The Growing Need for Dementia and Frailty Prevention in Greece

Greece, like many European countries, faces significant challenges linked to demographic ageing. The rising prevalence of dementia and cognitive decline among the older population represents a major public health concern, particularly in urban areas like Thessaloniki. Early-stage cognitive decline often goes unnoticed but significantly impacts quality of life and healthcare resources in later stages. The digital divide and limited access to continuous monitoring underscore the urgent need for innovative, accessible, and user-friendly solutions that foster active ageing, maintain cognitive health, and enhance the autonomy of older adults.

Literature on dementia incidence is extensive; it should be noted though that the only relevant research in Greece was published 20 years ago. The reported annual incidence rate was 57 per 1000 persons above 70 years old[1], quite higher than rates simultaneously reported for Europe [10.5 to 15.6/1000 (men), 15.2 to 19.4/1000 (women), 65 y and above][2] and more recently for the world (17.18/1000, above 60 y old)[3].

The Greek population is characterized by genetic (low APOE-ε4 prevalence) and lifestyle (eg, Mediterranean diet) oddities. Moreover, even in similar populations there is great variation in reported rates.

According to the Hellenic Epidemiological Longitudinal Investigation of Aging and Diet (HELIAD) study age-standardized and gender-standardized prevalence of MCI in people aged 65 years and older in Greece is 13.11%. The amnestic and multidomain MCI subtypes are more common than their nonamnestic and single-domain counterparts, respectively. Almost two thirds of cases are because of suspected Alzheimer disease. Every additional year of age increases the odds of prevalent MCI by 7.4%, every additional year of education decreases the odds of MCI by 6.3%, and apolipoprotein E (*APOE-ε4*) carriage increases the odds of MCI by 57.9%[4].

Few studies have been conducted in Greece concerning the prevalence of dementia and MCI. In a study at a rural area of Northern Greece, called M. Alexandros, the prevalence of MCI according to the age groups was 1.6% for the 65- to 69-year age group, 1.7% for the 70- to 74-year age group, 4.3% for the 75- to 79-year age group, and 2.7% for those aged 80+ group. In the same study, the prevalence of MCI due to depression was 8.8%, a percentage similar to ours (8.6%), and 5.9% had only depression, a percentage much lower than ours (33.9%). A previous study in the municipality of Pylaia, an urban area in Thessaloniki, had indicated higher numbers of prevalence of dementia: 4.24% for the 70- to 74-year age group, 10.7% for the 75- to 79-year

[1] Tsolaki M, Fountoulakis C, Pavlopoulos I, et al. Prevalence and incidence of Alzheimers disease and other dementing disorders in Pylea, Greece. Am J Alzheimers Dis Other Demen 1999;14:138–148.

[2] Launer LJ, Andersen K, Dewey ME, et al. Rates and risk factors for dementia and Alzheimer's disease: results from EURODEM pooled analyses. EURODEM Incidence Research Group and Work Groups. European Studies of Dementia. Neurology. 1999;52:78–84.

[3] Fiest KM, Jette N, Roberts JI, et al. The prevalence and incidence of dementia: a systematic review and meta-analysis. Can J Neurol Sci. 2016;43(suppl 1):S3–S50.

[4] Vlachos, G. S., Kosmidis, M. H., Yannakoulia, M., Dardiotis, E., Hadjigeorgiou, G., Sakka, P., ... & Scarmeas, N. (2020). Prevalence of mild cognitive impairment in the elderly population in Greece: results from the HELIAD study. *Alzheimer Disease & Associated Disorders*, *34*(2), 156-162.

age group, 10.64% for the 80- to 84-year age group, 11.8% for the 85- to 89-year age group, and 36.7% for those aged 90+ group. The urban versus rural way of living may account for the difference in findings between the latter study and the present one. Moreover, the application of Mungas correction in the present study and its absence in the previous one might explain the different findings. Another study from the Northern Greece showed that 37.6% of the men and 41.6% of the women had cognitive impairment (Figure 1).

