David Josef Herzog

Assessment of Ambient Assisted Living systems for patients with Mild Cognitive Impairment.

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Signature:

Doctoral dissertation submitted to the
University Fernando Pessoa
as a requirement for the Doctoral Degree in
Systems and Information Technologies
(Sistemas e Tecnologias da Informação),
under the supervision of
Prof. Rui Jorge da Silva Moreira and
Prof. José Manuel de Castro Torres,
Faculty of Science and Technology
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ABSTRACT.

According to the World Health Organization, about 50 million people worldwide suffer from dementia. Ten million new cases added every year. Mild Cognitive Impairment (MCI) affects more than 15% of the population aged 65. Technological solutions, such as smart home technology with ubiquitous computing devices, 24/7 telemedical observation and support can alleviate the growing problem and lower pressure on the healthcare system. This approach is also preferable for homecare patients in distant and rural areas.

MCI patients are mostly home-based. Ambient Assisted Living (AAL) systems provide tools for automatic registration of vital signs and other medically and socially important information. AAL system for MCI patients is a logical answer to the problem. At the same time, many of the proposed AAL systems are proprietary, technically complicated and have a high price tag for implementation and service. Also, some proposed technical solutions not entirely reflect the opinion of healthcare stakeholders.

The current study was proposed as a way to bridge the possible differences in the positions. An online anonymous questionnaire for healthcare professionals was created to prove or disprove the number of interconnected hypotheses about the necessity and feasibility of AAL system for MCI patients. The main focus was made on the hypotheses: "There is necessity of AAL systems for the healthcare" and "AAL systems are capable of providing assistance for patients with Mild Cognitive Impairment". The questionnaire was presented to more than three hundred potential respondents. Around a hundred and twenty agreed to fill it, and sixty completed the whole questionnaire. Results were analyzed to produce some directions guideline for future technical applications of AAL systems for MCI patients and future research.

Descriptive statistics show support for the implementation of general AAL and variants for MCI patients. Comparative analysis of ordinal data for specific groups of respondents is done with help of non-parametric tests. Mann–Whitney–Wilcoxon test and Kruskal-Wallis test are applied. Table questions results are analyzed with chi-square for frequency tables. Group analysis demonstrated relative positive uniformity in of responses in the support of AAL of MCI patients.

RESUMO.

Segundo a Organização Mundial da Saúde, cerca de 50 milhões de pessoas em todo o mundo sofrem de demência. Dez milhões de novos casos adicionados a cada ano. O comprometimento cognitivo leve (MCI) afeta mais de 15% da população com 65 anos. Soluções tecnológicas, como tecnologia de casa inteligente com dispositivos de computação onipresentes, observação e suporte telemédico 24 horas por dia, 7 dias por semana, podem aliviar o problema crescente e diminuir a pressão sobre o sistema de saúde. Essa abordagem também é preferível para pacientes de cuidados domiciliares em áreas distantes e rurais.

Os pacientes com CCL são, em sua maioria, domiciliares. Os sistemas Ambient Assisted Living (AAL) fornecem ferramentas para registro automático de sinais vitais e outras informações médicas e socialmente importantes. O sistema AAL para pacientes com MCI é uma resposta lógica para o problema. Ao mesmo tempo, muitos dos sistemas AAL propostos são proprietários, tecnicamente complicados e têm um alto preço para implementação e serviço. Além disso, algumas soluções técnicas propostas não refletem inteiramente a opinião das partes interessadas na área da saúde. O presente estudo foi proposto como forma de colmatar as possíveis diferenças nas posições. Um questionário anônimo online para profissionais de saúde foi criado para comprovar ou refutar o número de hipóteses interligadas sobre a necessidade e viabilidade do sistema AAL para pacientes com CCL. O foco principal foi feito nas hipóteses: "Há necessidade de sistemas de AAL para a saúde" e "Os sistemas de AAL são capazes de prestar assistência a pacientes com Comprometimento Cognitivo Leve". O questionário foi apresentado a mais de trezentos respondentes potenciais. Cerca de cento e vinte concordaram em preenchê-lo e sessenta preencheram todo o questionário. Os resultados foram analisados para produzir algumas diretrizes para futuras aplicações técnicas de sistemas AAL para pacientes com MCI e pesquisas futuras. Estatísticas descritivas mostram suporte para a implementação de AAL geral e variantes para pacientes com CCL. A análise comparativa de dados ordinais para grupos específicos de respondentes é feita com a ajuda de testes não paramétricos. Aplicam-se os testes de Mann-Whitney-Wilcoxon e Kruskal-Wallis. Os resultados das questões da tabela são analisados com qui-quadrado para tabelas de frequência. A análise do grupo demonstrou relativa uniformidade positiva nas respostas no suporte de AAL de pacientes com CCL.

RÉSUMÉ.

Selon l'Organisation mondiale de la santé, environ 50 millions de personnes dans le monde souffrent de démence. Dix millions de nouveaux cas ajoutés chaque année. Les troubles cognitifs légers (MCI) touchent plus de 15 % de la population âgée de 65 ans. Les solutions technologiques, telles que la technologie de la maison intelligente avec des appareils informatiques omniprésents, l'observation et le soutien télémédicaux 24 heures sur 24, 7 jours sur 7, peuvent atténuer le problème croissant et réduire la pression sur le système de santé. Cette approche est également préférable pour les patients en soins à domicile dans les régions éloignées et rurales.

Les patients MCI sont pour la plupart à domicile. Les systèmes Ambient Assisted Living (AAL) fournissent des outils pour l'enregistrement automatique des signes vitaux et d'autres informations importantes sur le plan médical et social. Le système AAL pour les patients MCI est une réponse logique au problème. Dans le même temps, bon nombre des systèmes AAL proposés sont propriétaires, techniquement compliqués et ont un prix élevé pour la mise en œuvre et le service. De plus, certaines solutions techniques proposées ne reflètent pas entièrement l'opinion des acteurs de santé.

L'étude actuelle a été proposée comme un moyen de combler les différences possibles dans les positions. Un questionnaire anonyme en ligne destiné aux professionnels de la santé a été créé pour prouver ou réfuter le nombre d'hypothèses interconnectées sur la nécessité et la faisabilité du système AAL pour les patients MCI. L'accent a été mis principalement sur les hypothèses: "Il existe une nécessité de systèmes AAL pour les soins de santé" et "Les systèmes AAL sont capables de fournir une assistance aux patients atteints de troubles cognitifs légers". Le questionnaire a été présenté à plus de trois cents répondants potentiels. Environ cent vingt ont accepté de le remplir, et soixante ont rempli tout le questionnaire. Les résultats ont été analysés pour produire des lignes directrices pour les futures applications techniques des systèmes AAL pour les patients MCI et l'avenir de la recherche.

Les statistiques descriptives montrent un soutien à la mise en œuvre de l'AAL général et des variantes pour les patients MCI. L'analyse comparative des données ordinales pour des groupes spécifiques de répondants est effectuée à l'aide de tests non paramétriques. Le test de Mann-Whitney-Wilcoxon et le test de Kruskal-Wallis sont appliqués. Les résultats des questions de tableau sont analysés avec le chi carré pour les tableaux de fréquence. L'analyse de groupe a démontré une uniformité positive relative dans les réponses à l'appui de l'AAL des patients MCI.

Dedication.

Dedicated to my family and friends, who supported me in time of writing this thesis during COVID-19 pandemic.

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First and foremost I would like to thank my supervisors, Prof. Dr. Rui Jorge da Silva Moreira and Prof. Dr. José Manuel de Castro Torres for their indispensable counsel, clear-sited guidance, astute advice and limitless patience. Their superb academic accomplishment and extensive professional expertise immensely helped me to formulate the PhD research goals and to access scientific the fields, where I possessed modest or hardly any experience. Their ceaseless support gave me encouragement in times when my investigation looked too formidable to overcome. During years of my work, they remain as friendly and attentive as in the first months of my scientific exploration for this thesis. Special credit I want to give to their ability for shortening my "medically voluminous" texts.

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Separate acknowledgment, with serious reservations, goes to the virus SARS-CoV-2, which gave me a feeling of importance and urgency in my work. It showed the real and desperate need in applications of technologies for distant healthcare.

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List of Abbreviations.

