communication Technologies (ICT) over the past few decades have driven transformative changes in the interactions between individuals and their environments. These advances have resulted in a diverse array of ICT-based assistive products and related services. Such solutions have mostly been designed to monitor, support, or improve daily living activities, personal health or safety, mobility, communication, and physical activities and to help older people to emerge from social isolation (Chen & Schulz, 2016).

Information and communication technology-based assistive technologies (ICT-based AT) can play an important role when dealing with the challenges of ageing in place (Biermann et al., 2018).

"Assistive technology, an umbrella term, includes both low-tech and high-tech products aimed at maintaining or improving an individual's functioning and independence."

Various sectors and disciplines have been using their owns terms to describe technology that overlaps with, or constitutes a subcategory of, assistive technology. Such terms include, among others, ambient assisted living, gerontechnology, smart homes technologies, welfare technology, and assistive technology devices (Tónay et al., 2023; World Health Organization, 2022).

"As highlighted in the WHO Global Report on Assistive Technology, everyone is likely to need assistive technology (AT) during their lifetime."

With the emergence of an increasing number of ICT-based assistive products and related services, evidence of its effectiveness in assisting older adults and people with disabilities is key (Brandt et al., 2020). Several factors may influence the effectiveness of an ICT-based assistive product. For example, the level of understanding required to use technology, availability of repair and maintenance services, support from family and professionals, individual adaptation, characteristics of the product, the setting in which it is used, and the goals and needs of the person using it (World Health Organization, 2022).

Evidence shows that a comprehensive needs assessment to identify an appropriate ICT-based AT for the person is pivotal. However, the evidence on the effectiveness of ICT-based AT is not always high quality, primarily because studies have few participants, are not methodologically rigorous (few randomised controlled trial [RCTs]) and do not tend to acknowledge the relevance of the sociodemographic data of end users (e.g., older adults tend to use technology less frequently compared to younger age groups, due to factors such as lack of familiarity, perceived complexity and physical limitations). Furthermore, those that use technology tend to have higher levels of academic qualifications (Harris et al., 2022).

It is therefore important to systematise the existing evidence on the methods (as well as the gaps) used to evaluate ICT-based AT in the context of supporting ageing in place.

1.3. Assessing ICT-based AT: needs and challenges

Measuring the impact of ICT-based AT is essential to support evidence-based policies while ensuring universal access to effective solutions (World Health Organization, 2022). This has been emphasised by the Global Alliance of Assistive Technology Organizations (GAATO).

The OECD-DAC Network on Development Evaluation (EVAINet) (2020) defines impact as:

> **positive and negative primary and secondary long-term effects produced by the intervention, whether directly or indirectly, intended or unintended.**
>
> ROGERS, 2014, P.14

A common approach when assessing new technological solutions is to look at the technical features of the device or software, assess the usability and user experience among target users, and evaluate the factors that influence its uptake. However, assessing technology requires going beyond the device to consider surrounding factors such physical and mental health, quality of life and social connectedness, as well as ethics, impact on quality of care, family workload, economy, and social impact. In fact, the positive impact of an ICT-based AT can go beyond improving health, well-being, participation, and inclusion of individual users, since families and societies may also benefit (World Health Organization, 2022).

ICT-based AT holds the potential to enhance the lives of older adults and people with disabilities at an acceptable cost (e.g., low marginal costs per additional user). However, to achieve those potential improvements, the technologies must be tailored to address the unique challenges and specific needs of that population.

"Assessing technology requires going beyond the device to consider surrounding factors such physical and mental health, quality of life, and social connectedness, as well as ethics, impact on quality of care, family workload, economy, and social impact."

Several issues may hinder the use of a solution and interfere with its impact, as amply highlighted in the literature (cf., Gatto & Tak, 2008; Gitlow, 2014; Peute et al., 2022; Silva et al., 2020; Siegel et al., 2014; Wagner et al., 2010). Those issues include the ones listed hereunder.

"Several issues may hinder the use of a solution and interfere with its impact."

i. Digital literacy and self-efficacy

Age is a well-known determinant of technology use. Older adults often face difficulties when navigating and using devices, applications, and systems due to limited digital literacy or apprehension stemming from a lack of experience in handling technology;

ii. Attitudes and beliefs

Some older adults may hold negative attitudes or beliefs towards technology, perceiving it as complex or irrelevant to their lives;

iii. Privacy and security concerns

Older adults may have heightened concerns about the privacy and security of their personal information when using technology, leading to mistrust. As many solutions are integrated into the environment of older persons and involve the collection of activity and surveillance data, they can be perceived as intrusive and pose privacy and self-determination concerns;

iv. Cost and affordability

Limited financial resources can hinder access and ownership of devices and software applications. The cost of maintaining technology can be prohibitive;

v. Design and usability

Poorly designed user interfaces that fail to consider the age-related changes, needs and preferences of older adults can present usability challenges;

vi. Physical and sensory limitations

Age-related changes in physical and sensory systems, such as, reduced fine motor skills (e.g. dexterity), hearing loss and limited vision can hinder older adults' from effectively interacting with technological interfaces;

vii. Self-image and self-perception of health

The use of assistive technologies was found to be related to older adults' fear of feeling/perceiving themselves as being older or sicker than before, thus threatening thier positive self-image and identity, specifically in terms of self-sufficiency;

viii. Social isolation and lack of support

Feelings of isolation and a lack of guidance or encouragement from family or peers can deter older adults from engaging with technology. Also, usability evaluations have shown that a solution's uptake can be impeded by (fear of) losing social interaction and face-to-face contact.

To ensure that an ICT-based assistive product and related service is tailored to its users, a robust evaluation process must be undertaken in terms of usability and user experience (Silva et al., 2020). The assessment methods and procedures should be designed with sensitivity towards the physical function and cognitive ability of older people (e.g., testing time, visual instructions). Several challenges have been reported with respect to the effectiveness or impact evaluation of ICT-based assistive products and services (e.g., Finkelstein, Wu & Brennan-Ing, 2023; Harjumaa & Isomursu, 2012). Some of them include:

i. Generalisability of findings

ICT-based AT are tailored to specific populations and settings, which can limit the generalisability of findings. It is crucial to define the target population and intervention context to ensure the relevance and applicability of the results beyond the study sample;

ii. Blinding of study participants

It is usually not possible;

iii. Ethics

Ethical challenges in randomising and obtaining ethical approval of studies that often include devices that measure health and carry out monitoring or surveillance, that is, they use personal and sensitive data (privacy protection);

iv. Long-term impact

ICT-based AT are often designed for long-term use, and their impact may unfold over time. Conducting long-term follow-up assessments can be resource-intensive and may require strategies to minimise participant dropout and ensure compliance;

v. Sensitivity of the instruments used

Instruments with low sensitivity may fail to capture changes in response to interventions;

vi. Outcomes

Defining appropriate outcome measures that capture the impact of ICT-based AT can be complex. These solutions often aim to improve aspects of individuals' lives, including functional abilities, quality of life, social participation, and healthcare outcomes. Selecting valid and reliable outcome measures aligned with the goals of the intervention that are sensitive to change can be difficult;

vii. Real-world implementation

ICT-based AT are often embedded in participants' homes. This introduces challenges related to varying environmental contexts, user behaviours and preferences, and other external factors that may influence the technology's effectiveness such interference from other devices, caregiver involvement, internet connectivity and infrastructure, and maintenance. For instance, ensuring that the trial reflects real-world conditions while maintaining experimental rigor can be complex, which reinforces the importance of conducting these experiments and assessment protocol outside of laboratory environment settings.

Addressing these challenges requires careful planning, interdisciplinary collaboration, and flexibility in trial design. Researchers should consider consulting with experts in gerontology and human-computer interaction to navigate these challenges effectively.

In sum, evaluating the effectiveness and impact of ICT-based AT on older adults, their families and society presents unique challenges. It is essential to have a reliable and diverse set of metrics that comprehensively capture the various dimensions of impact.

This Evaluation Metrics Library (EML) aims to fulfil that need. The library encompasses metrics that cover key aspects such as quality of life, functional and cognitive status, physical health, and social connectedness. This enables a more comprehensive understanding of the impact of ICT-based AT to foster effective solutions in this important field.

The metrics offered by this library serve as a common framework for evaluation, facilitating collaboration, knowledge sharing, and evidence-based decision-making (cf., Box 2).

"The metrics offered by this library serve as a common framework for evaluation, facilitating collaboration, knowledge sharing, and evidence-based decision-making."

As the field continues to evolve, so too must this library, incorporating new and upcoming metrics and best practices to stay at the forefront of evaluation in the realm of ICT-based AT. This resource has been curated to provide researchers, evaluators, practitioners, decision-makers, and other stakeholders with a reliable and diverse set of metrics to evaluate already available and new ICT-based AT. The goal is to promote rigorous evaluation practices in the field, while facilitating evidence-based decision-making, fostering advancements, and promoting the adoption of effective solutions in this important field.

Facilitating consistency: providing a common framework for evaluating the impact of ICT-based AT, promoting consistency and comparability across different evaluations.

Enabling comprehensive assessments: offering a wide range of metrics that capture various dimensions of impact.

Supporting research and collaboration: serving as a resource for researchers and evaluators by providing a foundation for conducting rigorous studies, promoting collaboration, and facilitating the sharing of best practices and findings.

Driving improvement and innovation in ICT-based AT for older adults and people with disabilities: by establishing a set of metrics, the library stimulates continuous improvement and innovation in the field.

Box 2. Overview of the Evaluation Metrics Library Goals.

2. Methodology

To develop this library, a threefold methodological approach was followed:

i. Database search

A review, based on a scoping review method, was conducted to gather data from studies that assessed the effectiveness of ICT-based assistive products and related services among community-dwelling older adults or people with disabilities. Additionally, reviews and meta-analysis studies focusing on the assessment of ICT-based AT were examined;

ii. Revision of international organisations' documentation

Websites and documents from relevant international organisations (e.g., World Health Organization, United Nations) were analysed, to identify key metrics that should be considered when evaluating ICT-based AT products and related services;

iii. Consultation with experts

Experts in the field of ICT-based AT from Portugal and Spain were consulted to obtain insights and guidance on the evaluation of ICT-based AT products and related services, including on the metrics to be covered in the assessment.

Figure 2 provides an overview of these steps, which are detailed in the following sections.

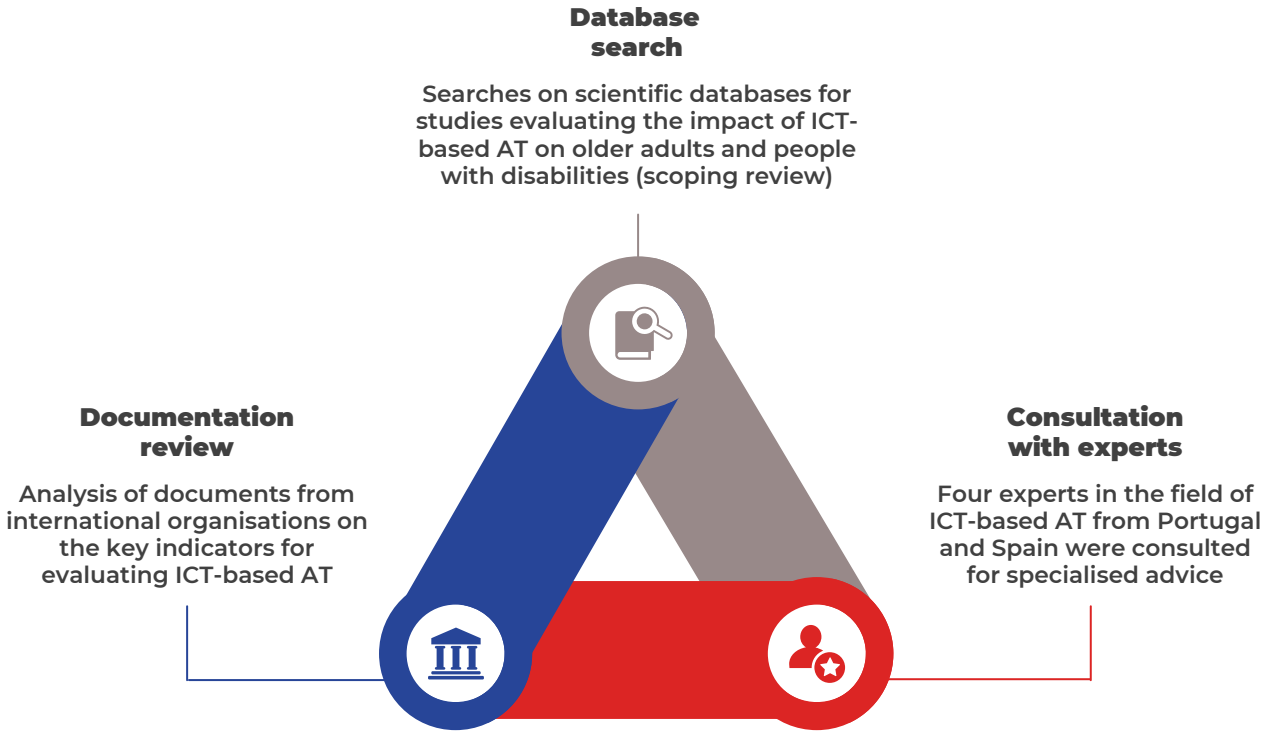


Figure 2.
Methodological approach to develop the Evaluation Metrics Library.