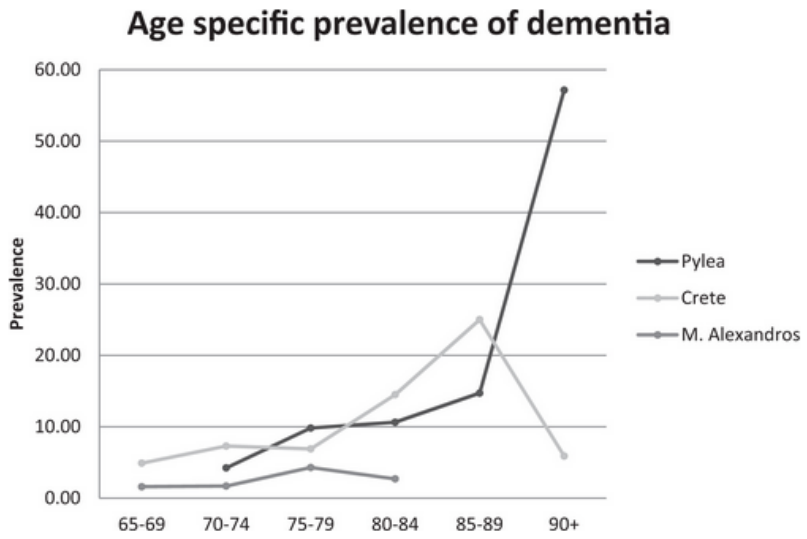


Figure 1: Prevalence of dementia at some regions of GREECE

CERTH involvement and experience with dementia.

The Centre for Research and Technology Hellas (CERTH) offers a pioneering model for digitally enabled active ageing, bringing together advanced research, innovative technological solutions, and practical interventions. CERTH's state-of-the-art **nZEB Smart Home infrastructure** provides a unique environment, leveraging cutting-edge digital technologies, virtual reality, and artificial intelligence to support cognitive health and active living among older adults. Within the COMFORTage project, CERTH utilizes its extensive expertise in digital innovation, particularly in smart environments and data-driven personalized care, to proactively address dementia and frailty through a multifaceted approach combining cognitive training, physical activity, and personalized health monitoring.

Some key achievements are highlighted below:

- **Fully operational** Digital Innovation Hub since 2017
- **Constantly evolving collaborations** in Regional, National, & EU level
- Already participates as a pilot infrastructure in more than **20 R&D** projects
- **Active role** in most EU initiatives for DIHs so far

The domains of research of the Digital Innovation Hub powered by CERTH/ITI

Figure 2: A Digital Innovation Hub powered by CERTH/ITI:

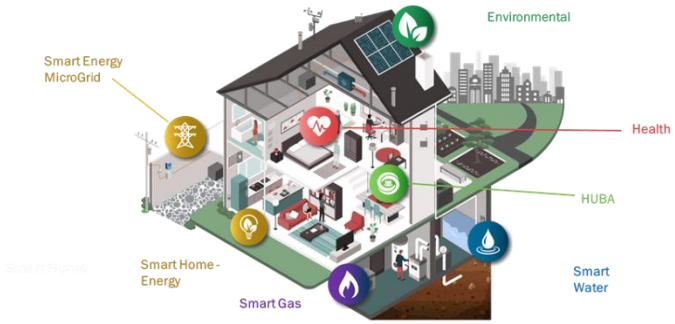
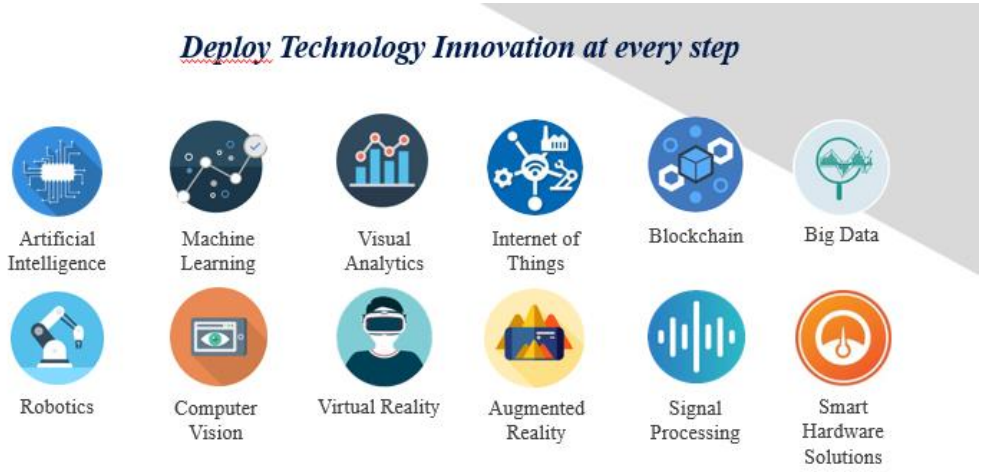