AAL – Ambient Assisted Living

AD – Alzheimer Disease

ADFL – Activities of Daily Functional Living

ADL – Activities of Daily Living

AHCS – Ambient Home Care Systems

AI – Artificial Intelligence

AMIGO – Ambient Intelligence for the Networked Home Environment

ANOVA – Analysis of Variance

API – Application Programming Interfaces

BAN – Body Area Network

BelAmi – Bilateral German-Hungarian Collaboration Project on Ambient Intelligence Systems

BMI – Body Mass Index

BP – Blood Pressure

BR – Breath rate

CAALYX – Complete Ambient Assisted Living Experiment

CASAS – Center for Advanced Studies in Adaptive Systems

CAR – Complex Activity Recognition

CEP – Complex Event Processing

COPD – Congestive Obstructive Pulmonary Disease

COTS – Commercial-Of-The-Shelf

CPS – Cyber-Physical Systems

CPU – Central Processing Unit

DMD – Doctor of Medical Dentistry

DTI – Diffusion Tensor Imaging

ECG – Electrocardiography

EEG – Electroencephalography

EHR – Electronic Health Records

EMG – Electromiography

GPS – Global Positioning System

HAR – Human Activity Recognition

HCHS – Historical Calculation Health Service

HIS – Health Intelligent Server

HR – Heart Rate

IADL– Instrumental Activities of Daily Living

IFTTT – “IF This Then That”

IoT – Internet of Things

IQ – Intelligence Quotient

IQR – Interquartile Range

IT – Information Technology

KS-test – Kolmogorov–Smirnov test

KW-test – Kruskal–Wallis test

LAN – Local Area Network

LCD – Liquid Crystal Display

MCQ – Multiple Choice Question

MD – Medical Doctor

MCI – Mild Cognitive Impairment

MEMS – Micro Electromechanical System

ML – Machine Learning

MND – Mild Neurocognitive Disorder

MRI – Magnetic Resonance Imaging

MWW – Mann-Whitney-Wilcoxon

NN – Neural Network

OASiS – Object-centric, Ambient-aware, Service-oriented Sensornet

OS – Operational System

OSA – Offline Speech Analysis

PAN – Personal Area Network

PC – Personal Computer

PET – Positron-Emission Tomography

PERSONA – Perceptive Spaces prOmoting iNdepentent Aging

PIR – Passive Infra-Red

PTT – Partial Thromboplastin Time

QoS – Quality of Service

REM – Rapid Eye Movement

RFID – Radio Frequency Identification

RR – Respiratory Rate

SAAPHO – Secure Active Aging Participation and Health for the Old

SD – Standard Deviation

S-L-transform – Schmid-Leiman oblique rotation

SOA – Service Oriented Architecture

SOPRANO – Service-oriented Programmable Smart Environments for Older Europeans

SP – Service Provider

SWS – Smart Wearable Sensing

TOF – Time-O-Flight

TUP – Time Up and Go test

UCD – User-Centered Design

US – Ultra-Sound

VoIP – Voice Over Internet Protocol

WAN – Wide Area Network

WHO – World Health Organization

WBAN – Wireless Body Area Network

WLAN – Wireless Local Area Network

WMSN – Wireless Mesh Sensor Network

WNM – Wireless Mesh Network

WSN – Wireless Sensor Network

WSU – Washington State University

XML – Extensible Markup Language

XSLT – Extensible Stylesheet Language Transformations

Chapter I: Introduction

I.1. Problem.

Research ground.

This research is done as a prerequisite for a more detailed design of the Ambient Assisted Living (AAL) system for patients with Mild Cognitive Impairment (MCI). With known basic requirements an opinion of potential healthcare stakeholders helps to elaborate a more comprehensive system and establish an outline for the inclusive design framework in this specific case of AAL. In order to establish the AAL framework for MCI patients was constructed targeted questionnaire for healthcare workers, predominantly with experience of professional involvement with this category of patients. Questions in the questionnaire are designed to extract maximum information about the professional opinion on a number of technical and organizational problems in the design of AAL for MCI patients. Results are analyzed statistically and compared with similar works in the field. On the basis of it provided recommendations of specialized AAL system for MCI patients and farther research directions.

There is a current necessity to address problems of implementation of general AAL system for home-based patients with chronic conditions. While somatic medical problems are more widespread and receive more attention (Memon *et al*., 2014), psychiatric conditions are less presented as a target for the AAL system. Besides the proposed follow-up systems for patients with chronic psychiatric conditions (Alam *et al.*, 2012; Alam *et al.*, 2016), the most prominent area is the AAL system for home-based patients with dementia. The current demographic tendencies demonstrate higher life longevity, which is partially responsible for more chronic conditions, somatic and psychiatric alike, including dementia. There are several successful projects for dementia patients and those with a milder state, Early Mild Cognitive Impairment (EMCI) and Mild Cognitive Impairment (MCI) (Stavropoulos *et al*., 2014). However, the predominant nature of dementia condition blurs the demarcation between AAL for dementia patients, who have a tendency for more often institutionalization (Godall *et al*., 2021) and MCI patients, who are mostly home-based.

Pretext.

The Fourth Industrial Revolution connects information technologies (IT) and old operational technologies in one cyber-physical system, where open to environment Machine Learning (ML), machine-to-machine (IoT) and machine-to-human interactions are combined in one smart environment of pervasive computing (Petrillo *et al.*, 2018). Human-to-smart environment interaction becomes a significant social and technological point of interest, which has to be appropriately addressed. Pervasive computing helps to create a smart environment (Augusto *et al.*, 2010). Wide inclusion of patients into AAL projects gives maximal healthcare cover for underserved areas, lowers medical expenses and generate utilitarian value for all stakeholders. The system has to be well integrated into a home environment, e.g. to be ubiquitous, pervasive and seamless, and to be flexible for personalization and context awareness.

The human-oriented approach determines two areas: outdoor domain, smart city and smart environment, a mostly social sphere, and indoor domain, more focused on the individual sphere. Multiple directions of technological development came to fruition a few decades ago and were embodied in existing systems of smart home (Park *et al.*, 2003). Personal indoor smart environment, smart home, is a relatively wide concept, which encompasses systems of applications for healthy people, with the ability to control and adapt habitat in accordance with needs and wishes of the owner. The fundamental technical concepts for the “smart house” are “ambient intelligence”, ubiquitous computing, Internet of Things (IoT), seamless electronic devices and permanent interaction between a person and electronic environment (Park *et al.*, 2003).

Context.

AAL is focused on technologically supported everyday life home activities. Healthcare application of it, consequently, is oriented on the AAL usage for ill, infirm, disabled people, with the awareness of other stakeholders: family members, carers, healthcare system and civil administration. There is an unavoidable overlapping between smart home technologies for healthy active people and AAL for elderly and impaired (Manoj and Thyagaraju, 2018).

AAL technology can be divided into supportive and informative, including protodiagnostic. A person can be "projected" and represented as a data aggregate (van der Meulen and Bruinsma, 2019) and, to some extent, treated as such. The healthcare system has a natural interest to collect and analyze most important medical data and significant, but less precise information about the general conditions. The most important, critical data is possible to distill into information about vital signs: heart rate, blood pressure, breath rate, body temperature. Other information includes various modes of activity: sleep and awakening patterns, movement patterns; utilities, phone, internet usage (Riboni *et al*., 2015; Debes *et al.*, 2016).

Medical applications of new information technologies are numerous, from biotelemetry to robotic surgery, but not limited only by the healthcare area. Smart home technologies routinely include intruder alarm, fire alarm, water and electricity abnormalities alarms. Data collection is not singular utilization of the technology. AAL healthcare mostly consists of appliances and systems, compensating for partial disabilities on the home level. Some home appliances can be integrated into the system as an integrative part or, at least, the RFID-supplied item to prevent its loss: hearing aid, glasses, walking supports. It also can be used for person tracking (Jiménez *et al.*, 2013).

Disabilities can be divided by the type of the damaged organ system, with AAL focused accordingly: general health, cardiac and respiratory vital signs` control; neurological and orthopedic movement control and help; mental health behavioral supervision. Technologically empowered Activities of Daily Living (ADL) assessment, behavior and walking patterns assessment for dementia and other mental health patients give an important improvement in prediction, prevention and early treatment in the case of deterioration or emergency. There is an extensive graduated checklist of disabilities and functioning limitations, created by WHO: The International Classification of Functioning, Disability and Health, or ICF (World Health Organization, 2001). It includes all types of disabilities in the health and social contest and lists specific healthcare, social care and environmental factors. Another WHO tool is WHOQOL, a questionnaire for Quality of Life (QoL) assessment.

I.2. Hypothesis.

The hypothesis is formulated on a wide basis. It can be mapped out as a coherent system of statements and sub-hypotheses. For the current research, it is important to locate the starting point of the argument. Most of the works are based on the strong assumption of technological advantage of AAL system for homecare in the case of chronic health condition or recuperation after an acute health failure event, operation or trauma (Acampora *et al.*, 2013). While the benefits of AAL are clearly demonstrated by the numerous theoretical and practical proofs, the helpfulness of technology is less obvious for the healthcare stakeholders (Offermann-van Heek and Ziefle, 2018; Haluza and Jungwirth, 2015; Cesta *et al.*, 2018). Sometimes primary end-users and secondary end-users, specifically professional caregivers and health professionals, differ in opinions on priorities of health issues and privacy, or on technical points using more robotics or wearables (Singh *et al.*, 2017).

Consequently, the first step in hypothesis formulation has to be constructed around an argument about the usefulness of the AAL system in healthcare. The branched version includes the utilitarian level of it, a particular point of importance and specific problematic spots, strengths and weaknesses of the general AAL system. The generalized null hypothesis will be “AAL system for MCI patients is not necessary”. In the surveys, researchers often deal with subjective opinions, but in the case of healthcare professionals, their judgment is frequently based on objective outcomes of experience and the projections of professional concerns. We also have to hypothesize that professional opinion in the case of AAL system implementation, especially on the conceptual stage, is practically important and brings specified advantages before opinions of other stakeholders on healthcare questions.