2.1. Database search

A literature search was conducted on PubMed, Web of Science (Clarivate), and Scopus (including Embase). Three independent researchers conducted systematic searches of the databases for articles (searches from March to May 2023); no time restrictions were applied. A Boolean search strategy using a combination of descriptors and their synonyms was applied.

The database research focused on studies that evaluated the effectiveness of ICT-based assistive products and related services (considering related concepts as ambient assisted living, digital solution, digital technology) on community-dwelling older adults or individuals dependent on others to perform daily living activities.

The review included studies meeting the following eligibility criteria:

i. evaluated the impact of assistive technologies or ambient assisted living;

ii. conducted with older adults or persons with disabilities;

iii. written in English, Spanish or Portuguese.

Studies published in conference proceedings or grey literature were excluded, as were those including participants living in assisted residences or nursing homes. There was no restriction on the type of technological product, or the outcomes evaluated. Figure 3 illustrates the initial search.

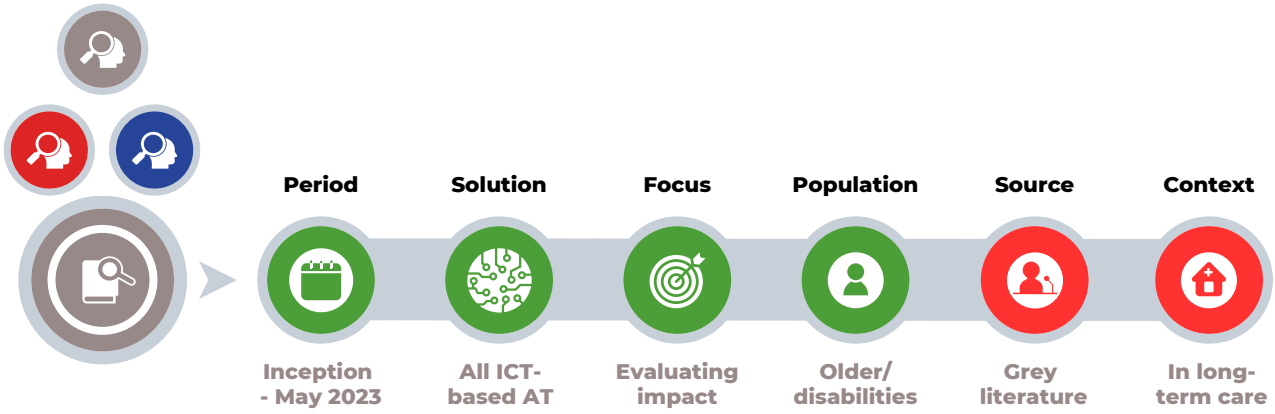


Figure 3.
Literature search by the three researchers: inclusion (green) and exclusion (red) criteria.

2.2. Review of international organisations' documentation

To address the challenges posed by the heterogeneity of methodological approaches and examined technologies, we have reviewed some documentation provided by international organisations, including the World Health Organization (WHO) and the United Nations (UN).

Reference documents on ICT-based AT by prominent international organisations typically draw upon both available evidence and expert inputs. These reference documents often extend beyond the existing literature by incorporating consensus formation processes. The following websites and documents were consulted:

i. World Health Organization:

- Strategic action framework to improve access to assistive technology in the Eastern Mediterranean Region (World Health Organization, 2022);
- Global report on assistive technology (World Health Organization, 2022).

ii. United Nations:

- Decade of Health Ageing 2021-2030: Plan of action (World Health Organization, 2020); and
- International Telecommunication Union (ITU): Ageing in a digital world – from vulnerable to valuable (United Nations, 2021); and Towards building inclusive digital communities (United Nations, 2021).

These reports and handbooks were thoroughly analysed to identify the metrics that have been highlighted as essential for evaluating the impact of ICT-based AT for older adults or people with disabilities.

Questions that guided the search include:

1. What methodological frameworks currently exist to evaluate ICT-based AT?
2. What indicators and instruments (e.g., scales) are being used more frequently to assess the effectiveness of ICT-based AT among community-dwelling older adults or people with disabilities?
3. What study designs have been employed to assess the effectiveness of ICT-based assistive products and services, and what are the shortcomings associated with these designs?
4. Which methodological approaches (quantitative, qualitative, or mixed methods) have been applied to assess the effectiveness of ICT-based assistive products and services, and what are their strengths and weaknesses when applied to assessing these solutions?
5. On whom have the effects of technologies been assessed? (e.g., end users, caregivers, health professionals)
6. In addition to impact measures, what other dimensions have been considered/evaluated, and what role do they play in a comprehensive assessment of ICT-based assistive products and services? (e.g., perceived usefulness, usability, user experience, digital competencies, acceptance, and caregivers' or health professionals' support).

These questions served as a guide to gain a deeper insight into how ICT-based AT products and related services are being evaluated, identify the challenges and shortcomings involved, and derive lessons for future evaluations.

Figure 4.
Questions guiding the review of international organisations' documentation.

2.3. Consultation with experts

Four experts in the field of ICT-based AT from Portugal (n=2) and Spain (n=2) were consulted to obtain insights and guidance on the evaluation of ICT-based AT products and related services. These experts possess expertise in areas such as assistive technologies, ambient assisted living, gerontechnology, usability, user experience and program evaluation. Interviews with these experts were conducted between 10-23 May 2023.

The interviewed experts from Spain (male) are both professors from the University of Salamanca, and members of the University Institute for Community Integration (INICO).

The interviewed experts (female) from Portugal are integrated members of the Centre for Health Technology and Services Research (CINTESIS) R&D Unit, affiliated to the University of Porto (UP) and to the University of Aveiro (UA).

These semi-structured interviews were conducted via videoconference and lasted approximately 60 minutes each. They included several questions (cf., Box 3).

At the conclusion of these individual meetings with the experts, the EML was presented and thoroughly discussed to improve its quality based on the valuable insights and expertise shared by the experts.

1. What would be, in your perspective, the indicators/metrics that should be considered when evaluating the impact of ICT-based AT products and related services?

2. Who would be the targets of that evaluation (e.g., end users, caregivers, professionals)?

3. What type of instruments or measurement tools should be used to collect data?

4. What should be the frequency/timings of the evaluation process?

5. Who should perform this evaluation?

6. Do you think there are other relevant aspects to consider when evaluating the impact of ICT-based AT products and related services?

Box 3. Semi-structured interview guide for the experts.

3. Results

Results in this section bring together the information from:
1. Database research;
2. Revision of international organisations' documentation, and
3. Consultation with experts.
Insights from the three sources were triangulated to propose a comprehensive set of impact evaluation metrics for the assessment of ICT-based assistive products and services targeted at older adults and/or persons with disabilities. The metrics library is presented in section 4 (4. The library).

3.1. Database search

The literature search in scientific databases (cf., section 2. Methodology) targeting intervention studies that evaluated the effectiveness of ICT-based assistive products and services among community-dwelling older adults or people with disabilities resulted in a final number of 26 records (cf., Appendix for a more detailed description).

First, a total of 303 records that met the inclusion criteria were identified. After removing duplicates, 264 unique records remained. Based on the application of eligibility criteria to titles and abstracts by three independent researchers, 195 studies were excluded. The remaining 69 articles were retained for full-text review. 43 were determined to be ineligible, resulting in 26 articles. The PRISMA-ScR flow diagram (cf., Figure 5) depicts the flow of information through the different phases of the review.

The information extracted from the selected studies (n=26) can be referenced in the appendix.
The included studies are described, providing comprehensive details on their design, participants, examined solutions (interventions), results, and evaluation metrics.

The review has revealed a significant level of heterogeneity in the quality of intervention studies assessing ICT-based AT and related services. The methods and techniques utilised across studies to evaluate the effectiveness of ICT-based assistive products and services exhibited, as expected, considerable variation. This variation can be attributed, in part, to the wide range of solutions examined. For instance, the ICT-based assistive products and services explored in these studies ranged from mobility devices – such as walking sticks and walker devices (e.g., Cruz et al., 2019; Brodin et al., 1995; Hirmas-Adauy et al., 2019; Hoenig et al., 2003; Kabacinska et al., 2022; Mortenson et al., 2013), interactive digital gaming systems (e.g., Wang et al., 2022), mobile applications kits that consists of several Internet of Things (IoT sensors) (e.g., Moraru et al., 2022), accelerometers (Park et al., 2017), and assistive devices for activities of daily living (e.g., Hoenig et al., 2003; Lilja et al., 2003; Skymne et al., 2012; Sonn et al., 1994).

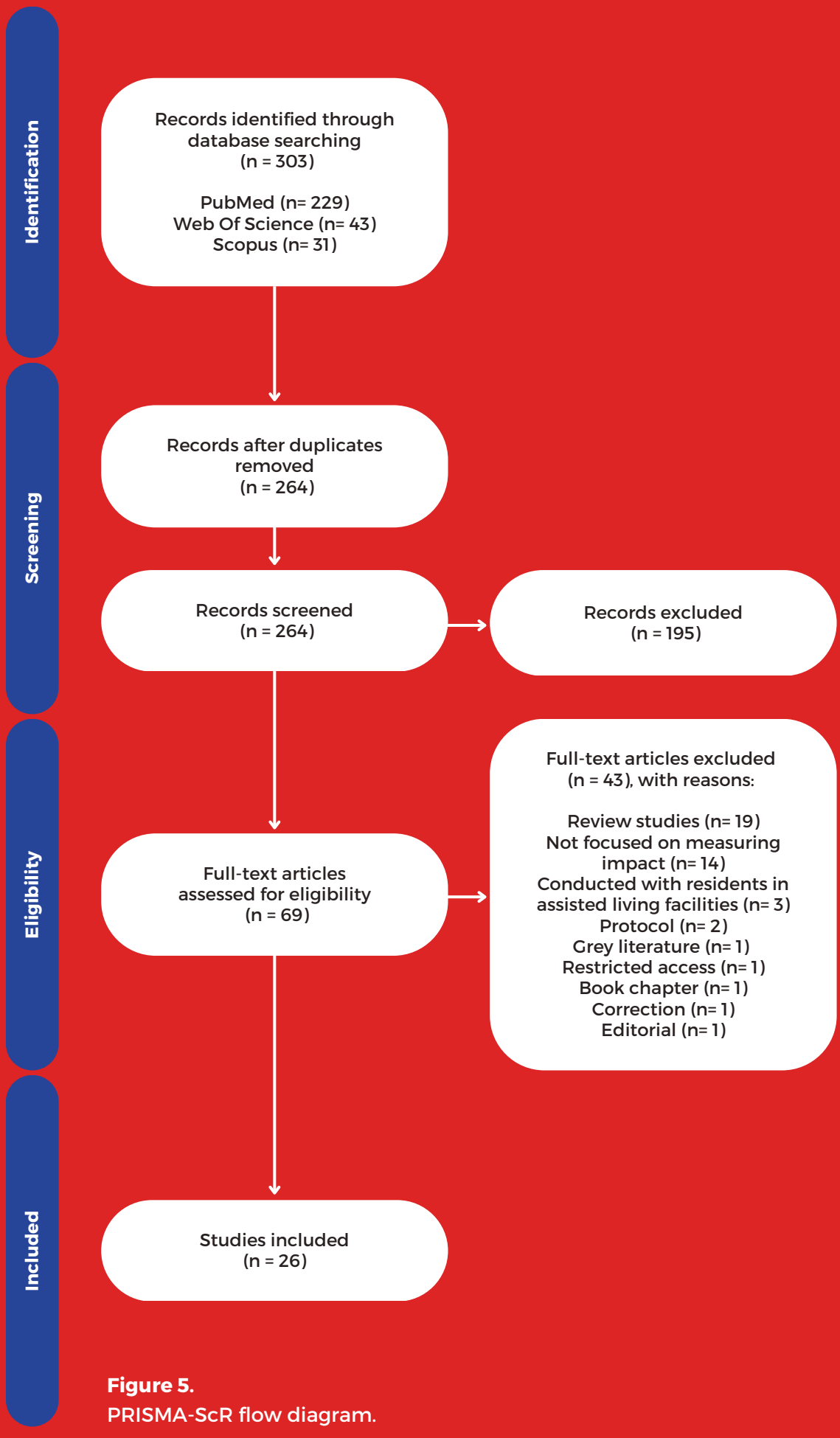


Figure 5.
PRISMA-ScR flow diagram.