Figure 3. nZEB Infrastructure in CERTH.

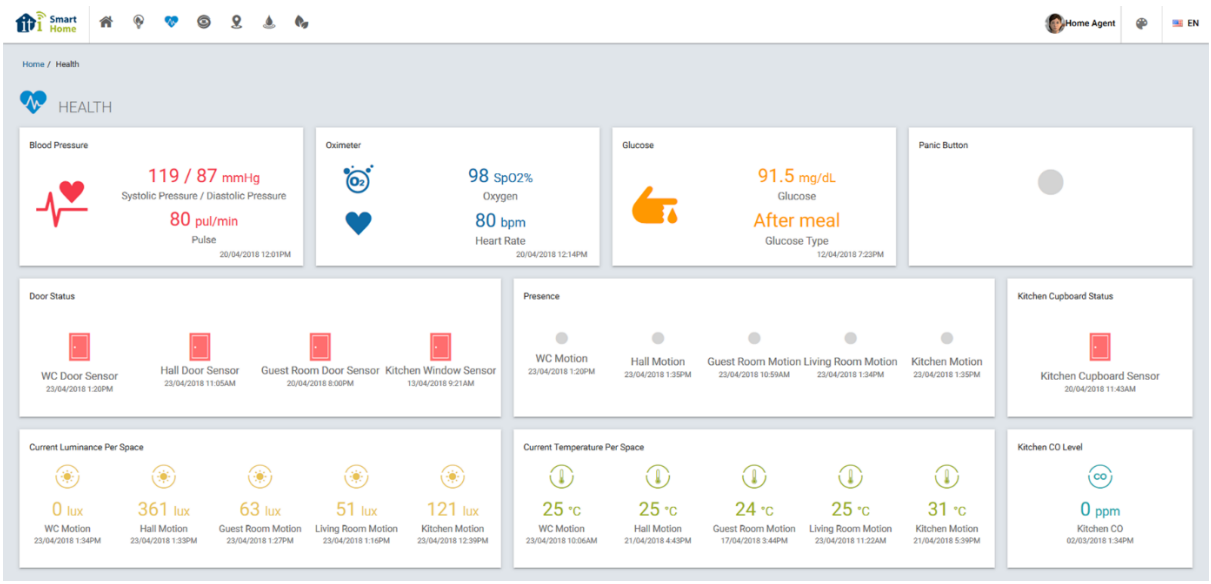
A timeline of the nZEB Smart Home DIH is described below:

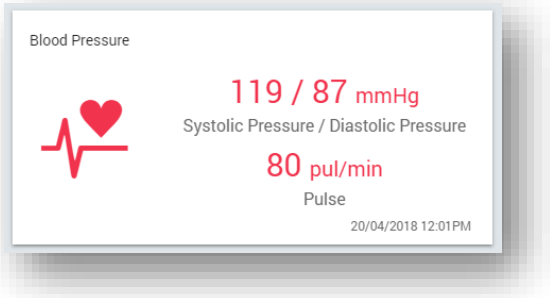
The expertise of CERTH/ITI smart home is described at a glance below:

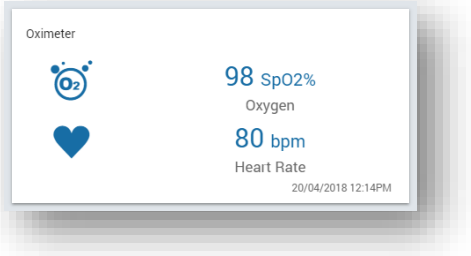


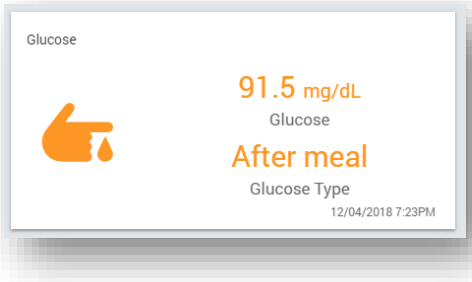
In particular according to the health domain Assistive Living and Health Monitoring is feasible in nZEB infrastructure through:

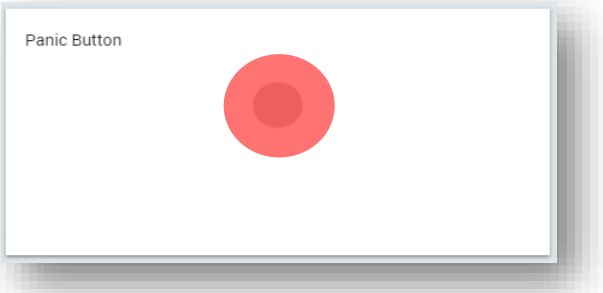
- Continuous, Connected Care **Patient Monitoring** through Various Medical & **Alarm Devices**
- Real-time **Predictive** Analytics
- **Treatment adherence**
- Behavioural monitoring and **peace of mind**
- Wellness and quality of life integrated services, along with **AI-driven Conversational Agent** (Virtual Assistant) for Self-management of chronic diseases











The services provided are the following

CERTH Pilot: A Future-Proof Digital Environment for Dementia Prevention and Personalized Active Ageing

CERTH's Comprehensive Approach within COMFORTage

The CERTH pilot, titled "Creation of future-proof, viable and active-testing environment for older adults," provides digitally enabled, personalized, non-pharmaceutical interventions targeting early detection, monitoring, and prevention of dementia and frailty. The pilot targets three distinct groups:

- **Healthy older adults** at high risk of future cognitive decline.
- **Older adults experiencing subjective memory complaints (SCI)**.
- **Individuals with Mild Cognitive Impairment (MCI)**.

Through a carefully structured study design, participants engage in personalized digital and virtual reality-based cognitive training exercises, physical activity programs, and continuous digital health monitoring, tailored individually through Digital Twins technology. This structured digital approach allows precise, dynamic adjustments in interventions, significantly enhancing therapeutic precision, early prediction capabilities, and patient engagement.

Through a carefully designed study, participants are engaged in personalized interventions that combine digital tools, virtual reality-based exercises, physical activity programs, and continuous health monitoring, enabled by Digital Twins technology. This approach ensures that the

interventions are specifically tailored to each participant's unique needs, which vary depending on their cognitive and physical health status.

For **healthy individuals**, the focus is on enhancing cognitive resilience and maintaining physical activity to promote overall well-being. In contrast, **participants with subjective memory complaints** receive interventions aimed at improving cognitive awareness and reducing anxiety about memory, while **individuals with mild cognitive impairment (MCI)** engage in more targeted cognitive exercises designed to slow down the progression of memory decline and other cognitive challenges.

The use of **Digital Twins technology** allows for the creation of an individualized model of each participant's health, enabling real-time adjustments to their intervention plan. For example, the cognitive training may be more intense and frequent for individuals with MCI, whereas it may be used in a lighter, preventative mode for healthy participants. Similarly, the physical activity programs are tailored to the individual's physical abilities and progression.

This dynamic and personalized approach guides appropriate intervetnions aligned with each participant's current needs, and therapeutic outcomes. The ability to adjust interventions based on real-time data improves early prediction capabilities for cognitive or physical decline, and increases patient engagement by making the interventions relevant and adaptable to unique cases.