The AAL system is usually expected to be planned with customization options or specifications for particular health conditions. In every case the usefulness of every AAL function, device or application has to be balanced between medical, technological, social, financial, administrative and legal gains and losses. The value of every achievement or problem is weighted against the general outcome and systemic focus points. It is possible to make a hypothesis about the usefulness of the AAL system for every medical condition of concern and negate it by the relating null hypothesis. The functionality of the AAL system in psychiatry (Alam *et al.*, 2015; Alam *et al.*, 2016), narrowly in the case of MCI and dementia, is a point of debate. There are systems created for the benefit of dementia patients, their relatives and those, who suffer from milder forms of memory and cognitive impairment (Spanoudakis *et al.*, 2010; Stavropoulos *et al.*, 2014; Napoli *et al.*, 2019).

While every cited work claims well-proven usefulness, there is still a necessity to support or disprove some points or the whole point in the case of a specific AAL system for MCI patients. The connected issue is to find out if the system for dementia patients is as useful as the system for MCI patients and some or most of the AAL system for dementia patients are applicable for the much milder cases.

The hypotheses web can be distilled in a simple ornithological hierarchy: the practicability of the general AAL system, the utility of the AAL system in psychiatry, especially for patients with cognitive and memory problems, and the feasibility of a full-fledged system for MCI patients. Inside of the hypothesis about the necessity to design a particular system for MCI patients, there are subsets built upon every specific function and concerns about privacy and social support. Although patient-centred approach to design is explicit, an opinion of healthcare stakeholders provided for technical stakeholders helps to conceptualize the scheme.

I.3. Approach and Contributions.

The current work provides:

- Background survey/review on State of The Art (SOTA) technology use for AAL, and MCI patients in particular;
- Review on the application of questionnaires for assessing AAL;
- Unique Questionnaire construction, employing combinative approach;
- Questionnaire-base results analysis;
- Discussion on the basis of obtained results and similar research in the field;
- Recommendations about general AAL technologies, specific aspects of AAL for MCI patients and prospects of farther research

AAL is a relatively new technology and is not yet routinely used in healthcare. The usefulness and technological feasibility of the general AAL system is supported by a considerable volume of research and practical applications (Rashidi and Michalidis, 2012). However, there are concerns about acceptability by patients (Himmel and Ziefle, 2016) or healthcare stakeholders. Quality of Life (QoL), or Quality of Service (QoS) are often regarded as more important for caretakers. Secondary end-users, especially healthcare workers, are interviewed less frequently. The professional caregivers are systematically more skeptical about the possibility of successful implementation of AAL system (Offermann-van Heek and Ziefle, 2018; Haluza and Jungwirth, 2015). The most common method of feedback collection and evaluation is a questionnaire for the primary end-user, the person who receives the care. This user-centered approach put healthcare stakeholders in second place (Garschall *et al.*, 2016), while often excluding the administrative part of insurance industry participants. At the same time, inclusive design and participatory approach require more balanced involvement of all stakeholders (Teles *et al*., 2017). Some researchers even express an opinion about a number of tension dyads in the AAL: human versus AAL care; paternalism versus autonomy; individual versus community and empowerment versus productivity (Paraschivoiu *et al*., 2020). The successful technological approach for institutionalized dementia patients is presented in the recent survey (Goodall *et al*., 2021). However, AAL for MCI patients includes a significant number of technological details, which have to be discussed thoroughly with every stakeholder.

Preliminary procedures for the AAL design include the conceptualization stage. When specific needs of patients are identified, the opinion of medical specialists in the area becomes more important for further project development. The process is iterative, and the initial phase requires the first survey to be done in the all-encompassing form. Current research is envisaged as an initial questionnaire for healthcare stakeholders. The primary contribution is the complex and developed problem-centered survey with balanced parts and the possibility to compare answers in different sections with help of statistical methods. An additional feature is a heterogeneous group of respondents with professional medical experience. It gives an option for group comparative analysis. The questionnaire can be used in future for wider groups or more narrowly focused surveys about AAL system and, specifically, AAL system for MCI patients.

The questionnaire itself is web-based and delivered with help of Google Forms. This approach helped to form an international group of respondents. Principles of voluntary participation, anonymity, thorough but clear explanations are upheld. The lines of the investigation follow hypotheses. The results are analyzed with help of descriptive statistics and comparative non-parametric methods in the JASP statistical package.

I.4. Thesis Structure.

The thesis is structured as follows: after the necessary preamble with apparatus of content, used tables, figures and abbreviations is placed an ongoing introductory chapter, then chapters about technical and medical aspects of AAL, SOTA on AAL surveys and questionnaires, research results, discussion and conclusion.

Introduction.

The current introduction is divided into an overview of the wide problem, stemming from the demography, technological development and healthcare advances. The contextual factors are given in the part with problem formulation: the nature of AAL, its applications and surveys. The third part is discussing the place of AAL in the care for patients with MCI and the reason for the research.

Chapter II.

The chapter about AAL background encompasses the technical and medical sides of the system. The technology is described in a dense and thoroughgoing way, but the focus is made more on the generally important elements, such as computing devices, sensors, networks, smart devices, middleware and software. All the theoretical information about ontological principles of architecture, the basis for algorithms and Artificial Intelligence (AI) predictive techniques, as well as an exhaustive list of technical details, standards and protocols are left outside of the scope for the necessity to keep the overhaul balance with other chapters and to preserve the essence of the research as a healthcare-oriented. For the same reason the medical aspects of AAL: system is described in some detail, with a purpose to give an appropriate background to any reader regardless of his scientific affiliation. The next part of the chapter narrows the focus on the psychiatric topics, with dementia and MCI at the focal point. The necessary subjects of spatial movements, ADL, sleep and wake patterns are all presented in the discussion and described within a framework of AAL concept. The chapter is finalized by the list of AAL projects.

Chapter III.

Chapter III describes State of The Art on questionnaire-based assessments. It starts from the ways to conceptualize and model the AAL system before the prototype creation and testing. For the planned and existing systems, an impact assessment is described from the position of appropriate frameworks: “Reach”, “Effectiveness”, “Adoption”, “Implementation”, “Maintenance” (Re-AIM); Model for Assessment of Telemedicine (MAST) and Unified Theory of Acceptance and Use of Technology (UTAUT). The next part is a detailed description of general questionnaires and specialized versions for AAL surveys. It takes through the preparatory process, focuses group establishment and sampling procedure. In this research, the respondent's groups are healthcare stakeholders. Then attention is given to computer-assisted web questionnaires (CAWQ) and Dillman principles for internet surveys. Afterwards, the types of questions are described, including Multiple Choice Questions (MCQ) scaled questions, matrix questions, control questions and open structured questions with the unfinished statement, before listing rules for questionnaire construction. This includes questions` order, structure, sections order and criteria for cognitive load, consistency and validity control, questions` flow and error types. The final part of the chapter is assigned to the relevant statistical methods.

Chapter IV.

This chapter consists of research preparation and a description of the methodology. Research goals are essential for the hypothesis formulation. When the necessary hypotheses group is formulated, the methodology is laid out in an explicit and elaborated manner. The respondent's group is depicted and the principles of the survey are explained. The lines of investigation are highlighted, with points of planned intersections for the comparative analysis. The types of the data and the way of its analysis are brought up and technical matters are discussed. After the set-up, the questionnaire content and structure are outlined. There are issues of general design, the relationship between parts, thematic blocks, sections and their order, metrics and types of questions. There are described the forms of questions, questions` flow in sections, questions` webs and forms of control. On a bigger scale the sections order, sections flow, comparative size of sections and its internal order are given. The following part explains the content of sections and questions. It mentions specific aspects of personal information and personal experience, planned to be collected from the respondents and reasons for it. Afterwards, sections all of the questionnaire and their descriptions are listed in the existing order.

Chapter V.

In this chapter is presented collected data and descriptive statistics is applied. The reliability, background information about participants is supplemented by the personal data about the medical profession, medical and IT experience. Age and gender stricture are given in accordance with claimed medical professions. The data is presented with help of tables and graphs. Then sections are listed with questions and statistical information about answers. Matrix questions are presented in the form of tables. Every section or part is finished by the conclusive remarks. In the last section, consisting of an open question, the qualitative analysis is performed.

Chapter VI.

In a contrast to the previous chapter, here methods of statistical analysis differ. According to the planned research groups are formed on the basis of the medical and IT experience. These groups are compared with help of non-parametric tests. Results are presented in tables and supplied with comments. Matrix questions are also compared. The resulting conclusion for the chapter finalizes it.

Chapter VII.

The last chapter brings the discussion and summarized conclusion. The future work is discussed.

The chapter is followed by the references and Appendix I with all data from the questionnaire.

Chapter II: AAL Background.

II.1. AAL System. Technical Aspects.

Significant part of scientific and practical aspects of AAL are dedicated to the hardware and software. The AAL is an application of more general Internet of Things. It can be presented schematically as a number of hierarchically placed layers, as reflected in Figure 1.