Indicators used in these studies to measure the impact/effectiveness of the ICT-based assistive product and service were, therefore, diverse and were mainly focused on the end user. For instance: frequency of falls (e.g., Cruz et al., 2019; Hirmas-Adauy et al., 2019), frailty level (e.g., Cruz et al., 2019), functional capacity/status (e.g, Hirmas-Adauy et al., 2019; Horowitz et al., 2006; Mann et al., 1999; Roelands et al., 2002), physical activity (e.g., Taraldsen et al., 2020), depression (e.g., Horowitz et al., 2006; Lee et al., 2020), cognitive and psychological impairment (e.g., Hoenig et al., 2003; Nishiura et al., 2021), (presence of) pain (Hirmas-Adauy et al., 2019; Mann et al., 1999), ability to live independently (e.g., Moraru et al., 2022), gait speed (e.g, Park et al., 2017), social interactions (e.g., Lee et al., 2020), autonomy (e.g., Dupuy et al., 2017; Sawadogo, 2022), and quality of life (e.g., Brodin et al., 1995; Taraldsen et al., 2020). Some process indicators, such as usability and acceptability, were also used (e.g., Leuty et al., 2013; Shin et al., 2023; Wang et al., 2022). Some studies also emphasised the importance of considering the informal caregiver in the ICT-based assistive products and services and suggested measures such as burden (e.g., Dupuy et al., 2017; Mortenson et al., 2013).

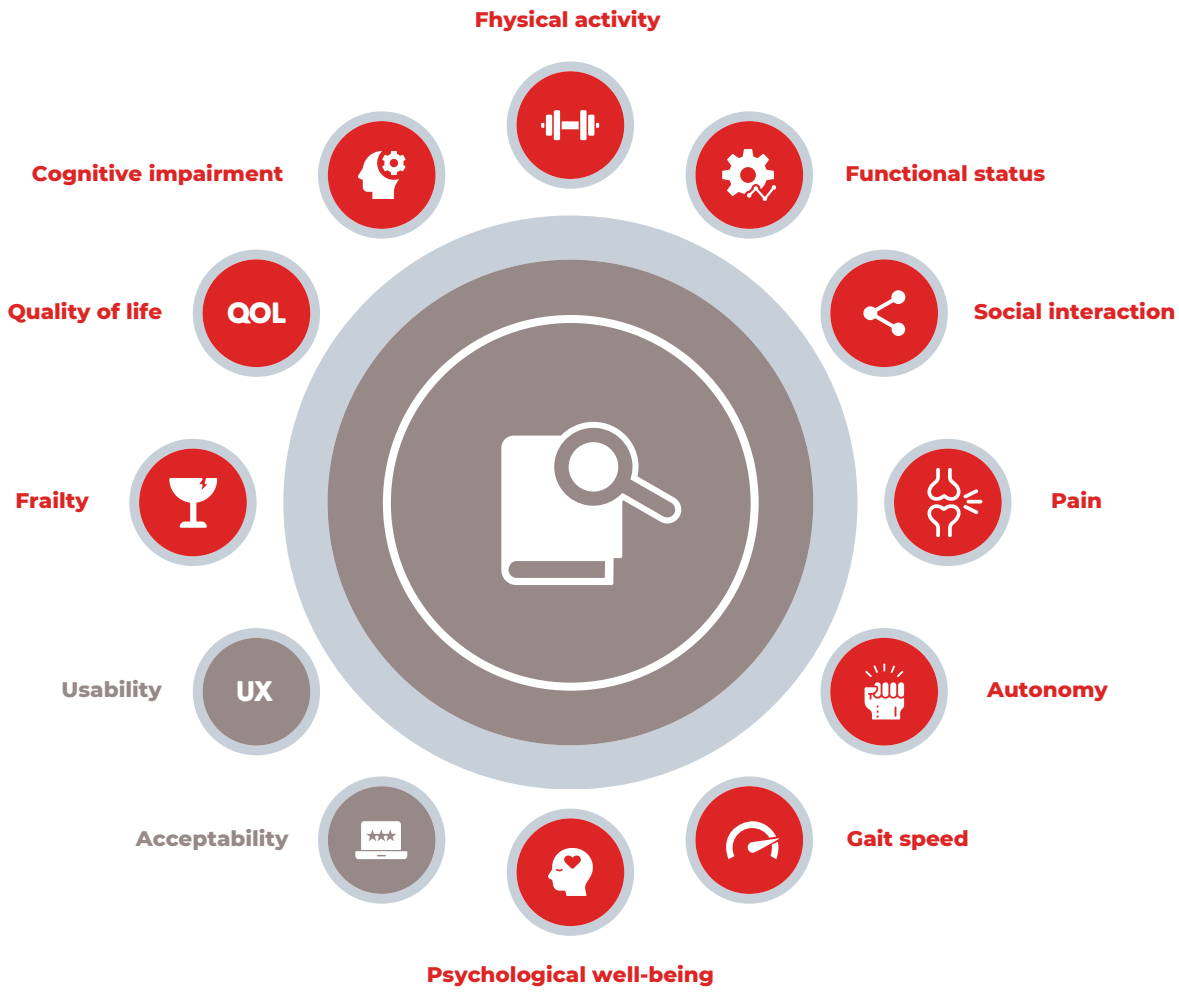


Figure 6.
Impact (red) and process (grey) indicators most frequently found in the literature review.

3.2. Review of international organisations' documentation

Alongside the literature review on the determination of the effectiveness of ICT-based assistive products or services on health or well-being outcomes, documentation from international organisations were considered. This information is typically generated based on available evidence and a panel of experts, with consensus formation processes.

This complementary review added perspectives and insights that could not be obtained solely from the literature review; it provided valuable insights on dimensions that should be considered when evaluating the impact of an ICT-based AT supporting ageing in place, such as, for example, quality of life, physical health, cognitive function, and autonomy. It also provided information about some important process indicators to consider, such as overall satisfaction of users with ICT-based assistive products and services (e.g., specific dimensions of the rapid Assistive Technology Assessment tool, rATA).

Furthermore, insights were first sought on the conceptual definitions of terms such as “assistive technology”, “assistive product”, “ICT-based AT”, or “Ambient Assisted Living”, as the terminology in the field is often ill-defined. These sources also provided important information on the evaluation fundamentals of assistive technology.

3.3. Consultation with experts

The third source of information for this EML relied on the experts' perspective, who highlighted the importance of capturing end users' perception of the impact of ICT-based assistive products and services. Experts 1 and 2 emphasised that evaluating *"end users' perceptions about the impact, gains and changes promoted by the ICT-based AT is key for the evaluation"*.

Key questions were identified and suggested by the experts to be used in the impact evaluation, such as "Does this ICT-based assistive product or service help you? Is it useful?", "To what extent does it promote your independence and autonomy?", and "Did this ICT-based assistive product or service impact your quality of life?"; "If so, in what ways?".

Furthermore, experts stressed several considerations (cf., Box 4). The experts considered that by incorporating these recommendations, the evaluation process is more likely to capture a comprehensive view of the impact of ICT-based assistive products and services on end users and provide valuable insights for future improvements.

i. Targeting end users and their caregivers as the primary recipients of the impact evaluation (including perception measures for both the person using the solution and their caregivers);

ii. Adopting a mixed-method approach to gather comprehensive data;

iii. Conducting pre (baseline) and post evaluations to assess changes over time;

iv. Examining the characteristics of the assessment tools (e.g., sensitivity to change) used to evaluate the dimensions considered (e.g., quality of life);

v. Acknowledging end users' economic context, as well as their digital abilities;

vi. Developing a brief and accurate protocol for data collection to prevent respondent fatigue and enhance the data quality.

Box 4. Main considerations by the experts.

4. The Library

The triangulation of information sources was key to identifying evaluation metrics for each defined target group, including end users, caregivers, and health or social care professionals. Additionally, it helped to determine the optimal timings for the evaluation. Findings from the multiple information sources were discussed within the project team to reach a consensus on the metrics and guidelines to be included in this library.

Overall, the library focuses on deriving a comprehensive list of evaluation metrics for the end users, i.e., the older person or the person with a disability who uses the ICT-based assistive product and related services, and their informal (unpaid) caregivers. The perspective of health and social care professionals who support the end users or their caregivers is also considered.

A comprehensive evaluation of the impact of ICT-based assistive products and services on society would encompass the entire ecosystem of stakeholders. This includes the end users, their supporters and five key elements:

i. Leaders

Those responsible for overseeing the implementation and usage of ICT-based AT within health and social support organisations;

ii. Stakeholders or investors

Those who have a vested interest in the impact of ICT-based assistive products and services;

iii. Suppliers

Those providing the necessary hardware, software, or services to support the ICT-based assistive products and services;

iv. Regulators, government agencies, and others

Any entity responsible for overseeing and regulating the use of ICT-based assistive technology within a specific industry or territory; and

v. Other

Any relevant stakeholders stakeholders such as end user associations.

However, conducting a comprehensive evaluation involving the entire ecosystem requires extensive collaboration and time, and can be costly.

This EML prioritises enabling the implementation of comprehensive assessments within end users and their informal caregivers who may benefit directly or indirectly from the use of ICT-based assistive products and related services. To this end, it identifies impact metrics and perceived impact metrics, while also taking into consideration process metrics.

"The library focuses on deriving a comprehensive list of evaluation metrics for the end users (...) and their informal (unpaid) caregivers. The perspective of health and social care professionals who support the end users or their caregivers is also considered."

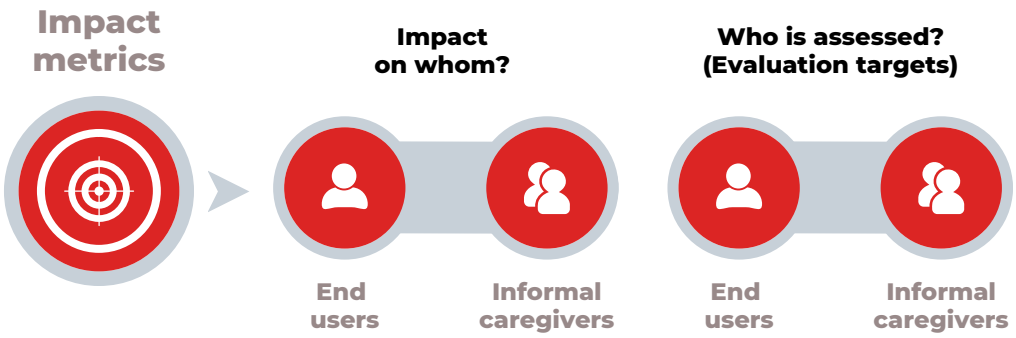
Impact metrics & evaluation targets

Evaluation Target 1| End users

Ten essential metrics were identified: 1. Quality of life (QoL); 2. Life satisfaction; 3. Functional status; 4. Physical health (e.g., fitness level, frailty/sarcopenia, level of physical activity); 5. Mental health (related to the ability to manage emotions; depression, anxiety); 6. General health; 7. Cognitive status; 8. social connectedness and participation; 9. Adverse health events; and 10. Autonomy. Details on these metrics can be found on page 39.