Innovative Technology Empowering Personalized Healthcare

CERTH leverages cutting-edge technological solutions within its advanced smart home environment to offer personalized interventions for older adults and healthcare providers. By integrating virtual and augmented reality applications (such as the Virtual Supermarket and Gravity Ball), Digital Twins for individualized monitoring, intelligent conversational virtual assistants, and IoT sensors for comprehensive health and environmental tracking, CERTH creates a seamless ecosystem for older adults' health management.

Through the combination of these innovative tools and sophisticated machine learning analytics, CERTH aims to offer tailored interventions and actionable insights. The goal is to empower older adults to take a proactive role in managing their cognitive and physical health while enabling healthcare providers to monitor, assess, and respond to patient needs more effectively. This approach is expected to improve the QoL of older adults, strengthen preventive care, and optimize the management of chronic conditions such as dementia and frailty.

Objectives and Expected Benefits

CERTH's primary aim in COMFORTage is to:

- Provide proactive, early-stage detection and interventions to mitigate dementia and frailty progression.
- Empower older adults through increased understanding, self-management, and reporting of cognitive and physical health symptoms.

- Enhance interactions between participants and healthcare professionals, enabling timely personalized care and interventions.
- Systematically evaluate and validate the usability, effectiveness, and acceptance of digitally-enabled interventions through well-defined performance indicators.

Figure 4. CERTH's Pilot Continuous Feedback.

The ultimate goal is not only to delay the onset of cognitive decline but also significantly enhance participants' overall quality of life, independence, and wellbeing.