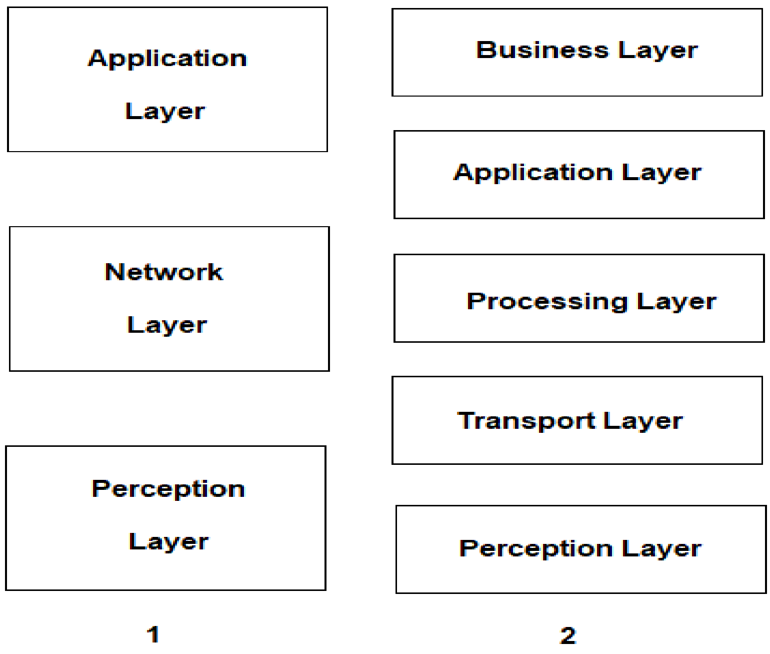

Figure 1: Internet of Things layers.

Interpretation: The column 1 shows basic structure, while column 2 divides network layer into transport and processing layers, while application layer in column 1 is presented as application and business layers in column 2.

The Perception layer is represented by sensors and Local Area networks. The Processing layer consists of computing units and network devices, which use middleware, transmission protocols and allow API and external applications (Memon *et al.*, 2014). Application layer is home for applications proper.

Computing Units.

Computers and computerized devices are crucial for AAL. Processing power is one of the main characteristics, as well as any size of the device, its networking capabilities, ability to run middleware and software, usability and User interface (UI) convenience (McKeever *et al.*, 2009).

Traditionally dedicated servers and PC units were used for AAL system implementation. The role of servers today is widely extended, especially for cloud middleware applications (Cubo *et al.*, 2014; Kartsakli *et al.*, 2015). At the same time, miniaturization produced lines of lesser size devices, used in AAL system: notebooks, laptops, PDAs, tablets, smartphones, smartwatches (Rashidi and Mihailidis, 2013; Memon *et al.*, 2014). There is a proposal to use interactive TV sets for AAL (López-de-Ipiña *et al.*, 2011).

The concept of the Internet of Things (IoT) allows the creation of the local networks, constructed from devices with computer power. Single-board computers are significant part of it. It enables so-called “Fog computing” and Edge computing, when information processing is spread between IoT nodes. Fog computing concept is proposed and practically applied in some AAL system (Nikoloudakis *et al.*, 2016).

Another development line produced Cyber-Physical Systems (CPS). In CPS hardware, software and network are entangled as one united block, which cannot be divided without loss of function. As part of this concept smart gateways are proposed for AAL and health monitoring (Rahmani *et al.*, 2018).

Network Devices.

OSI model traditionally describes seven layers of any network. Hardware devices are related to the physical layer, while data transmission between network nodes corresponds with the data layer. Bridges, hubs, switches, routers, smart sensors and other network nodes form the physical layer. AAL is organized as a local network or combination of various local networks: Personal Area Network (PAN), Body Area Network (BAN), Local Area Network (LAN). Information is collected from the WLAN for further transmission to AAL Service Provider (SP) and others via the internet. Some devices may be connected independently. For example, through mobile gateways, in the case of outdoor activities (Valero *et al.*, 2011).

The wired option is more often used for information transfer via phone landline, with utilization internet functions. Mobile Wide Area Networks (WAN) networks are actively employed for e-health services and AAL and often preferred as a universal option for indoor and outdoor activity (Bisio *et al.*, 2015).

Sensors.

Functionally parts of AAL system can be presented in groups: Sensors, collecting information about movements, position, physiological signs, e.g. breathing, heart rate, blood pressure, blood glucose etc. Motion is registered with the help of Passive Infrared (PIR), Active Infrared, ultrasound sensors (Memon *et al.*, 2013; Rashidi and Mihailidis, 2013).

Activity may be registered with cameras and microphones. Radio frequency identification (RFID) sensors collect categorical information about an object. Magnetic sensors inform about closed/open doors of rooms and furniture. Pressure sensors are based on several different principles: piezoelectric, capacitive, electromagnetic, to list just a few (Acampora *et al.*, 2013). Part of the sensor network monitors microclimate: air temperature, humidity, possible gas leaks (Chen *et al.*, 2009). Sensors, active or passive, can be wearable, seamlessly integrated into home environment and objects. On-chip sensors include their own central processing unit (CPU) and memory. Most often they are operated by TinyOS (Levis *et al.*, 2005). Sensors include communication part and, mostly body wearable, on-chip micro-electromechanical system (MEMS).

By ubiquitous pervasive presentation, they form a basis for ambient intelligence (AmI) and context awareness (McKeever *et al.*, 2009). Sensors may work independently, for example, in medical devices, or be integrated into networks. There are different body sensors, like gyroscope, accelerometer, electrocardiography (ECG), electroencephalography (EEG), electromyography (EMG), pulse oximeter, permanent glucometer, thermal sensor etc., which can be interconnected into Body Area Network (BAN). BAN allows to collect analogue signals from wearable sensors and transmit it in digitized form through radio platform (Acampora *et al.*, 2013). BAN gives an option of intra-BAN communication. Inter-BAN communication is the transfer from BAN to access points for beyond-BAN communication (Cao *et al.*, 2009). BAN (Wireless BAN, WBAN) usually has a transmission range up to 2 meters, while Personal Area Network – up to 10 meters. Personal Area Network (PAN) connects sensors, placed into objects and home environment of Synergistic PANs (SPANs) to create smart spaces (Jovanov, 2019).

The more advanced version of ambient sensors` network, embedded into everyday objects, is often called Wireless Mesh Networks (WNMs) (Akyildiz *et al.*, 2005), or Wireless Mesh Sensor Networks (WMSNs) (McNaull *et al.*, 2012). The concept of the Internet of Things (IoT) underpins the importance of ubiquitous sensors` networks in AAL (Levis *et al.*, 2005).

Software.

The software encompasses databases, protocols, operational systems (OS), gateway software, application programming interfaces (API), software frameworks, ontology languages, middleware, applications, embedded programs. AAL software systems have to possess several characteristics: personalization, context awareness, adaptability, anticipatory ability. According to the project EVAAL2, AAL system must present core functionalities: 1) Sensing, 2) Reasoning, 3) Acting, 4) Communicating 5) Interacting (Garcés *et al.*, 2016). Possible to add ubiquity, important for AAL, and transparency, for creating an unobtrusive environment (O'Grady *et al.*, 2010; Moreira *et al.*, 2016).

II.2. AAL System. Medical Aspects

General Overview.

The smart home is a home-based system of the systems, which consists of monitoring sensors, connected together as a net to the analytical and automated appliances, with local and distant control of indoors management and environment. The smart home concept encompasses several utilitarian dimensions: in-house automated systems with control and monitoring; communication; health monitoring; entertainment (Pal *et al.*, 2018). Smart homes can be integrated with smart IoT environment and permanent ubiquitous health monitoring under the aegis of AI (Amin *et al.*, 2019).

Medical aspects of AAL mentioned above are divided into supervision and monitoring part and support part. There are numerous AAL healthcare support systems, which can be subdivided into several groups in accordance with the needs of patients, who have systemic impairments, or its narrow type, built for patients with a singular pathology.

Comparative analysis tends to be more technical than medical (Memon *et al.*, 2014). For a similar reason, important medical parameters are often treated together with less important ones. One of the ways to miss necessary functions is to encompass all aspects of AAL in one Opencare platform (Acampora *et al.*, 2013; Memon *et al.*, 2013).

From the healthcare point of view, home-based patients need to be monitored with a focus on the critical parameter. Most important parameters are vital signs, such as heart rate, blood pressure, breath rate, body temperature. The top causes of death include heart diseases, vascular damage, e.g. stroke, and respiratory diseases (Vos *et al.*, 2020).

Most of the health conditions can be observed with help of different sensors, which give necessary information immediately. They help to control the condition of the person, health dynamic, follow up of the medication and treatment procedures, subject to biological compatibility (Patel *et al.*, 2012). Sensors also widely used for monitoring in-home environment.

Heart Rate. Electrocardiography. ECG.