Evaluation Target 2| Caregivers

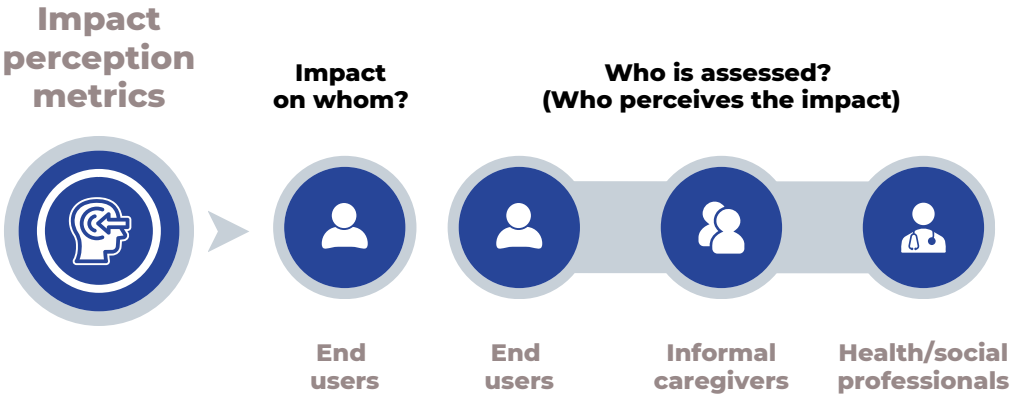
Three metrics were identified: 1. Quality of Life (QoL); 2. Burden/stress level; and 3. Caregiving demands and time available for selfcare. Details on these metrics can be found on page 68.



Impact perception metrics

It is essential to examine the perceived impact of ICT-based assistive products and services on the end user from multiple perspectives, including the end user themselves, informal caregivers, and health/social support professionals who offer assistance to end users.

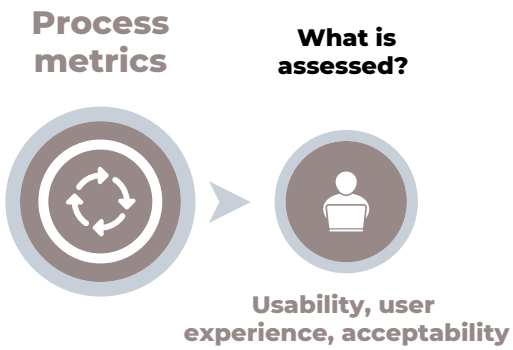
Insights from caregivers and professionals on the impact of the technology on the lives of end users are invaluable for a comprehensive assessment. Details on these metrics can be found on page 75 and in the blue boxes alongside the impact metrics for end users.



Figures 7. (above) and 8. (below)
Impact and impact perception metrics.

Process metrics

In addition to impact metrics, process indicators were identified, including: 1. Usability, user experience and acceptance; and 2. Overall satisfaction with the ICT-based AT. These aspects of the interaction process are crucial as they can greatly influence the ultimate impact that an ICT-based AT solution has on end users and their supporters (details on page 77).



Figures 9.
Process metrics.

The following pages provide a detailed description of the identified metrics that are considered most relevant for the impact evaluation of each target group. It includes a list and description of instruments to assess each evaluation field, highlighting their main characteristics such as the target population, and administration procedures. Information regarding the availability of translated versions of the instruments in Portuguese and Spanish languages, as well as the licensing and permissions required for their use, is also provided.

Instruments with free access were compiled in a folder and can be consulted by request (see contact details on the last page of this document). This information holds value for evaluators seeking to design an assessment protocol and select suitable instruments aligned with the objectives of the evaluation, as well as the objectives of the ICT-based assistive product and services being evaluated.

In the assessment of certain dimensions, additional indicators that are not covered by the suggested assessment instruments are included. These additional indicators, such as medicine intake, pain, or perceived burden, can be useful for enhancing the evaluation protocol.

Furthermore, an example of an evaluation protocol was created and can be consulted by request. It incorporates the metrics described in this document and includes the collection of important socio-demographic data, which can be useful when assessing the impact of ICT-based AT. Factors such as socio-economic status, support systems, and other socio-demographic information can significantly influence the outcomes. This protocol includes several validated questionnaires, some of which are used in full, whereas others are used partially. The evaluation protocol includes short-answer questions to provide an opportunity for the evaluated person to further express their perceived impact of the solution. These questions allow for a more nuanced understanding of their experiences and perspectives.

The protocol is intended to be a suggestion, and the selected assessment instruments were chosen for their wide usage in research and practice and for having validated versions for both European Portuguese and Spanish languages, with a preference for concise formats. It serves as an illustrative example for reference and guidance, therefore its relevance should be carefully analysed, considering various factors, namely the participants' characteristics and the specific technology.

Impact metrics

Target 1
End users

End users (also known as primary end users) refer to who are the ultimate consumers or direct beneficiaries of the ICT-based assistive products and related services. In this Library, end users are understood to be older adults and/or people with disabilities.
For these end users, 10 key metrics were taken into consideration (cf., below).

- **Quality of life**
- **Life satisfaction**
- **Functional status**
- **Physical health**
- **Mental health**
- **General health**
- **Cognitive status**
- **Social participation**
- **Adverse health events**
- **Autonomy**

End users | Impact metric 1
Quality of life

Metric definition

QoL refers to an individual's subjective perception of their overall well-being and satisfaction with various aspects of their life. It encompasses both objective (e.g., physical health, living conditions, and access to resources) and subjective (e.g., happiness, life satisfaction, and fulfilment) factors.

9 Instruments

6 Available in Portuguese

4 Available in Spanish

6 Free access

Instrument*	Population	Administration	Time #	Translations		Free access
1.1. World Health Organization, Quality of Life Questionnaire WHOQOL - 100-item (World Health Organization, 1994)	Adults	Self-completion, completed by the interviewer or through interview	About 30 minutes	✓	✓	✓
1.2. World Health Organization Quality of Life Questionnaire - Brief (WHOQOL-Brief) (World Health Organization, 1998)	Adults	Self-completion, completed by the interviewer or through interview	About 5 minutes	✓	✓	✓
1.3. EuroQol 5 dimensions questionnaire (EQ-5D) (EuroQol, 1987)	General	Self-completion, face-to-face or telephone interview	< 5 minutes	✓	✓	✗
1.4. Quality of Well-Being Scale (QWB) (Kaplan, Bush, & Berry, 1970s)	Adults	Interviewer-administered; new version: self-administered	10-15 minutes			✗
1.5. Quality of life in Neurological Disorders (Neuro-QoL) (Cella D, et al., 2011)	People with neurological conditions	Self-report	2-5 minutes			✓
1.6. Quality of Life in Alzheimer's Disease (QoL-AD) (Logsdon, Bibbons, McCurry, & Teri, 1999)	People with dementia (PwD) and caregivers	PwD: interview; Caregivers: questionnaire	PwD: 10-15 minutes; Caregiver: about 5 minutes	✓		✗

* Original version: author(s), publication year and items to consider.
# The time needed to administer the instrument depends on a large number of factors, including the individual's cognitive and communicative abilities, among others.

Instrument*	Population	Administration	Time #	Translations		Free access
1.7. Patient Health Questionnaire (PHQ-9) (Spitzer et al., 1999)	Adults	Self-completion	1-3 minutes			✓
1.8. GENCAT ["Generalitat de Catalunya"] (Verdugo et al., 2008)	Adults using social services	Answered by professionals based on direct observation	10-15 minutes	✓	✓	✓
1.9. FUMAT (Verdugo, Sanchez, & Martínez, 2009)	People with disabilities	Administered by social service professionals who have known the person for at least 3 months	About 10 minutes	✓		✓

Complementary items on the perception of the impact of ICT-based AT use on quality of life	We suggest complementing these scales with the following questions: "Generally, do you feel that the ICT-based AT that you are using has been impacting your quality of life?" OR "Did you find any differences between your quality of life before and after the use of this ICT-based AT?" If they answer: "Yes", ask: "Can you please specify in what ways?"

* Original version: author(s), publication year and items to consider.
# The time needed to administer the instrument depends on a large number of factors, including the individual's cognitive and communicative abilities, among others.

Requesting permission to use the instruments: useful links
1.3. EQ-5D: https://euroqol.org/
1.4. QWB: https://eprovide.mapi-trust.org/instruments/quality-of-well-being-scale#coas_member_access_content
1.5. Neuro-QoL: https://www.healthmeasures.net/index.php?option=com_instruments&view=search&Itemid=977
1.6. QoL-AD: https://eprovide.mapi-trust.org/instruments/quality-of-life-in-alzheimer-s-disease

End users | Impact metric 2
Life satisfaction

Metric definition

Life satisfaction is a key indicator of a person's normative opinion about their overall well-being. It encompasses a person's cognitive and affective judgment of their life as a whole, taking into account various domains such as relationships, health, work, personal achievements, and overall well-being.

1 Instrument

Available in Portuguese

Available in Spanish

FREE

Free access

Instrument*	Population	Administration	Time #	Translations	Free access
2.1 Satisfaction with Life Scale (SWLS) (Diener et al., 1985)	Adults; more suitable for use in non-clinical populations	Self-completion	1-5 minutes	✓	✓	✓

Complementary items on the perception of the impact of ICT-based AT use on life satisfaction	We suggest complementing the use of this scale with the following questions: "Generally, do you feel that the ICT-based AT that you are using impacts your life satisfaction?" OR "Did you find any differences between your life satisfaction before and after the use of this ICT-based AT?" If they answer: "Yes", ask: "Can you please specify in what ways?"

* Original version: author(s), publication year and items to consider.
# The time needed to administer the instrument depends on a large number of factors, including the individual's cognitive and communicative abilities, among others.

End users | Impact metric 3
Functional status/independence

Metric definition

Functional capacity combines the intrinsic ability of the individual, the environment in which the person lives, and the way people interact with their environment. Optimising functional capacity is widely recognised as a key component of healthy ageing.

10 Instruments

5 Available in Portuguese

4 Available in Spanish

5 Free access

Instrument*	Population	Administration	Time #	Translations		Free access
3.1 Barthel Index (BI) (Mahoney, & Barthel, 1965)	Older adults	Self-report (SR) or direct observation (DO)	SR: 2-5 minutes DO: about 20 minutes	✓	✓	✓
3.2. Lawton & Brody Instrumental Activities of Daily Living Scale (IADL) (Lawton & Brody, 1969)	Older adults	Direct observation	10-15 minutes	✓	✓	✓
3.3. Katz Index (Katz, 1963)	Older adults	Hetero-administered	10-15 minutes	✓	✓	✓
3.4. Pfeffer's Functional Activities Questionnaire (Pfeffer et al., 1982)	Older adults	Self-completed by an informant	< 10 minutes			✓
3.5. Late-Life Function and Disability Index (LLFDI) (Jette et al., 2002)	Community -dwelling older adults	Self-report or performance-based	Variable [1]			✗
3.6. Older Americans Resources and Services Multidimensional Functional Assessment Questionnaire (OARS) (Fillenbaum & Smyer, 1978)	Older adults	Self-report; direct administration to older adults; an informant version can also be used	30-45 minutes [2]	✓		✗
3.7. Functional Autonomy Measurement System (SMAF) (Hébert, Guilbault, Desrosiers & Dubuc, 1984)	Older adults and people with disabilities	Hetero-administered by a health professional to the target person or an informant; observation and testing	About 45 minutes			✗

* Original version: author(s), publication year and items to consider.
# The time needed to administer the instrument depends on a large number of factors, including the individual's cognitive and communicative abilities, among others.
[1] Depending on the components or domains being evaluated and on the individual's pace.
[2] The length of the questionnaire can be adjusted by selecting specific sections or items according to the assessment needs.

Instrument*	Population	Administration	Time #	Translations		Free access
3.8. Functional Independence Measure (FIM) (Keith, Granger, Hamilton, & Sherwin, 1987)	Persons with functional mobility impairments	Observation and interviews with the target person or an informant	30-45 minutes	✓	✓	✗
3.9. Craig Handicap Assessment and Reporting Technique (CHART) – physical independence subscale (Whiteneck et al., 1992)	People with disabilities, recovering from brain injury/stroke , multiple sclerosis, spinal cord injury	In-person or telephone interviews	30-45 minutes [3]			✓
3.10. Adaptive Behaviour Assessment System—Third Edition (ABAS III) (Harrison & Oakland, 2003)	Older adults up to 89 years	Self-report	15-30 minutes [3]			✗

Complementary items on the perception of the impact of ICT-based AT use on functional status/independence level	We suggest complementing these scales with the following questions: "Generally, do you feel that the ICT-based AT that you are using impacts your independence level?" OR "Did you find any differences between your functional status/independence level before and after the use of this ICT-based AT?" If they answer "Yes", ask: "Can you please specify in what ways?" We also suggest adding other questions regarding the time spent (total or in average per day) performing the daily life activities - before and after the ICT-based AT.