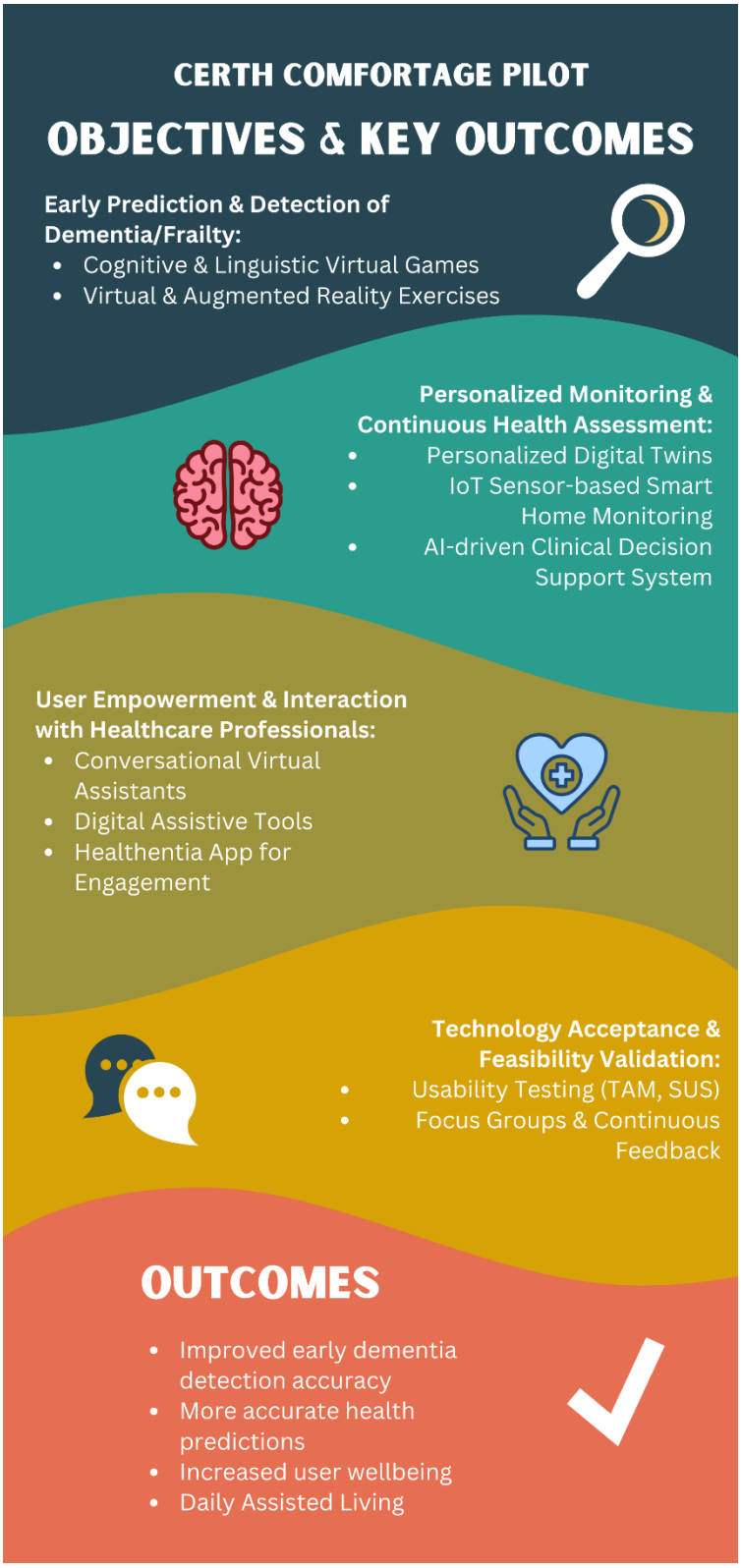


Figure 5. CERTH's Pilot study Infographic.

Pilot Study Design: Concise and Accessible

CERTH's study involves 60 participants, categorized into three distinct groups: healthy individuals, those with subjective memory complaints, and individuals diagnosed with mild cognitive impairment (MCI). Each participant is systematically assessed at three key phases: Baseline, Intermediate, and Final. The study tailors digital interventions to the specific needs of each group, focusing on their unique needs, challenges and cognitive profiles.

For **healthy individuals**, the interventions are designed to enhance cognitive resilience through engaging linguistic games and cognitive exercises, to mantain brain health and mental agility. For participants with **subjective memory complaints**, the aim is to provide appropriate tools that trigger memory, increase awareness of cognitive health, and reduce anxiety about memory loss. Participants with Mild Cognitive Impairment (**MCI)** receive personalized interventions that specifically target cognitive function decline, utilizing more intensive cognitive exercises and virtual scenarios designed to stimulate areas of the brain most impacted by early cognitive changes.

The use of intelligent virtual assistants is a key component in personalizing interventions. The assistants are not a one-size-fits-all tool; rather, they are designed to support specific therapeutic goals for each group. For example, the assistant may help **healthy individuals** track their cognitive performance or encourage them to engage in preventative exercises. For participants with **MCI**, the assistant offers personalized reminders, guides them through cognitive training sessions, and adapts based on real-time feedback to provide increasingly targeted support.

Throughout the study, physiological, cognitive, behavioral, and environmental data are continuously collected, providing a rich dataset that allows us to assess the effectiveness of the interventions in real-time. This data is used to dynamically adjust and personalize the approach for each participant. Personalized intervention plans are informed by ongoing analytics, ensuring that the solutions evolve to meet the participant's changing needs throughout the study.

The attached chart outlines how interventions are selected based on the participant's group, their initial assessment, and their progress throughout the phases of the study.

CERTH is not providing directly retrospective data but has made use of the data from **the Medical School of National and Kapodistrian University of Athens** to train the technical functionalities.

Why COMFORTage Matters to CERTH

Participation in COMFORTage positions CERTH at the forefront of precision-driven, digitally-enabled healthcare solutions. The deployment of Digital Twins, AI-powered predictive models, and IoT-based smart home technologies creates an unparalleled opportunity for personalized, proactive health management. CERTH's integration of robust research methodologies, innovative digital tools, and rigorous data analytics paves the way toward establishing novel, scalable models of dementia prevention and personalized care, significantly contributing to healthier ageing across Europe.

Looking Ahead: CERTH's Future Vision

By actively engaging in COMFORTage, CERTH aspires to set a new standard for digitally enabled, personalized elderly care. Leveraging its advanced digital environment and predictive healthcare capabilities, CERTH will continuously refine and scale its innovative care model, shaping the future of dementia prevention, active ageing, and personalized healthcare interventions at the national and international levels.