Heart function is central for the wellbeing. The resting heart rate (HR) of a healthy adult person is normally regular and has 60-80 beat per minute. It can vary with physical and emotional load, medication intake or underlying medical conditions. Heartbeat rate, regularity, its volume, peripheral signs of blood perfusion give important information about the health status. Ischemic heart disease, arrhythmia, heart valve pathologies, vascular diseases are diagnosed and controlled with permanent checks of these characteristics.

The heart rate can be measured by non-invasive Smart Wearable Sensing devices (SWS). Sensors or SWS are placed on the heart area, major arteries, peripheral arteries. They are pulse meters, ECG sensors or SWSs, echo cardiac sensors. Blood perfusion in different body parts can be assessed by electroplethysmography and photoplethysmography techniques (Pantelopoulos and Bourbakis, 2010). ECG, besides the heart rate and its rhythmicity, gives information about potential changes in the myocardial integrity and cardiac conduction condition.

Wearable sensors give immediate information, which, in the case of the emergency, trigger the complex healthcare system reaction. The drawbacks for any wearable device are: inconvenience; it can be affected by water or sweating, physical, mechanical impacts; they have to be attached to the reliable energy source. In some cases, sensors are seamlessly implemented as a part of smart shirts with textile-integrated non-invasive magnetic sensors (Teichmann *et al.*, 2014). They often are worn as wristbands or similar wearable items.

There are ways to assess heart rate distantly, for example with the help of Doppler radar (Otake *et al.*, 2021). But the method itself has its own limitations: lesser precision and lower ability to be directed on the heart area most of the time.

Application of the invasive electrode-bearing rhythm-control devices and chip-based invasive appliances gives an opportunity to use permanent wearable sensors. However, the usability of chronically implanted sensors is limited.

Breath Rate.

Respiratory diseases are the next major factor of pathology and death. The breath rate (BR) of a healthy adult person is normally relatively regular, with 16-20 cycles of inhalations and exhalations per minute. BR reflects not only lungs and respiratory system condition, but also general wellbeing. Respiratory distress occurs due to conditions on different levels: environmental oxygen deficiency; obstruction of airways, for example in asthma; lungs diseases; cardio-circular dysfunctions; blood pathology, such as in various anaemias. For these reasons, the respiration rate is one of the important vital signs to be monitored in most of the unstable health conditions.

The BR can be measured by wearable on-body sensors, wearable seamless shirt-integrated sensors, wearable breath analysis sensors (Mitchell *et al.*, 2010). The last ones can measure exhaled CO_2 to evaluate breath effectiveness. Sensors can be used to control exhaled acetone to control glucose metabolism for patients with diabetes (Righettoni *et al.*, 2012).

Blood oxygenation is often measured by the peripheral photoplethysmography and can be combined with pulse rhythm measurement and tissue perfusion level monitoring. Exist different wearable types of sensors for permanent use, designed as earbuds, finger rings or wristwatches (Tamura *et al.*, 2014). There are also methods of distant respiratory rate monitoring with help of infrared Doppler sensors by the Kinect (Procházka *et al.*, 2016).

Blood Pressure.

The normal arterial blood pressure (BP) of a healthy adult person is 110-140 mmHg systolic and 70-90 mmHg diastolic. The BP directly reflects myocardial function, heart valves integrity and functionality, and indirectly neuro-humoral heart rate, vascular tonus and blood volume regulation. Acute high blood pressure is called the hypertonic crisis and may cause acute problems, such as burst vessels, critically in the brain, heart or major vessels close to heart. Chronic hypertension causes heart enlargement with valves insufficiency, major vessels enlargement, higher intraocular pressure, widespread changes in microcirculation with the lower function of the affected tissues.

Low blood pressure leads to underperfusion of organs and tissues, most significant in the "oxygen-hungry" brain and myocard. Acute fall of the blood pressure is called shock. Shock leads to functional failure of the brain, heart, acute renal failure. Chronic hypotension causes brain, heart, renal or other underperformance.

The blood pressure can be measured by wearable pressure sensors, placed on the skin above underlying subcutaneous artery. Usual places are: wrists, biceps, ankles. The measurement can be done with help of inflated cuff, cuff-less pressure sensors, cutaneous tension sensors, photoplethysmographic sensors, measurement of pulse wave transit time, by combining two sensors along the blood flow (Yilmaz, Foster and Hao, 2010). Some researchers propose ultrasound sensors (Weber *et al.*, 2013).

Invasive methods are used to measure blood pressure in the main blood vessels to control their integrity (Lee, Shi and Lee, 2019). Sometimes other bodily fluids require pressure measurements. However, exists number of problems, connected with implanted sensors and rooted in the demand of higher level for biocompatibility. Invasion damages cutaneous and bodily integrity, opening gate for potential infections, may cause blood loss and possibly harm the functionality. At the same time bodily fluids with solved gases and chemically active substances often negatively impact implanted sensors.

Body Temperature.

Surface Body Temperature (BT) of healthy adult person usually homeostatically fixed around 36.6°C if measured on the skin or in the oral cavity It is an important parameter of metabolism. Core body temperature is higher and achieves a level of 38°C.

The abnormal temperature will reflect: external exposure to the cold or hot environmental factors, with insufficient insulation protection, when usual mechanisms of thermoregulation are exhausted; or internal metabolic rate, local or general.

Locally temperature can raise because of the focal blood inflow and variety temperature-raising tissue factors stimulating metabolism. It is usually caused by septic or aseptic inflammation or metabolic reason: tumor, allergy, intoxication, physical impact and a few other factors. Temperature can go down because of lower perfusion, usually connected to the diminished blood flow through the narrow or obstructed vessels, caused by mechanical, environmental, biochemical or other factors. The whole-body temperature is raised as an internal answer to the generalized infection, autoimmune reaction, higher than normal thyroid metabolism etc. Lower than normal thyroid function also can cause abnormally low temperature, as well as few other neuro-humoral pathological conditions.

BT sensitivity and instability due to underdeveloped or damaged regulation mechanism is another reason for the necessity of control, as in the case of preterm birth or neonatal intensive care or metabolic dysregulation (Appelboom *et al.*, 2014).

Temperature is measured through the contact body wearable sensors or distantly, with help of infrared sensors. Wearables are designed in different forms as bracelets, watches, jewelry, smart clothes.

Non-contact infrared sensors are used less often for body temperature measurement. However, systems based on the temperature detection proposed for the indirect cardiac rate measurement (Garbey *et al.*, 2007) or breath rate measurement (André *et al.*, 2009).

Biochemical Parameters.

All biological systems, including the human body, function in accordance with homeostatic principle. Homeostasis means dynamic stability of all interconnected biochemical reactions. As a result, there is a number of constants, which signal about the normal functioning of the biological systems. Consequently, changes in biological constants are indicative in the case of pathology. By tracking key constants, we can observe changes in the health condition and react accordingly.

A number of critical parameters can change before physiological distress will cause a change in vital signs. The most known controlled parameter is the glucose level. In diabetes mellitus, glucose level regulation is impaired, and it can go higher than normal or fall lower. The danger of acute hypoglycemia or hyperglycemia is a systemic failure with negative consequences. Chronic hyperglycemia, typical for diabetes mellitus, causes an irreversible change of brain, heart, renal, retinal microcirculation, with potential functional failure or generalized neuropathy.

Glucose level is usually followed up at home by routine daily blood tests, 3-4 times a day. Even though the test itself is minimally invasive and requires only fingerpick, it still damages skin surface. It is also not very accurate. Additional problem is to keep written records by patients or healthcare professionals. To overcome the problem several AAL solutions are proposed, where glucometer is integrated into or connected to the AAL system and loads its results directly into health records (Jara *et al*., 2011). More invasive methods include chronic glucose sensor implant (Klimek and Tulwin, 2019).

There are other ways to measure glucose level, and they are non-invasive. These methods are based on urine, saliva, lacrimal liquid or non-invasive glucose level transcutaneous check (Gonzales *et al*., 2019). But most of these methods are less reliable and still require calibration with more traditional blood glucose check or minimal invasion finger prick check (Zhang *et al*., 2015). Urine glucose analysis, also more reliable than a decade ago (Buckingham *et al.*, 2013), still is not recognized as a clinical standard for homecare.

There is a wide range of biochemical indicators which can be used to monitor different conditions, from salt and wetness signals in the case of incontinence to hemoglobin level or Partial Thromboplastin Time (PTT) in the case of chronic anticoagulant therapy or hypercoagulation tendency. Many AAL systems include pulse oximeters. In every particular case sensors and appliances have to be adapted for home usage and be integrated into the AAL system.

Physical Activity.

Behavioral applications are commonly proposed for AAL system. While a significant number of methods is represented by internet and phone usage monitoring applications, most of the schemes include patient positioning systems. Walk reflects the level of human physical abilities. The normal walk consists of several phases and has a number of measured parameters, which can be adjusted by age and gender. The normal gait is in fact, superposition of several functions, performed at the same time. Besides the main function of safe and reliable transfer of the body in the varied environments, there is also a permanent necessity to maintain the posture and the balance. Absorption of mechanical shocks is another important function. There are also secondary and tertiary socio-psychological, cultural and subcultural functions, with implications of reverse influence on physical performance. The normal gait as a physical process is divided into several phases, which repeat cyclically. The gait cycle usually is comprised of eight phases. It can be structured as two big sequential phases for right and left leg, with stance taking 62% of the time and swing 38%. Each phase is then subdivided into four stages.