Requesting permission to use the instruments: useful links

3.5. LLFDI: https://eprovide.mapi-trust.org/instruments/late-life-function-and-disability-instrument
3.6. OARS: http://rimas.uc.pt/instrumentos/56/
3.7. SMAF: http://www.demarchesmaf.com/fr/~
3.8. FIM: https://www.udsmr.org
3.10. ABAS III: https://www.parinc.com/Products/Pkey/5

End users | Impact metric 4 Physical health

Metric definition

Physical health is an important indicator to understand if the level of physical fitness, functional capacity, frailty, or the level of physical activity are in balance and in tune, responses occur. Therefore, one should assess to what extent the assistive technology interferes with the levels of energy, strength, motor ability, pain, discomfort. These are crucial factors to understand how the user's physical health is.

18 Instruments

18 Available in Portuguese*

16 Available in Spanish*

14 Free access

* Including instruments that do not require translation.

Instrument*	Population	Administration	Time #	Translations		Free access
4.1. Physical fitness level or functional capacity [1]						
4.1.1. Senior Fitness Test (SFT) (Rikli & Jones, 1999)	Older adults	Direct observation	30-45 minutes [2]	NA	NA	✓
4.1.2. Timed Up & Go (TUG) (Podsiadlo & Richardson, 1991)	Older adults; persons with Parkinson's, Alzheimer's, Huntington's disease, multiple sclerosis, or stroke	Observation by the professional	About 1 minute	NA	NA	✓
4.1.3. 6 Minutes Walking Test (6MWT) (Harada, Chiu & Stewart, 1999)	Older adults; persons with cardio-pulmonary problems, muscle disorders, multiple sclerosis, Parkinson's	Administration and observation by the professional	6-10 minutes	NA	NA	✓
4.1.4. Gait speed (10, 6 or 4 meters walk test) (Bohannon, 1996)	Older adults; persons with a variety of medical conditions	Administration and observation by the professional	About 5 minutes	NA	NA	✓

* Original version: author(s), publication year and items to consider.
# The time needed to administer the instrument depends on a large number of factors, including the individual's cognitive and communicative abilities, among others.
[1] There is no need for translation/validation in these type of instruments (4.1.1 to 4.1.7). Please consider the cut-off points for the Portuguese and Spanish population.
[2] Depending on factors such as the individual's fitness level and familiarity with the tests. See the manual at: https://us.humankinetics.com/products/senior-fitness-test-manual-2nd-edition.

Remarks for the assessment of physical health indicators

1. Instruments should be selected based on the individual's level of physical activity and fitness level.
2. Some questions to determine the FITT (frequency, intensity, time/duration, type/mode) variables may be considered to determine physical activity levels in occupational, domestic, transportation/utilitarian, leisure activities (e.g., time spent in minutes and frequency in activities such as walking, dancing, swimming, cycling, or gardening).
3. Consider the use of sensors/wearables to collect data on the individual's physical health and physical activity level (e.g., accelerometers, pedometers, heart rate monitors, activity monitors).

Instrument*	Population	Administration	Time #	Translations		Free access
4.1. Physical fitness level or functional capacity (cont.)						
4.1.5. Short Physical Performance Battery (SPPB) (Guralnik et al., 1995) [3]	Community-dwelling older adults; people with multiple sclerosis, lung diseases, or cognitive impairment	Administration and observation by the professional	10-15 minutes	NA	NA	✓
4.1.6. Grip strength (Roberts et al., 2011), considering the American Society of Hand Therapists (ASHT) testing protocol (MacDermid et al., 2015)	General	Administration by the professional; Requires the use of a dynamometer	A few minutes	NA	NA	✓
4.1.7. Unipedal Stance Test (Springer et al., 2007)	Populations at risk of balance impairments	Administration and observation by the professional; based on task performance	About 2 minutes	NA	NA	✓
4.1.8. Berg Balance Test (Berg, 1992)	Older adults in clinical settings	Observation and scoring of the person's performance by a trained assessor	15-20 minutes	✓	✓	✓

* Original version: author(s), publication year and items to consider.
# The time needed to administer the instrument depends on a large number of factors, including the individual's cognitive and communicative abilities, among others.
[3] See the guide at: https://us.humankinetics.com/products/senior-fitness-test-manual-2nd-edition.

Instrument*	Population	Administration	Time #	Translations		Free access
4.2. Frailty/sarcopenia [4]						
4.2.1. Frailty Phenotype (weight loss, low physical activity, exhaustion, slowness, and weakness) (Fried et al., 2001)	Older adults	Hetero-administered	About 5 minutes	✓	✓	✓
4.2.2. SARC-F questionnaire (Malmstrom & Morley, 2013)	Older adults	Self-report; can be administered by healthcare professionals or researchers	About 5 minutes	✓		✓
4.2.3. Clinical Frailty Scale (Rockwood et al., 2005)	Older adults with disabilities	Observation and grading of the degree of dependence	A few minutes	✓	✓	✗
4.2.4. FRAIL Scale (Morley, 2012)	Late middle-aged adults	Self-report; can be administered by healthcare professionals or researchers	A few minutes	NA	NA	✓
4.2.5. PRISMA-7 (Raîche, Hébert, & Dubois, 2004)	Older adults	Self-report; can be administered by healthcare professionals or researchers	A few minutes	✓	NA	✗
4.2.6. Tilburg Frailty Indicator (TFI) (Tilburg Gobbens et al., 2010)	Community-dwelling older adults	Typically interviewer-administered, but a self-report version is available	5-10 minutes	✓	NA	✗

* Original version: author(s), publication year and items to consider.
# The time needed to administer the instrument depends on a large number of factors, including the individual's cognitive and communicative abilities, among others.
[4] The use of these instruments implies the use of other measures, such as the grip strength.

Instrument*	Population	Administration	Time #	Translations		Free access
4.3. Level of physical activity						
4.3.1. International Physical Activity Questionnaire (IPAQ) (Craig et al., 2003)	People aged 15-65 years, and healthy older adults	Self-report questionnaire (Long form - LF and short form - SF)	LF: 20-30 minutes SF: 5-10 minutes	✓	✓	✓
4.3.2. Rapid Assessment of Physical Activity (RAPA) (Topolski et al., 2006)	Adults aged 50+	Self-report questionnaire	A few minutes	✓	✓	✓
4.3.3. Modified Baecke Physical Activity Questionnaire (Burema & Fritjers, 1982)	Older adults with joint and/or chronic pain	Self-completion or hetero-administered by a professional	15-20 minutes [5]	✓	✓	✓
4.4. Other regarding behaviour change/ adherence						
4.4.1. Exercise Adherence Reporting Scale (EARS) (Newman-Beinart et al., 2017)	Adults with chronic diseases in rehabilitation	Self-completion	5-10 minutes [6]	✓		✗

Complementary items on the perception of the impact of ICT-based AT use on physical health	We suggest complementing these instruments with the following questions: "Generally, do you feel that this ICT-based AT have been impacting your physical health?" OR "Did you find any differences between your physical health before and after the use of this ICT-based AT?". If they answer: "Yes", ask: "Can you please specify in what ways?"

* Original version: author(s), publication year and items to consider.
# The time needed to administer the instrument depends on a large number of factors, including the individual's cognitive and communicative abilities, among others.
[5] Depending on the individual's recall ability and the level of detail required.
[6] Depending on the specific version and the number of items included.

Requesting permission to use the instruments: useful links
4.2.3. Clinical Frailty Scale: https://www.dal.ca/sites/gmr/our-tools/clinical-frailty-scale.html
4.2.5. PRISMA-7: https://www.expertise-sante.com/outils-cliniques/outils-rsipa/prisma-7/
4.2.6. TFI: Robberto J. Gobbens; gobrj@hr.nl
4.4.1. EARS: Naomi A Newman-Beinart; naomi.beinart@kcl.ac.uk

End users | Impact metric 5
Mental Health

Metric definition

Mental health refers to mental well-being in which an individual develops personal skills, can cope with life challenges, works productively, and contributes affirmatively to the community.

3 Instruments

3 Available in Portuguese

2 Available in Spanish

3 Free access

Instrument*	Population	Administration	Time #	Translations		Free access
5.1. Depression						
5.1.1. Center for Epidemiologic Studies–Depression scale (CES-D) (Radloff, 1977)	General	Self-report questionnaire	10-20 minutes	✓		✓
5.1.2. Geriatric Depression Scale (GDS) (Yesavage et al., 1983)	Older adults	Self-completion (30-item or 15-item version) [1]	30-item: 15-20 minutes 15-item: 5-10 minutes	✓	✓	✓
5.2. Anxiety						
5.2.1. Hospital Anxiety and Depression Scale (HADS) (Zigmond & Snaith, 1983) [2]	Adults	Self-completion	15-20 minutes	✓	✓	✓

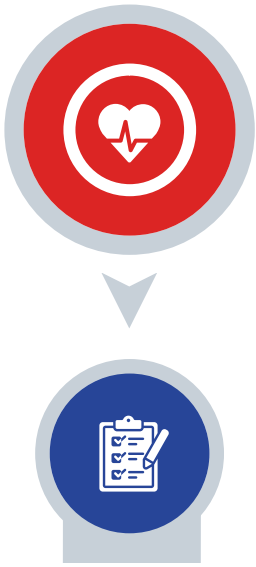
Complementary items on the perception of the impact of ICT-based AT use on mental health	We suggest complementing these scales with the following questions: "Generally, do you feel that this ICT-based AT that you are using has been impacting your mental health?" OR "Did you find any differences between your mental health before and after the use of this ICT-based AT?" If they answer: "Yes", ask: "Can you please specify in what ways?"

* Original version: author(s), publication year and items to consider.
# The time needed to administer the instrument depends on a large number of factors, including the individual's cognitive and communicative abilities, among others.
[1] Please note that there are also versions of 10, 5 and 4 items.
[2] The result can be compounded (psychological distress) or related to anxiety or depression; various types of final score.

End users | Impact metric 6
General Health

Metric definition

The concept of health is complex and multidetermined, so it varies according to the individual's context and historical, personal, social and/or cultural background. It encompasses emotional, social, sexual, and spiritual dimensions, which is why it is so closely linked to quality of life. Therefore, having more health directly implies having a more favourable experience of life. For this indicator we considered parameters such as vital signs, pain, pharmacological treatment and perception of health status, namely psychological well-being and the impact of health on the daily life of the assistive technology user.



9 Instruments or Parameters

All available in Portuguese*

All available in Spanish*

Permission required #

* Including parameters that do not require translation.
# For instruments.

6.1. Vital parameters	
6.1.1. Blood pressure	This parameter is evaluated through specific equipment, incorporated or not on the IC-based AT.
6.1.2. Glycaemic index	This parameter is evaluated through specific equipment, incorporated or not on the IC-based AT.
6.1.3. Pulse rate	This parameter is evaluated through specific equipment, incorporated or not on the IC-based AT.
6.1.4. Respiration rate (rate of breathing)	This parameter is evaluated through specific equipment, incorporated or not on the IC-based AT.
6.1.5. Oxygen saturation	This parameter is evaluated through specific equipment, incorporated or not on the IC-based AT.
6.2. Pain	
6.2.1. The Numeric Pain Rating Scale	This parameter can be evaluated through a structured questionnaire.
6.3. Pharmacological treatment	
6.3.1. Medicine intake (changes)	This parameter can be evaluated through a structured questionnaire.

Instrument*	Population	Administration	Time #	Translations		Free access
6.4. Health status perception						
6.4.1. Short Form Questionnaire SF-36 (long version) or SF-12 (short version) (Sherbourne, 1992)	Adults	Self-completion; 36-item version (SF-36) and 12-item version (SF-12)	SF-36: 5-10 minutes SF-12: 2-5 minutes	✓	✓	✗
6.4.2. General Health Questionnaire (GHQ-28) (Goldberg & Hillier, 1979)	General	Self-completion	5-10 minutes	✓	✓	✗

Complementary items on the perception of the impact of ICT-based AT use on general health	We suggest complementing these measurements with the following questions: "Generally, do you feel that the ICT-based AT that you are using has been impacting your health?" OR "Do you find any differences between your general health level before and after the use of this ICT-based AT?" If they answer: "Yes", ask: "Can you please specify in what ways?"

* Original version: author(s), publication year and items to consider.
# The time needed to administer the instrument depends on a large number of factors, including the individual's cognitive and communicative abilities, among others.

Requesting permission to use the instruments: useful links
6.4.1. SF-36 and SF-12: https://www.qualitymetric.com/health-surveys/the-sf-12v2-pro-health-survey/
6.4.2. GHQ-28: https://www.gl-assessment.co.uk/assessments/products/general-health-questionnaire

End users | Impact metric 7
Cognitive status

Metric definition

Cognitive status aims to assess the functions and capacities that allow the person to carry out his/her daily activities, namely, perception, attention, memory, language, executive functions, visual and spatial capacities. The instruments presented in this indicator check for any decline in these functions, since with the ageing process there may be cognitive impairment.

7 Instruments

6 Available in Portuguese

6 Available in Spanish

2 Free access

Instrument*	Population	Administration	Time #	Translations		Free access
7.1. Mini-Cog Instrument (Borson, et al., 2000)	General	Hetero-administered by a healthcare professional or a trained administrator	3-5 minutes	✓	✓	✗
7.2. Montreal Cognitive Assessment (MoCA) (Nasreddine et al., 2005)	Persons aged 55 to 85	Hetero-administered by a healthcare professional or a trained administrator	10-15 minutes	✓	✓	✗
7.3. Mini Mental Status Examination (MMSE) (Folstein et al., 1975)	Persons with suspected dementia or brain injury	Hetero-administered by a healthcare professional or a trained administrator	10-15 minutes	✓	✓	✓
7.4. Prospective-Retrospective Memory Questionnaire (PRMQ) (Smith, Della Sala, Logie, & Maylor, 2000)	Adults	Self-report by the target person or by an informant	10-15 minutes	✓	✓	✓
7.5. Cognitive Difficulties Scale (CDS) (McNair & Khan, 1983) [1]	General	Self-report	No info			✗
7.6. Short Portable Mental Status Questionnaire (SPMSQ) (Pfeiffer, 1975)	Older adults	Hetero-administered by a healthcare professional or a trained administrator	5-10 minutes	✓	✓	✗

* Original version: author(s), publication year and items to consider.
# The time needed to administer the instrument depends on a large number of factors, including the individual's cognitive and communicative abilities, among others.
[1] Information on how to request authorisation to use this instrument is not available.

Instrument*	Population	Administration	Time #	Translations		Free access
7.7. COGNISTAT Cognitive Assessment (Kiernan et al., 1987)	Adults	Interview and observation by a trained health professional (long form -LF, short form - SF)	LF: 20-30 minutes SF: about 5 minutes	✓	✓	✗

Complementary items on the perception of the impact of ICT-based AT use on cognitive status	We suggest complementing these scales with the following questions: "Generally, do you feel that this ICT-based AT that you are using has been impacting your cognitive status/function?" OR "Do you find any differences between your cognitive status (e.g., memory, orientation) before and after the use of this ICT-based AT?" If they answer "Yes", ask: "Can you please specify in what ways?"

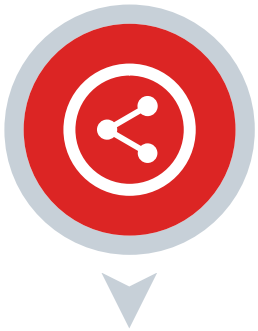
* Original version: author(s), publication year and items to consider.
# The time needed to administer the instrument depends on a large number of factors, including the individual's cognitive and communicative abilities, among others.

Requesting permission to use the instruments: useful links
7.1. Mini-Cog: https://mini-cog.com/step-by-step-mini-cog-instructions/
7.2. MoCA: https://mocacognition.com
7.6. SPMSQ: https://www.briggshealthcare.com/Short-Portable-Mental-Status-Questionnaire-SPMSQ
7.7. COGNISTAT: https://www.cognistat.com/

End users | Impact metric 8
Social participation

Metric definition

Social participation refers to the integration of people into different support networks, be it social, family, friends and their integration into the community. The quality of social relationships is important for maintaining physical and mental well-being throughout life. Poor social relationships can lead to isolation.



6 Instruments

4 Available in Portuguese

2 Available in Spanish

2 Free access

Instrument*	Population	Administration	Time #	Translations		Free access
8.1. Loneliness						
8.1.1. UCLA Loneliness Scale 3-Item or 20-item versions (Russell, Peplau & Ferguson, 1978)	Adults	Self-completion or hetero-administered (long form - LF, short form - SF)	LF: 15-20 minutes SF: 3-5 minutes	✓	✓	✓
8.1.2. De Jong Gierveld Loneliness Scale (11-item and 6-item) (De Jong Gierveld & Kamphuis, 1985; De Jong Gierveld & Van Tilburg, 2006)	Older adults	Self-report (long form -LF, short form- SF)	LF: about 15 minutes SF: 5-10 minutes		✓	✓
8.1.3 ALONE (Deol et al., 2022)	Older adults	Hetero-report	A few minutes	✓		✗
8.2. Social isolation						
8.2.1 Lubben Social Network Scale (LSNS) (18-item, LSNS-R, and 6-item versions) (Lubben, 1988)	Older adults	Self-report (long form -LF, short form- SF)	LF: 15-20 minutes SF: 5-10 minutes	✓		✗
8.2.2. Social isolation scale (SIS) (Nicholson et al., 2020)	Older adults	Self-report	5-10 minutes	✓		✗

* Original version: author(s), publication year and items to consider.
# The time needed to administer the instrument depends on a large number of factors, including the individual's cognitive and communicative abilities, among others.

Instrument*	Population	Administration	Time #	Translations	Free access
8.3. Participation					
8.3.1. ICF Measure of Participation and Activities Screener (IMPACT-S) (Post et al., 2008)	Adults	Self-report	No info		✖

Complementary items on the perception of the impact of ICT-based AT use on social participation	We suggest complementing these instruments with the following questions: "Generally, do you feel that this ICT-based AT that you are using has been impacting your social connectedness and social participation/community engagement?" OR "Do you find any differences between your social connectedness and participation before and after the use of this ICT-based AT?" If they answer "Yes", ask: "Can you please specify in what ways?"

* Original version: author(s), publication year and items to consider.
# The time needed to administer the instrument depends on a large number of factors, including the individual's cognitive and communicative abilities, among others.

Remarks for the assessment of social participation

There are other instruments focused on measuring aspects of social participation, such as the WHO Disability Assessment Schedule 2.0 (WHODAS 2.0) that measures the degree of difficulty in participating, or the CHART instrument that measures the degree of handicap in an individual's ability to participate in society and maintain social relationships.

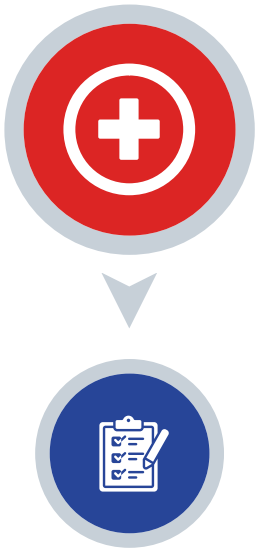
Requesting permission to use the instruments: useful links
8.1.3. ALONE: João Tavares, joaoptavares@ua.pt
8.2.1. LSNS: https://www.bc.edu/content/bc-web/schools/ssw/sites/lubben/description/permission-to-use-scales.html
8.2.2. SIS: João Tavares, joaoptavares@ua.pt
8.3.1. IMPACT-S: Marcel W. M. Post, mpost@umcutrecht.nl

End users | Impact metric 9
Adverse health events

Metric definition

Adverse events are occasions that result in:

- death;
- require either inpatient hospitalisation or the prolongation of hospitalisation;
- are life-threatening;
- result in a persistent or significant disability/incapacity or result in a congenital anomaly/birth defect.



5 Parameters*

* As parameters, no translation or authorisations apply.

9.1. Adverse events	
9.1.1. Number of serious events that required hospitalisation (e.g., life-threatening events such as severe allergic reaction, heart attack or stroke)	This parameter can be evaluated through a structured questionnaire.
9.1.2. Number of non-serious events (e.g., common cold, mild headaches, fatigue or mild allergic reaction)	This parameter can be evaluated through a structured questionnaire.
9.2. Medication	
9.2.1. Adherence	This parameter can be evaluated through a structured questionnaire (e.g., mean number of medicine intake errors, mean number of missed doses).
9.2.2. Intake errors	This parameter can be evaluated through a structured questionnaire (e.g., mean number of medicine intake errors, mean number of missed doses).
9.2.3. Missed doses	This parameter can be evaluated through a structured questionnaire (e.g., mean number of medicine intake errors, mean number of missed doses).
 Complementary items on the perception of the impact of ICT-based AT use on adverse health events	We suggest complementing the measurement of these parameters with the following questions: "In a general way, do you feel that this ICT-based AT that you are using impacts your security/safety with respect to health?" OR "Do you find any differences between your security/safety regarding your health before and after the use of this ICT-based AT?" If they answer: "Yes", ask: "Can you please specify in what ways?"

End users | Impact metric 10 Autonomy

Metric definition

Autonomy refers to the perceived ability to control, cope with and make personal decisions about how one lives on a day-to-day basis, according to one's own rules and preferences.

1 Instrument

Available in Portuguese

Permission required

Instrument*	Population	Administration	Time #	Translations	Free access
10.1. Autonomy-Connectedness Scale (ACS-30) (Bekker & van Assen, 2010) [1]	General	Self-report questionnaire	10-15 minutes	✔	✖

Complementary items on the perception of the impact of ICT-based AT use on autonomy	We suggest complementing these instruments with the following questions: "Generally, do you feel that this ICT-based AT that you are using have been impacting your autonomy, that is, your power to take decisions?" OR "Do you find any differences between your autonomy level before and after the use of this ICT-based AT?" If they answer: "Yes", ask "can you please specify in what ways?"

* Original version: author(s), publication year and items to consider.
# The time needed to administer the instrument depends on a large number of factors, including the individual's cognitive and communicative abilities, among others.
[1] Adapted by Moleiro, Ratinho & Bernardes (2017).

Requesting permission to use the instrument: useful links
10.1. m.h.j.bekker@tilburguniversity.edu

Impact metrics

Target 2 Caregivers

Caregivers are individuals who provide support, assistance, and care to people who have physical, cognitive, or emotional needs. Caregivers are often family members, or friends, who provide unpaid care and support to older adults and/or people with disabilities. These unpaid carers are also known as informal caregivers. Informal caregivers are often understood as secondary end users. They are directly in contact with a primary end user and may also benefit from ICT-based AT directly when using ICT-based products and services and indirectly when the care needs of primary end users are minimised.
For these caregivers, 3 key metrics were taken into consideration (cf., below). Moreover, a metric on the perception of the ICT-based AT impact on the person being cared for (the end user) is included.

- **Quality of life**
- **Burden / Stress**
- **Caregiving demands**

Caregivers | Impact metric 1
Quality of life

Metric definition

QoL refers to an individual's subjective perception of their overall well-being and satisfaction with various aspects of their life. It encompasses both objective factors (such as physical health, living conditions, and access to resources) and subjective factors (including happiness, life satisfaction, and fulfilment).

3 Instruments

3 Available in Portuguese

3 Available in Spanish

2 Free access

Instrument*	Population	Administration	Time #	Translations		Free access
1.1. World Health Organization, Quality of Life Questionnaire WHOQOL - 100-item (World Health Organization, 1994)	Adults	Self-completion, completed by the interviewer or through interview	About 30 minutes	✓	✓	✓
1.2. World Health Organization Quality of Life Questionnaire - Brief (WHOQOL-Brief) (World Health Organization, 1998)	Adults	Self-completion, completed by the interviewer or through interview	About 5 minutes	✓	✓	✓
1.3. EuroQol 5 dimensions questionnaire (EQ-5D) (EuroQol, 1987)	General	Self-completion, face-to-face or telephone interview	< 5 minutes	✓	✓	✗

Complementary items on the perception of the impact of ICT-based AT use on quality of life	We suggest complementing the the instruments with the following questions: "In a general way, do you feel that the ICT-based AT that your relative is using impacts your quality of life?" OR "Do you find any differences between your Quality of Life before and after the use of this ICT-based AT by your relative ?" If they answer "Yes", ask: "Can you please specify in what ways?"

* Original version: author(s), publication year and items to consider.
# The time needed to administer the instrument depends on a large number of factors, including the individual's cognitive and communicative abilities, among others.

Requesting permission to use the instruments: useful links
1.3. EQ-5D: https://euroqol.org/

Caregivers | Impact metric 2
Burden / Stress

Metric definition

Burden refers to the consequences that occur following the provision of care to a sick, disabled, or dependent person. Burden is associated with a deterioration in the caregivers' quality of life and increased morbidity of the care recipient.