One of the most important parameters is walking speed. In the meta-study, speed measurements are checked in 40 studies on more than 23 000 adults in different countries (Bohannon and Williams Andrews, 2011). Normal walking speed is around 1.2-1.4 m/s, while pathological is supposed to be lower than 0.6 m/s (Fritz and Lusardi, 2009). Abnormal walking may reflect musculoskeletal pathology, neurological dysfunction, skin pathology or more general abnormality. Some researches propose walking speed to be the six vital sign (the fifth is Body Mass Index, BMI).

There are numerous ways to measure convenience in-home walking speed. Stationary sensors are based on Doppler effect or electromagnetic tracking system, wide area pressure sensors, furniture pressure sensors, video and audio sensors. Wearable inertial sensors include accelerometers, gyroscopes, electromyographic sensors, pressure sensors, goniometers (Tao *et al.*, 2012). Accelerometers can be used to measure acceleration-deceleration and start/stop time, because they may change in some pathological conditions. More complex activities than walking also routinely registered in most AAL systems. Utilities usage (Fell *et al.*, 2017) or mounted sensors, signaling about refrigerator usage, doors and windows operation, other activities are usually monitored with help of different sensors and ontological models (Augustyniak and Ślusarczyk, 2018; Ihianle *et al.*, 2018). Walking speed can be predicting sign for the future health condition (Purser *et al.*, 2005), as well as Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL) (Salguero *et al.*, 2018; Snyder et al., 2018).

Table 1: Katz Index of Independence, ADL scale. (Katz et al., 1983)

ACTIVITIES POINTS (1 OR 0)	INDEPENDENCE: (1 POINT) NO supervision, direction or personal assistance	INDEPENDENCE: (0 POINTS) WITH supervision, direction, personal assistance or total care
BATHING POINTS: ___	(1 POINT) Bathes self completely or needs help in bathing only a single part of the body such as the back, genital area or disabled extremity.	(0 POINTS) Needs help with bathing more than one part of the body, getting in or out of the tub or shower. Requires total bathing.
DRESSING POINTS: ___	(1 POINT) Gets clothes from closets and drawers and puts on clothes and outer garments complete with fasteners. May have help tying shoes.	(0 POINTS) Needs help with dressing self or needs to be completely dressed.
TOILETING POINTS: ___	(1 POINT) Goes to toilet, gets on and off, arranges clothes, cleans genital area without help.	(0 POINTS) Needs help transferring to the toilet, cleaning self or uses bedpan or commode.
TRANSFERRING POINTS: _____	(1 POINT) Moves in and out of bed or chair unassisted. Mechanical transferring aides are acceptable.	(0 POINTS) Needs help in moving from bed to chair or requires a complete transfer.
CONTINENCE POINTS: ________	(1 POINT) Exercises complete self-control over urination and defecation.	(0 POINTS) Is partially or totally incontinent of bowel or bladder.
FEEDING POINTS: ___	(1 POINT) Gets food from plate into mouth without help. Preparation of food may be done by another person.	(0 POINTS) Needs partial or total help with feeding or requires parenteral feeding

Interpretation: The maximal score is 6, which shows no necessity in support. Lower score requires assistance in accordance with rubric and need of particular patient.

ADL is estimated by the level of independence with: bathing, dressing, toileting, transferring, continence, feeding. IADL usually includes the use of public transportation, shopping, preparing meals, paying bills, managing bank account. While ADL and IADL usually measured with help of periodic questionnaires, AAL allows permanent automatic assessment.

Other Measurements.

Various additional functions and functional assessments are often included or potentially can be integrated into the AAL system. Electronic scale gives weight follow up, important in some medical conditions, connected to water retention or weight problems. BMI is usually calculated by division of body mass on the height squared (kg/m^2) and often recognized as fifths vital sign.

Object usage, for example, medication box, can be included, especially in the case of problems with compliance and memory problems. Specific devices, as electronic capsules, are sometimes employed in more problematic cases.

Variety of specific devices and sensors are used in different pathologies as a part of AAL system, from hearing aid-enabled glasses, camera o sensor-enabled glasses, smart shoes, bionic prosthetic with RFID and MEMS, electronic inhalers and injectors (Snyder *et al.*, 2018). It can be implanted drug injectors, intraocular, intra-bladder, intraperitoneal, intracranial pressure sensors (Yu *et al.*, 2014).

A separate group consists of electromyography (EMG) wearable sensors. Muscular electric impulses are measured in neuromuscular pathologies. They also can be employed for emergency cases as epilepsy with grand mal events, in combination with positioning sensors.

Mental Health Applications.

Monitoring of mental health cases in the AAL system can be divided into two big groups. One deals with psychiatric emergencies, such as suicide, psychotic events, major depression, alcoholic or drug-induced events. In every such case, the patient is potentially dangerous for himself through the self-harm or self-neglect or can be dangerous to other people.

The other type is long-term supervision, which can deal with emergencies, but mainly intended to be diagnostic and supportive in the case of a chronic condition with potential for physical and mental deterioration. Behavior detection is based on the complex events analysis, activity time ratio, daily activity rates, complex event processing (CEP) and pattern recognition against existing pre-collected sets (Veronese *et al.*, 2018). Other systems are focused on the RFID of global positioning system (GPS) objects usage (Hodges *et al.*, 2010).

For emergency cases, different prediction models based on the sensors combinations and behavioral data sets (Alam *et al.*, 2016). Other systems propose a connection with previous patient's records for better diagnostics (Alam *et al.*, 2012). Identification and prediction of abnormal behavior with the help of neural networks (NN) is proposed by another team (Lotfi *et al.*, 2012).

II.3. AAL for MCI and Dementia.

One of the widespread chronic conditions is lowering of the intellect of various genesis. Home-based patients with MCI, Alzheimer's Disease (AD) require significant medical and social attention. Technical solutions, such as AAL, are focused on leveraging burden for carers, healthcare providers and society.

Specific Aspects.

Standard intelligence is generally reflected by intelligence quotient (IQ). The normal IQ is 85-115 (100+/-15), +/-1 SD. MCI is diagnosed, when permanent general IQ decline from previously normal level is lower than 85 and higher than 70. Patients with dementia have stable IQ lower than 70. There are multiple methods of intelligence tests, various types of intelligence and diagnostic is non-trivial, but for simplicity IQ level is relevant enough, with more than 50% cases of MCI and dementia constituted by AD.

There are many more causes for MCI and dementia: pseudobulbar affect, Parkinson’s disease, frontotemporal lobar degeneration, Lewy body disease, vascular diseases, traumatic brain injury, substance/medication use, human immunodeficiency virus (HIV) infection, prion diseases, Huntington's disease. MCI is assessed by behavioral and IQ tests, computer tomography (CT), magnetic resonance imaging (MRI), diffusion tensor imaging (DTI), positron-emission tomography (PET), in addition to other clinical tests, such as specific blood tests, spinal puncture and biopsy. The Wernicke-Korsakoff syndrome is often developed due to alcohol abuse and secondary thiamine (B_1) deficiency, as well (Kaplan and Sadock, 2020).

Dementia as a condition has specific modes of behavior. Patients have problems memorizing necessary information and have difficulties to perform everyday tasks. Reminders have to be more persistent, patient and avoid provoking a negative emotional reaction. Unfinished tasks, like open doors, gas stoves, water supply may have adverse results. Misuse of objects creates danger for patients, their close relatives, carers, neighbors and visitors. Wandering without a clear objective, especially in the environment with obstacles, stairs, windows without protection is potentially harmful for dementia patients.

ADL.

Special service-oriented application (SOA) AAL platform "DemaWare" is specially created to address part of these issues, but partially based on obtrusive camera wearing for complex activity recognition (Stavropoulos *et al.*, 2014, 2015). Other AAL platforms often integrate one or more solution for patients with memory and executive mental problems. Behavioral problems are addressed by the system with positioning and reasoning component (Bouchard *et al*., 2006). There are certain additions for ADL questionnaires in the case of dementia sufferers (Opara, 2012) and Lawton scale for IADL (McGrory *et al.*, 2014) which have to be addressed in AAL design. However, questionnaires and scales live space for improvement (Sikkes *et al.*, 2009).

Building an automated system for cognitive tasks assessments is the next level of automatization, and checked on a limited number of activities (Dawadi *et al.*, 2013). The wider scope of daily tasks is also analyzed (Sacco *et al.*, 2012). Some research results, built on the smart home CASAS project data, show the possibility for reasoning and prognosis. The finding of a strong correlation between Time Up and Go test (TUP) and ADL, especially general mobility, and, to the lesser extent, with other specific tests and data features (Alberdi *et al.*, 2018).

Design of tailored AAL required a number of planning steps, from the needs of the patients and caregivers, through the realistic scenario, to the design of the system, testing, and implementation for permanent use (Amiribesheli and Bouchachia, 2018).