3 Instruments

2 Available in Portuguese

2 Available in Spanish

FREE

Permission required

Instrument*	Population	Administration	Time #	Translations		Free access
2.1. Zarit Burden Interview Assessment Tool (ZBI) (4-item or 12-item or 22-item) (Zarit, Reever & Bach-Peterson, 1980)	Informal caregivers of dependent persons	Self-administered or hetero-administered by an interviewer	About 5 minutes for the shortest version	✓	✓	✗
2.2. Care-related Quality of Life Instrument (CarerQol-VAS & CarerQol-7D) (Hoefman et a.l, 2011) [1]	Informal caregivers	Self-completion or hetero-administered by a professional	About 10 minutes for both measures of well-being (CarerQol -VAS) and subjective burden (CarerQol -7D)	✓		✓
2.3. Positive Aspects of Caregiving (PAC) (11-item and 9-item) (Boener et al., 2004; Tarlow et al., 2004)	Informal caregivers	Self-completion or hetero-administered	10-15 minutes	✓	✓	✗

Complementary items on the perception of the impact of ICT-based AT use on burden	We suggest complementing this questionnaire with the following questions: "Generally, do you feel that the ICT-based AT that your relative is using impacts your burden/stress level?" OR "Do you find any differences between your burden/stress level before and after the use of this ICT-based AT by your relative?" If they anwser: "Yes", ask: "Can you please specify in what ways?"

* Original version: author(s), publication year and items to consider.
# The time needed to administer the instrument depends on a large number of factors, including the individual's cognitive and communicative abilities, among others.
[1] See the website at https://www.imta.nl/questionnaires/carerqol/

Requesting permission to use the instruments: useful links
2.1. ZBI: https://eprovide.mapi-trust.org/instruments/zarit-burden-interview

Caregivers | Impact metric 3
Caregiving demands

Metric definition

Caring can be a demanding and exhausting job, implying a higher level of emotional and physical stress. This is an important metric because it allows understanding the intensity of informal caregiving, which includes parameters as workload, time spent on caregiving, sharing of caregiving tasks, the subjective perception of burden, time available for self-care and free time.

5 parameters*

* As parameters, no translation or authorisations apply.

3.1. Caregiving workload	
3.1.1. Subjective perception of burden	Please refer to the suggested questions in the blue box below.
3.1.2. Time spent providing care per day or week	Please refer to the suggested questions in the blue box below.
3.1.3. Share of caregiving tasks with another person	Please refer to the suggested questions in the blue box below.
Questions on the perception of the impact of ICT-based AT use on caregiving workload	Suggested questions: "How demanding is your current work as a caregiver?" (before and after the introduction of the ICT-based AT) "How many hours per week do you dedicate to caregiving tasks?" (before and after the introduction of the ICT-based AT) "Do you share the task of caregiving with another person?"
3.2. Subjective perception of time available for self-care	
3.2.1. Subjective perception of free time	Please refer to the suggested questions in the blue box below.
3.2.2. Subjective perception of reduction of burden/ efforts in caregiving tasks	Please refer to the suggested questions in the blue box below.
Questions on the perception of the impact of ICT-based-AT use on time available for self-care	Suggested questions: Do you feel satisfied with the time you have for yourself? (before and after the introduction of the ICT-based AT) Do you feel that this ICT-based AT helps you to reduce the time or effort spent in caregiving tasks? (only after the introduction of the ICT-based AT)

* Original version: author(s), publication year and items to consider.
# The time needed to administer the instrument depends on a large number of factors, including the individual's cognitive and communicative abilities, among others.

Impact perception metrics

Perception of the impact of ICT-based AT on the end user

This indicator addresses if, to what extent and how the caregivers or the health and social professionals understand the implications of using an ICT-based product or service on the life of the end user.
Therefore, it is necessary to investigate whether the ICT-based AT is effective and meets the actual needs of users, whether it is suited to their specificities and meets their expectations.

Perception of informal caregivers

Perception of health and social support professionals

Instrument*	Population	Administration	Time #	Translations	Free access
1. Perception of informal caregivers					
1.1. Caregiver Assistive Technology Outcome Measure (CATOM) (Mortenson et al., 2015)	Informal caregivers of older people with disabilities	Structured interview (face-to-face or phone)	13-20 minutes		✖
Questions on the perception of the ICT-based AT impact on the person being cared for	We suggest complementing this interview with the following questions: "Do you feel that this ICT-based AT can fulfil your relatives' needs? That is, does this ICT-based AT helps him/her, does it resolve his/her problems/challenges/difficulties?" "Have you notice any relevant change in your relative (e.g., in his/her well-being, functionality, social participation, self-esteem, cognitive status, global health)?" "In general, what are, in your opinion, the main benefits and disadvantages of this ICT-based assistive product or service?"				
2. Perception of health and social professionals					
2.1. Needs satisfaction	Please refer to the suggested questions below.				
2.2. Subjective impact	Please refer to the suggested questions below.				
2.3. Benefits and disadvantages	Please refer to the suggested questions below.				
Questions on the perception of the ICT-based AT product or service impact on the end user	"Do you feel that this ICT-based AT can fulfil your patient's/client's needs? That is, does this ICT-based AT helps him/her, does it resolve his/her problems/challenges/difficulties?" "Have you noticed any relevant change in your patient/client (e.g., in his/her well-being, functionality, social participation, self-esteem, cognitive status, global health)? Please justify." "In general, what are, in your opinion, the main benefits and disadvantages of this ICT-based AT for your client?"				

* Original version: author(s), publication year and items to consider.
# The time needed to administer the instrument depends on a large number of factors, including the individual's cognitive and communicative abilities, among others.

Requesting permission to use the instrument: useful links
CATOM: Louise Demers; louise.demers@umontreal.ca

Process metrics

Process

Process indicators are a set of measurable metrics and criteria used to assess the usability and user satisfaction of a technology. They provide insights into how well a technology or system is performing in terms of its usability and user experience.

By considering these process indicators, technology designers, developers, and evaluators can gain valuable insights into the strengths and weaknesses of an ICT-based AT, enabling them to identify areas for improvement and optimize usability and user satisfaction.

The usability and user satisfaction of an ICT-based assistive product and its associated services can significantly influence the potential impact they have on users' lives.

For these process indicators, 2 key metrics were taken into consideration (cf., below).

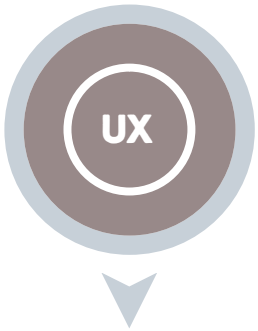
Usability, user experience and acceptance

Overall satisfaction with the ICT-based AT

Process metric 1
Usability and user experience

Metric definition

The user experience of assistive technology refers to the feeling the user has when using the technological product, but also to the perception of how it interferes with the performance of tasks; it takes into account several factors, namely the ability and ease of using the product, the appropriateness and relevance of the product.
According to ISO 9241-11 usability is the measure *"by which a product can be used by specific users to achieve specific objectives with effectiveness, efficiency and satisfaction, in a specific context of use"*. Thus, products can have products can have different levels of usability given the contexts in which it is used.



7 Instruments/parameters

6 Available in Portuguese *

4 Available in Spanish *

2 Free access #

* Including parameters that do not require translation.
# For instruments.

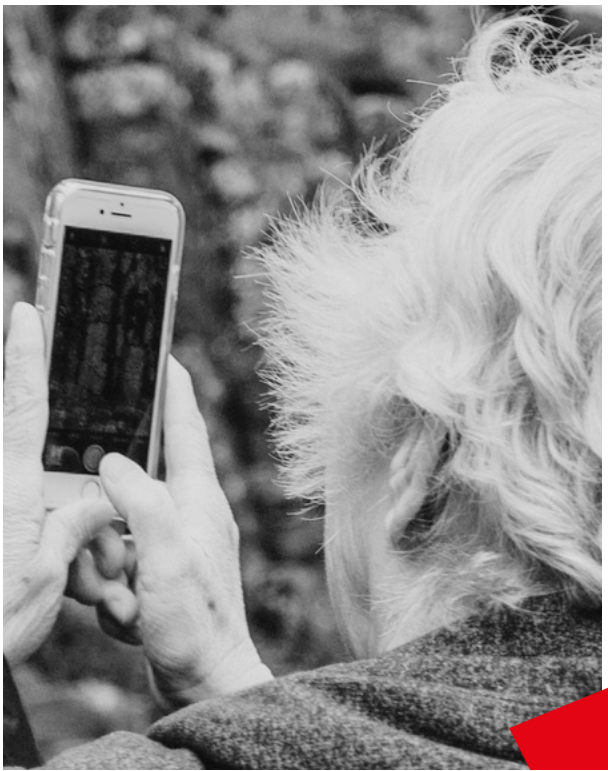
Instrument*	Population	Administration	Time #	Translations		Free access
1.1. Senior Technology Acceptance Model (STAM) (Smith, 2008) [1]	Older adults	Interviews, focus groups or any other technique	Variable [2]	NA	NA	NA
1.2. Post-study system usability questionnaire (PSSUQ) (originated from an internal IBM project, 1988)	General	Self-completion or hetero-administered through interview	5-10 minutes	✓		✓
1.3. Usefulness, satisfaction, and ease of use scale (USE) (Lund, 2001)	General	Self-completion or hetero-administered through interview	5-10 minutes	✓		
1.4. System Usability Scale (SUS) (Brooke, 1986)	General	Self-completion or hetero-administered through interview	5-10 minutes	✓	✓	✓
1.5. Software Usability Measurement Inventory (SUMI) (Kirakowski, 1995)	General	Self-completion or hetero-administered through interview	10-30 minutes	✓	✓	✗
1.6. Questionnaires focusing on:						
1.6.1. User Experience (UX)	This parameter can be evaluated through a structured questionnaire.					
1.6.2. Net Promoter Score (NPS)	This parameter can be evaluated through a structured questionnaire.					

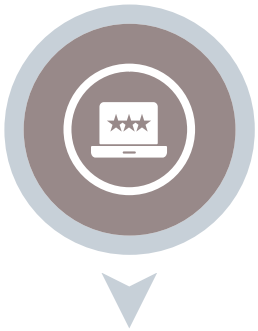
* Original version: author(s), publication year and items to consider.
# The time needed to administer the instrument depends on a large number of factors, including the individual's cognitive and communicative abilities, among others.
[1] As STAM is a theoretical framework that provides guidance on understanding and predicting the acceptance and adoption of technology among older adults, it does not prescribe a specific mode of administration. It can be applied by survey interviews, focus groups or by using any other techniques.
[2] Depending on the research design, data collection methods, and the instruments used to assess the constructs within the model. Since the STAM itself is a theoretical framework rather than a specific measurement instrument, the time of administration will depend on the tools employed to gather data related to the model.

Process metric 2
Overall satisfaction

Metric definition

The metric 'overall satisfaction with the ICT-based AT' considers that the user's perception of the devices and the factors that contribute to their use allows them to understand the satisfaction with the equipment according to their expectations and reflect whether it suits their individual needs. Therefore, satisfaction of ICT-based AT subjectively assesses the user's level of contentment with the assistive technology. The use of assistive technology may imply demotivation and abandonment of the use of the technological product, so it is important to assess the level of satisfaction of users, understanding whether it mirrors their expectations, perceptions, attitudes and whether it meets their individual needs.





4 Instruments

2 Available in Portuguese

2 Available in Spanish

2 Free access

Instrument*	Population	Administration	Time #	Translations		Free access
2.1. User Interaction Satisfaction (QUIS) (Chin, Diehl & Norman, 1988)	General	No info	Variable [1]			✗
2.2. Rapid Assistive Technology Assessment (rATA) (World Health Organization, 2021)	General	Interviewer-administered by trained staff	Variable [2]	✓	✓	✓
2.3. Quebec User Evaluation of Satisfaction with Assistive technology (QUEST 2.0) (Demerset al., 1996)	Older adults; people with multiple health problems	Self-completion or hetero-administered through interview	15-30 minutes	✓	✓	✗
2.4. Tele-healthcare Satisfaction Questionnaire – Wearable Technology (TSQ-WT) (Chiari et al., 2009) [3]	General	Self-completion or hetero-administered through interview	10-15 minutes			✓

Questions on the user satisfaction with ICT-based AT

Suggested questions:
"In general, how satisfied are you with this ICT-based AT?"

Other questions may be considered regarding ethical issues (e.g., data protection, privacy) and trust in the solution.