In the European AD automated diagnostic project, Dem@Care patients` movement data is collected from the wearable ankle-mounted accelerometer. Additional data adaptation by creating more day and week time domains improves automated diagnostic (Bian *et al.*, 2018).

Memory is one of the functions, which often suffers profoundly in dementia and MCI. It creates multiple problems, especially with repetitive tasks. Some AAL components are built to compensate for the loss of the function. There are attempts to create systems (HERMES) with ability to remind about daily tasks, free time use (Costa *et al.*, 2009). Addition of smart objects, smart pill boxes, electronic calendars, smart white goods with reminders creates better environment for patients with memory loss.

Spatial Movement.

Connection between ADL tasks and cognitive impairment is well known and often reported (Pereira *et al.*, 2008). Moreover, strong positive correlation between quantitative gait characteristics and dementia is found in several studies. Mostly affected are step velocity and step length. Number of daily bounds (sessions, rounds) negatively correlates with cognitive status (Mc Ardle *et al.*, 2018).

In some studies proposed prediction of the mental status change, based on the walking features, as speed, angular velocity and balance (Mulas *et al.*, 2021). Other researchers found only spatial correlation between gait and cognition for health old people (Valkanova *et al.*, 2018).

However, in major longitudinal study of 2938 mentally healthy participants, of which 2233 participants were reassessed and 226 developed dementia. Future decline correlated with walking speed. It is also proposed that diminished mental processing speed plays crucial role in lower walking speed. One standard deviation in walking speed shows potential increase in possibility if future dementia (Welmer *et al.*, 2014).

The Sleep/Wake Cycle.

Normal rest/activity cycle is based on circadian rhythms. Sleep and wake depends on several external and internal factors. Sleep is supposed to be the main resting period. However, there are two phases, rapid eye movement (REM) and non-REM, when physiological signs differ greatly. Non-REM phase is divided into four stages and characterized by lower body temperature, lower movement activity, less frequent breathing with slight hypoxygenation, lower heart rhythm and, subsequently, blood flow (Waterhouse *et al.*, 2012). REM phase is physiologically more active, with close to awakening numbers of blood pressure, pulse, breath rate, while muscular tone is low. REM sleep is usually associated with dreams.

The cycle is regulated by the suprachiasmatic nucleus of the hypothalamus. The light input influences its cyclical activity, while pineal gland secreting melatonin, one of the most important hormones for the sleep-wake cycle (Colten, Altevogt and Institute of Medicine (U.S.). Committee on Sleep Medicine and Research., 2006).

Psychiatric conditions can change the chronotype, the sleep/wake pattern, as well as physical disorders. Sleep abnormality might be the first sign of deterioration and often correlate with the illness progress (Krystal, 2012). Shortened duration of sleep and its poor sleep quality predict suicidal ideations the following day (Littlewood *et al.*, 2019).

MCI and dementia also characterized by sleep abnormalities. It can be shown in EEG patterns. While normal rhythm is characterized by the specific EEG pattern, aberrations are seen more often on patients with MCI and AD (Taillard *et al.*, 2019). Sleep patterns can be registered as part of complex actigraphy. Registration of the sleep pattern is important for psychotic disorders in the time of manifestation, depression, substance and alcohol abuse (Aledavood *et al.*, 2019).

The combination of activities, movement and sleep patterns can give useful information.

MCI.

Mild Cognitive Impairment, MCI, or Mild Neurodegenerative Disorder (MND) is a cognitive condition with a stable level of intellectual functions, declined from normal and measured by IQ, is between 70 and 85. While MCI can be transitory between normal cognition and dementia, this pathology may stay for years and condition, in some cases, can improve.

MCI is not easily diagnosed. When MCI is a part of general cognitive deterioration process, early diagnosis leads to earlier treatment, which can slow down its development, stop it or even reverse it.

MCI usually recognized as part of dementia and most of the AAL systems are the same or similar to the AAL designed for dementia. The difference is the higher number of functions for active independent life and fewer elements, made for a significant cognitive disability.

ADL of patients with MCI is found to be lower than that of healthy old people. It can be connected to general activity during the day and to walking speed as well (Hayes *et al.*, 2008). Comparative analysis of data sets also shows the difference in IADL. It can help to detect cognitive decline early (Riboni *et al*., 2015).

ADL in MCI.

Executive functions of people with cognitive impairment are significantly worse in the case of dual-task tests: walking while talking, picking up objects, transferring objects, walking with obstacles or changing type of walk. People with lower cognitive functions show a clear difference in the walking speed in these tests (Coppin *et al.*, 2006). There are activities of daily functional living (ADFL) ADFL/IADL scales, developed for recognition MCI and differentiate it from the normal condition and dementia (Perneczky *et al.*, 2006; Pedrosa *et al.*, 2010; Cornelis *et al.*, 2017).

Some works are based on the successful machine learning (ML) analysis of CASAS AAL labelled dataset intended to find a difference between MCI patient behavior and healthy individuals (Paudel *et al.*, 2018). Several studies suggested that gait and cognitive functions have numerous associations: processing speed connected to rhythm, executive functions are associated with pace and velocity (Verlinden *et al.*, 2014). Data, automatically collected by sensors` is reliable for the unobtrusive continuous assessment (Kaye *et al.*, 2011). For configuration, please see Figure 2.

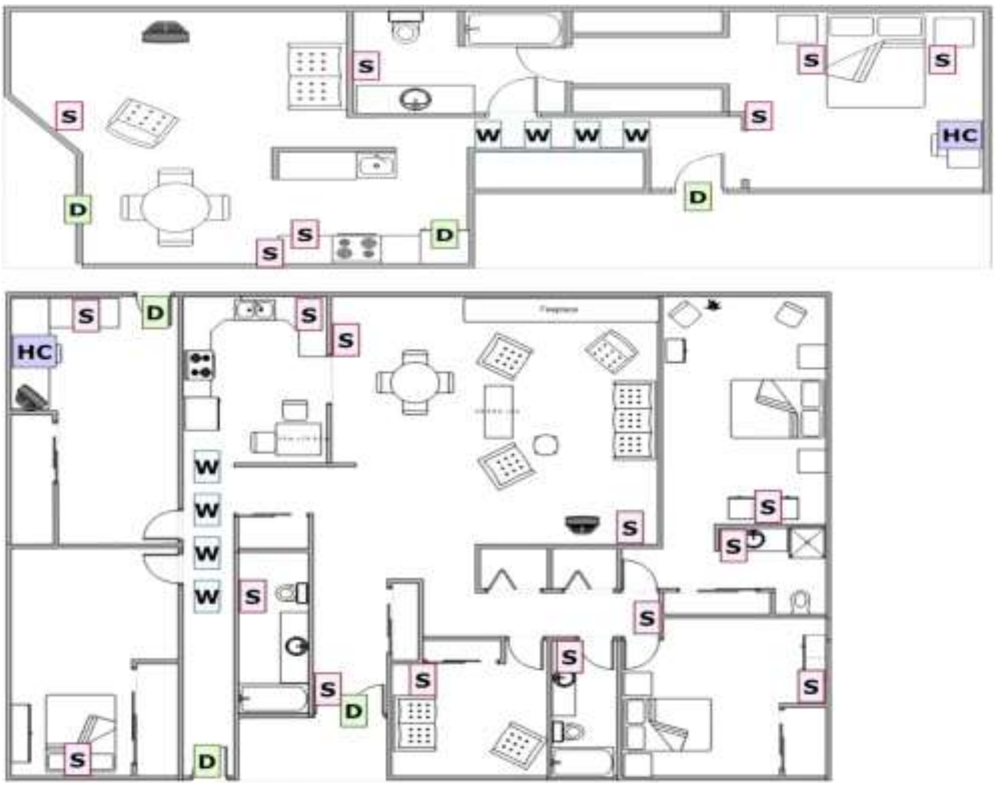

Figure 2: Examples of two home layouts with coverage of sensors

Text 1: "Examples of two home layouts with coverage of sensors indicated. Red boxes (S): locations of passive infrared motion detectors; green rectangles(D): contact sensors on exit/entry doors and refrigerator doors; blue boxes (W): sensor lines for measuring walking speed; HC: home computer location." (Kaye et al., 2011).

Interpretation: Sensors allow to locate the patient, to register ADL and to measure walking speed on the lines with "W" sensors.