* Original version: author(s), publication year and items to consider.
# The time needed to administer the instrument depends on a large number of factors, including the individual's cognitive and communicative abilities, among others.
[1] Depending on the number of scales used and the complexity of the system being evaluated. Typically, it takes around 15 to 30 minutes.
[2] This tool should be used only for rapid mapping of need, demand, supply and user satisfaction with AT. No specific information is available regarding time to complete.
[3] See the instrument at: https://tinyurl.com/5c5efc7x.

Requesting permission to use the instrument: useful links
QUIS: https://www.umventures.org/technologies/quis%E2%84%A2-questionnaire-user-interaction-satisfaction-0
QUEST 2.0: https://www.midss.org/sites/default/files/questeng.scoring_sheetpdf_0.pdf

4. Guidance

Evaluating the impact of ICT-based assistive products and services on the lives of older adults and people with disabilities can be a complex task that requires careful consideration of various factors.

The Integr@tención team systematised all the information from different sources, but some limitations need to be considered when analysing the results of this EML. First, the field of ICT-based AT is populated with a wide variety of terminology and ill-defined concepts, thereby posing a challenge to gather and synthesise the scientific and grey literature. Second, while the existence of manifold assistive technologies is an opportunity to promote inclusion, autonomy, and equity for older and/or people with dependency with diverse needs, such heterogeneity creates significant challenges in the identification of relevant research for this EML and narrative synthesis of outcomes, instruments and results stemming from that research. Third, as the field of ICT-based AT is rapidly evolving alongside the field of assessment measurements targeted at older populations, this library lists many instruments to assess each impact domain, all resulting from the comprehensive search and consultation with experts. However, not all instruments are translated into the languages of the "Integr@tención II" project, Spanish and Portuguese, and may or may not be validated. However, their inclusion expects that many of those instruments may be undergoing validation, or will be in the near future, so are included in this resource.

Despite the limitations presented, this EML can assist in the design of assessment protocols to determine the impact of ICT-based assistive products and services.

To help the evaluator make the most appropriate decisions, we have compiled general recommendations, based on some considerations and reflections that emerged during the process of constructing this EML.

General recommendations

1. Diverse metrics and indicators: keep it brief!

There is no one-size-fits-all approach for evaluating the impact of ICT-based assistive products and services. Potential evaluation areas include quality of life, autonomy, functional and cognitive status, global health, and social connectedness, but different metrics/indicators can be used depending on the specific technology and its goals. It is crucial to consider the type of ICT-based assistive product and service and select the metrics that seem more appropriate and relevant for the evaluation. Furthermore, the evaluation must be brief (not all metrics/indicators should be used) and we recommend using the shorter versions of the instruments identified in this EML.

2. Instruments must be sensitive to small changes

It is important to consider some psychometric characteristics of the instruments selected for the evaluation protocol, specifically their sensitivity to measure and detect small changes over time. Instrument sensitivity refers to the ability of a device or measurement tool to detect even the slightest changes in the parameter it is measuring. In the context of evaluating ICT-based assistive products and services, sensitivity becomes particularly vital when assessing small improvements or changes in physical, cognitive or functional abilities among older adults and/or people with disabilities. By employing instruments with high sensitivity, researchers/professionals can capture nuances that may not be apparent to the naked eye, leading to more precise evaluations and reliable results. The impact of ICT-based assistive products and services may manifest as small but meaningful improvements in various aspects of daily life.

3. Preliminary assessment of usability and acceptability

Before delving into impact evaluation, conducting a preliminary assessment of usability and acceptability is imperative. This involves gaining insights into how people interact with the technology, using qualitative techniques such as diaries or records. It is important to consider the “novelty effect”, that can either lead to frustration and limited usage or initial enthusiasm and continuous usage due to the novelty factor. It is also crucial to consider a familiarisation period with the technology. Two consulted experts suggested that end users should have the opportunity to experiment with the ICT-based AT for approximately four weeks (as a reference point). However, the actual duration may vary, depending on factors such as the end users' training needs and digital skills as well as the level of challenge associated with use of the technology.

4. Safety, privacy, ethics

Evaluations should address perceptions of safety and privacy, as well as the ethical considerations. Ensuring safety of older adults and people with disabilities during the evaluation process is paramount. Safety considerations encompass both physical and psychological aspects. Scientific studies emphasise the need to assess potential risks associated with the technology's use, such as falls, malfunctions or adverse effects. Evaluation protocols should include procedures to identify, prevent and mitigate potential safety hazards. This is why the WHO emphasises the importance of user-centred design and the involvement of end users in the evaluation process, to address safety concerns effectively. Furthermore, respecting privacy is crucial; these populations may have specific privacy needs due to their health conditions or personal circumstances. Evaluation protocols should incorporate privacy protection measures, ensuring that personal data collected during the evaluation is handled securely and confidentially. UN guidelines on privacy in ICT-based assistive products and services stress the significance of informed consent, anonymisation of data and adherence to legal and ethical standards regarding privacy rights. Ethical guidelines and frameworks help ensure the well-being and dignity of older adults and people with disabilities throughout the evaluation process (key ethical considerations include informed consent, autonomy, equity and accessibility, benefit and non-maleficence, and transparency).

5. Assessment methods

Passive assessment methods are also worth considering when assessing the usability and usage (e.g., frequency, usage patterns) of an ICT-based assistive product and service, as they do not impose additional tasks on the participants. Such methods may include surveillance, usability-performance measures (i.e., session log data, time and number or errors, aids required for the tasks, daily activities, achieved scores), data collected from sensors embedded in the person's environment or wearables (e.g., heart rate, sleep quality, exercise level). Usually, these data are collected through the technological solution being tested, but they may also be collected through additional technological tools specifically employed for evaluation purposes.
In fact, a recently published scoping review by Tónay et al. (2023) demonstrated that outcome measurements commonly combine both active methods (e.g., participating in an interview, contributing to a focus-group discussion, keeping a diary, or filling in a questionnaire) and passive methods.

Furthermore, a mixed-methods approach should be considered, by combining quantitative and qualitative methods, in an attempt to overcome the limitations of common standardised tools.

6. Long-term assessment

To achieve more accurate evaluations, it is essential to assess the impact of technologies over the long-term. This involves analysing the user's experience throughout their interaction with the technology. Examining the alignment between the user's needs and the perceived impact makes it possible to identify key factors that facilitate positive change in their lives and to understand any limitations or barriers to usage. Therefore, evaluations should consider the characteristics of the individuals being evaluated and define appropriate evaluation moments and procedures. There is no consistency regarding the follow-up periods, but most of the studies analysed emphasised the importance of continuous monitoring, particularly to understand the impact of the ICT-based AT use, as well as the need to adjust the evaluation.

7. Structuring assessment protocols

When structuring assessment protocols, factors such as the evaluation setting (laboratory or home environment), the inclusion of control groups, blinding of evaluators, and timing of evaluations (baseline, ongoing, post-intervention) should be considered.

Each evaluation moment should align with the goals, type of technology, and the characteristics of the users being assessed.

We safeguard some relevant considerations relating to the timings of the evaluation of ICT-based AT, since it is conditioned by a set of variables, namely the type of technology and characteristics of the end user. In fact, there is no specific timing evaluation that can be generalised to measure all ICT-based AT.

5.
Final remarks

> **"There is a critical need for effective and reliable methods for judjing the efficacy of technological interventions for improving the functioning of older persons, for assisting them in performing tasks necessary for everyday living, for enhancing their capacity to engage in desired behaviors, and for generally improving their quality of life."**
>
> HERTZOG & LIGHT, 2004, P.94

It is essential to use appropriate methods to assess the effectiveness of technological solutions targeted at older adults and people with disabilities to enhance their functioning and generally improve their quality of life (Hertzog & Light, 2004). However, there remains a dearth of comprehensive review studies that synthetise the methodological concerns, measurement tools, and other relevant factors for evaluating the impact of ICT-based assistive products and related services on older adults and people with disabilities.

During the research, the gaps and limitations in this field of knowledge may have interfered with the presented results. For instance, the literature review revealed significant variation in methodological approaches. This heterogeneity can be attributed to the: i. wide range of solutions being examined; ii. variations in sample characteristics; iii. specific targets of the evaluation (i.e., the individuals on whom the impact is being assessed); and the iv. specific aims of each intervention utilising ICT-based AT.

This presents challenges in selecting the most suitable metrics and instruments to evaluate the impact of ICT-based AT. To address these challenges, the work developed to build this EML combined the insights from the literature review with other sources, including the information conveyed on websites and documents from international organisations, and interviews with experts in the field.

This EML was then designed to provide a comprehensive collection of metrics that can be used to assess the effectiveness of ICT-based AT, specifically tailored for community-dwelling older adults and people with disabilities. This library encompasses metrics that cater to end users and their informal caregivers, covering key aspects such as quality of life, functional and cognitive status, social connectedness, mental health and more. The EML also emphasises the importance of capturing the perspectives of health and social professionals regarding the impact of ICT-based assistive products and services on the lives of end-users.

For each assessment field defined in this library, a collection of reliable instruments is provided, along with additional information regarding their application and characteristics (e.g., intended population, time, and mode of administration). This information serves as an initial resource for researchers, practitioners, or professionals to select the most appropriate instruments to evaluate the impact of ICT-based assistive products and services on targeted outcomes.

All the presented instruments are widely utilised in both research and practice, providing a standardised approach to assess the desired outcomes (e.g., quality of life), thereby enhancing comparability across studies. However, interviews and other qualitative data collection techniques are important for obtaining in-depth information about user experience and understanding perceived impact in dimensions that may not be captured by standardised instruments. One drawback is that interviews and other techniques for collecting qualitative data can be time-consuming, during both the data collection and analysis stages, and they may have limited comparability across studies. This library suggests a set of open-ended questions for each metric that can be incorporated into interview or focus group guides.

Furthermore, this EML has been constructed based on a variety of perspectives, employing a triangulation of methods. It incorporates research from scientific databases (based on a scoping review), consultation of documents from reputable organisations (e.g., WHO, UN), and interviews with experts in the field of ICT-based assistive products and services. By combining multiple sources of information, this EML offers a comprehensive and inclusive approach to evaluating the impact of ICT-based assistive products and services.

This EML can be considered a dynamic document that can evolve alongside advances in research, practice, and evaluation methodologies within the field of assistive technology. It can therefore provide practical guidance and serve as a living document, adapting to the ever-changing landscape of assistive technology and evolution practices.

The heterogeneity of ICT-based assistive products and services can, furthermore, be considered a positive aspect, as it drives the development of personalised and tailored solutions that cater to the specific needs of individuals or specific population groups. This diversity, in fact, brings forth “new ways” of evaluating that align with the evolution and incorporation of these technologies. Evaluations are, therefore becoming more adaptive, accommodating the unique needs and requirements of individuals, and enhancing their overall well-being.

By embracing a consultative approach and considering this EML as a living document, evaluators can stay informed about the latest developments, refine their methodologies, and contribute to the continuous improvement of ICT-based assistive products and services and their evaluation practices. Together, we can ensure these technologies truly empower and enhance the lives of people with diverse needs and abilities.

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Appendix

We would like to introduce the annexes accompanying this document, which provide additional information on the evaluation of the impact of ICT-based AT. These annexes consist of three distinct folders, each containing valuable resources for further exploration:

1. Scoping review results

This folder contains a comprehensive table presenting the selected articles from the scoping review. These articles have been carefully reviewed and curated to provide insights into the impact evaluation of ICT-based AT. The table offers a structured overview of the key findings and can serve as a reference for those interested in delving deeper into the subject.

2. Instruments repository

In this folder, you will find a collection of freely accessible instruments related to ICT-based AT evaluation. These instruments encompass original versions and, if available, translations into Portuguese and Spanish. By providing these resources, we aim to facilitate access to the instruments presented in this EML across different linguistic contexts.

3. Proposed ICT-based AT evaluation protocol

This folder offers a suggested protocol for assessing the impact of assistive technology. The protocol outlines a methodology for evaluating the impact and outcomes of ICT-based AT. It serves as a valuable guide for researchers, practitioners, and stakeholders involved in the field.

To access and consult these documents/folders, please submit a request to the following contact email: info@integratencion.eu.

We kindly ask you to provide your name, affiliation, and a brief statement of purpose for accessing the annexes. Once your request has been processed, we will promptly provide you with the necessary information to access the materials.
We trust that these resources will be of great assistance in understanding and evaluating ICT-based AT. If you have any further inquiries or require additional support, please do not hesitate to contact us at the aforementioned email address.

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