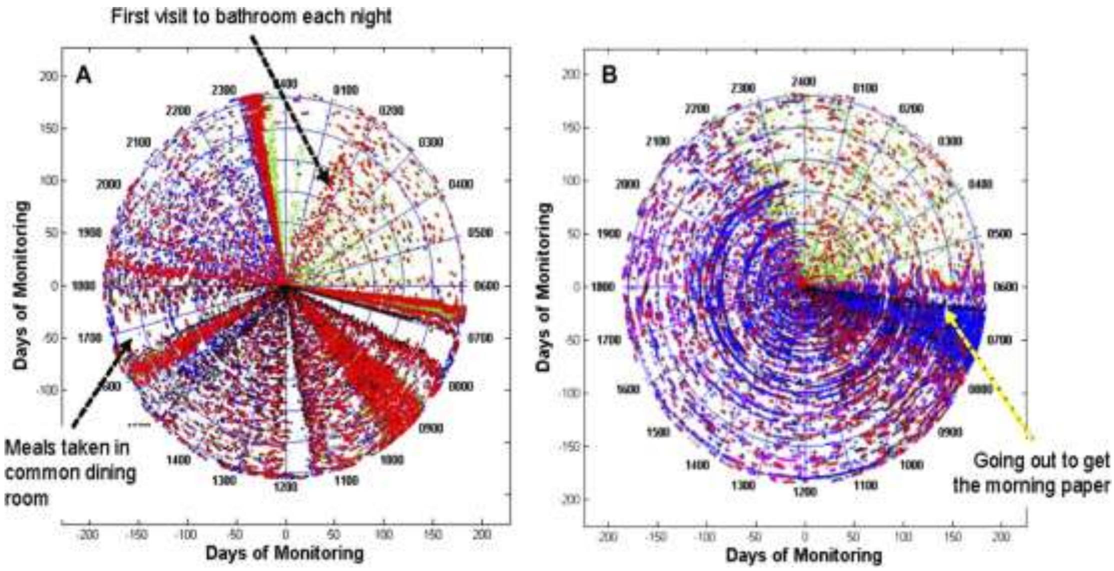

Figure 3: Spiral plot showing activity in two homes over 180 days of monitoring.

Text 2: Each day's activity forms one concentric circle in the plot, with the timing of sensor firings indicated by the 24-hr clock (midnight at the top and noon at the bottom). The solid blue concentric circles represent 30-day markers. The colors indicate where the sensor fired: red = bathroom, green = bedroom, blue = living room, black = front door. (A) This participant lives in a Continuing Care Retirement Community and takes meals in the common dining room, falls asleep at about the same time every night, and gets up most nights at the same time to use the bathroom. (B) This participant lives alone in the community, has more irregular sleep patterns, and leaves her home much less often." (Kaye et al., 2011).

Interpretation**:** The plot clearly shows 24-hour activity. It allows to register ADL, to evaluate activities and to see regularity and organizational structure.

Sleep Abnormalities in MCI.

While sleep deficit or disturbed rest often have negative impact on mental abilities, there are signs of the influence of cognitive dysfunction or conditions, leading to it, on the rest/activity patterns and sleep architecture. Sleep and wake pattern is often disturbed in MCI patients (Djonlagic *et al.*, 2019). Ability to register patient activities in AAL during day and night are clearly demonstrated (Figure 3) (Taillard *et al.*, 2019).

These findings can be supported on the level of EEG registration. These pathological changes can be predictive in the case of MCI and correlate with deterioration. Specific signs during non-REM sleep phase show future MCI in aging patients (Taillard *et al.*, 2019).

II.4. AAL Projects.

AAL is seen as one of the main methods of healthcare supervision for many home-based independent senior adults and partially able patients. In recent years numerous AAL concepts were proposed, and numerous projects were implemented and tested.

There is no clear convention what is called AAL system, AAL project or AAL platform. The platform can be the basis for several projects, as OpenAAL or UniversAAL. Project is often an original concept with implementation and several variations. Systems can be understood as parts of the whole AAL, described above when it is also a combination of subsystems. The detailed description makes it clearer but does not fully remove the difference in the terminology used. For example, AALIANCE project is a combined effort of several stakeholders to develop a number of AAL frameworks. http://www.aaliance.eu/

AAL system may differ in the complexity, type of targeted pathology, technical solutions, level of security, the involvement of stakeholders, price of implementation and support and a number of other parameters (Memon *et al.*, 2014). In order to describe typical AAL system, several projects were chosen to represent more or less standard solutions.

CASAS.

One of the best-known long-term AAL projects is CASAS. The project is run in the Center for Advanced Studies in Adaptive Systems (hence CASAS) of the Washington State University (WSU). There are numerous publications made by WSU researchers about smart cities, smart home technologies, AAL healthcare applications.

CASAS concentrates on the MCI and dementia patients. ADL and IADL are registered by the non-invasive sensor networks and analyzed by reasoning agents (Rashidi and Mihailidis, 2013). There are works produced by the center, where ADL recognition is enhanced by smartphone sensors, additional context-aware reasoning with coupled hidden Markov model (HMM). The method is applied for the multi-person condition

(Roy *et al*., 2016).

CASAS is often mentioned not only for its research but also as a source of one of the most comprehensive datasets http://casas.wsu.edu/datasets of ADL, data collection tools, synthetic sensor-based data, created with the help of ML (Dahmen and Cook, 2019).

PERSONA.

European AAL project PERSONA (Perceptive Spaces prOmoting iNdepentent Aging) encompasses a number of technological initiatives, focused on the creation of affordable, fully-fledged, flexible, scalable AAL environments. The main purpose is a comfortable environment for independent senior citizens. Assisted living is perceived as physical, technical, social support for patients and relatives. PERSONA support can be extended and be available in part outside the residential home, in the community environment.

The PERSONA works with various sensors: embedded, positioning sensors, smart textiles and can be interacted by liquid-crystal display (LCD) touchscreens and voice recognition (Colomer *et al.*, 2014). In PERSONA environment computational devices have distributed computing power by using gateways (Tazari *et al.*, 2010). However, proposed 3D posture registration by time-of-flight (TOF) cameras reduces privacy, overloads the system without significant achievement in the QoS or clinical necessity.

SOPRANO.

Service-oriented Programmable Smart Environments for Older Europeans (SOPRANO) is an international European project. The goal is to address the demands of the ageing population for independent living and create a comfortable smart environment with abilities to support, to predict and to react in the case of an emergency.

A number of sensors are used to monitor safety and activity: temperature sensor, smoke alarm, RFID, magnetic, and positioning sensors. The system is built to inform about falls, home emergencies, health status, physical and social functioning. A number of reminders help to keep with the medication regime and daily routine. SOPRANO is focused on iterative user involvement There is an ability to control electric appliances with remote control, as well as the system itself (Bierhoff *et al.*, 2013). SOPRANO is partially developed by Fraunhofer research organization, as well as a number of other projects

(AMIGO).

AMIGO.

Ambient Intelligence for the Networked Home Environment (AMIGO) is an international collaboration project. The main idea behind it was to integrate electronic and electric devices in the smart home in order to implement it in the most appropriate integral way and simplify control. Interoperability of devices includes PC and mobile phones. AMIGO was first oriented on the fully functional technologies, which helped to control domotic devices, security, bill payments. In the process of development, other functions were added to be more acceptable for aged people with partial disabilities (Baquero *et al.*, 2012).

AMIGO might be recognized as not fully functional AAL with pre-elements of IoT. The project was finalized in 2008 and its findings became part of the UniversAAL system.

MPOWER.

The project was initiated more than a decade ago and has objectives to build service-oriented AAL architecture (SOA), inter-operable with Google Health. MPOWER register activities and emergencies, communicate with healthcare services and allows audio and voice interaction. Electronic health records (EHR) utilize Extensible Stylesheet Language Transformations (XSLT). Extensible Markup Language (XML) is suitable for the used Simple Object Access Protocol (SOAP) protocol (Mikalsen *et al.*, 2009). Interoperability is one of the main purposes of the MPOWER middleware. Additional functions are sensors` information with context awareness, security service, medical information service.

OASIS.

OASiS is an Object-centric, Ambient-aware, Service-oriented Sensornet programming framework for wireless sensor network (WSN) applications. It is a European international project for independent elderly life. The aim is to integrate all relevant areas of activity into automated services` platform: e-work, e-learning, transport, domotics, healthcare. OASIS helps to regulate the social and physical activity, monitor the environment, advice on nutrition, control and report vital signs. The home environment has sensors for activity and movement monitoring (Bekiaris and Bonfiglio, 2009).

Reaction to physical change initiates the services` response. Modular, autonomous, object-oriented, ambient-aware applications are run on the basis of graphs of services (Koutsoukos *et al.*, 2008).

UniversAAL.

The platform UniversAAL, UNIVERsal open platform and reference Specification for Ambient Assisted Living, includes best parts of other projects: AMIGO, GENESYS, OASIS, PERSONA, SOPRANO, MPOWER (Ram *et al.*, 2013). An integrated part of the SOPRANO, the openAAL platform, also provided components for the UniversAAL. UniversAAL allows stakeholders, including relatives, to enter the system, yet security is one of the platform's objectives.

eCAALYX.

Complete Ambient Assisted Living Experiment (CAALYX) is an original European project. It includes three subsystems: the Roaming Monitoring, the Home Monitoring and the Central Care Service. The home system has numerous sensors, domotic devices, computing units and communication channels, VoIP and video contact through the TV set. Home system besides monitoring of the health condition and reporting emergency issues, (fall etc.) has the ability to control devices, schedule daily activities and support necessary contacts (Boulos *et al.*, 2007).

The roaming monitoring system is a wearable device, wearable sensors and WBAN plus mobile phone with GPS. This subsystem is functional indoors and outdoors.

The central care system has computing units with soft and user interface (UI) for healthcare staff. It is connected with two other subsystems over the internet and helps to establish telemedical care via direct contact with a patient and technical control.

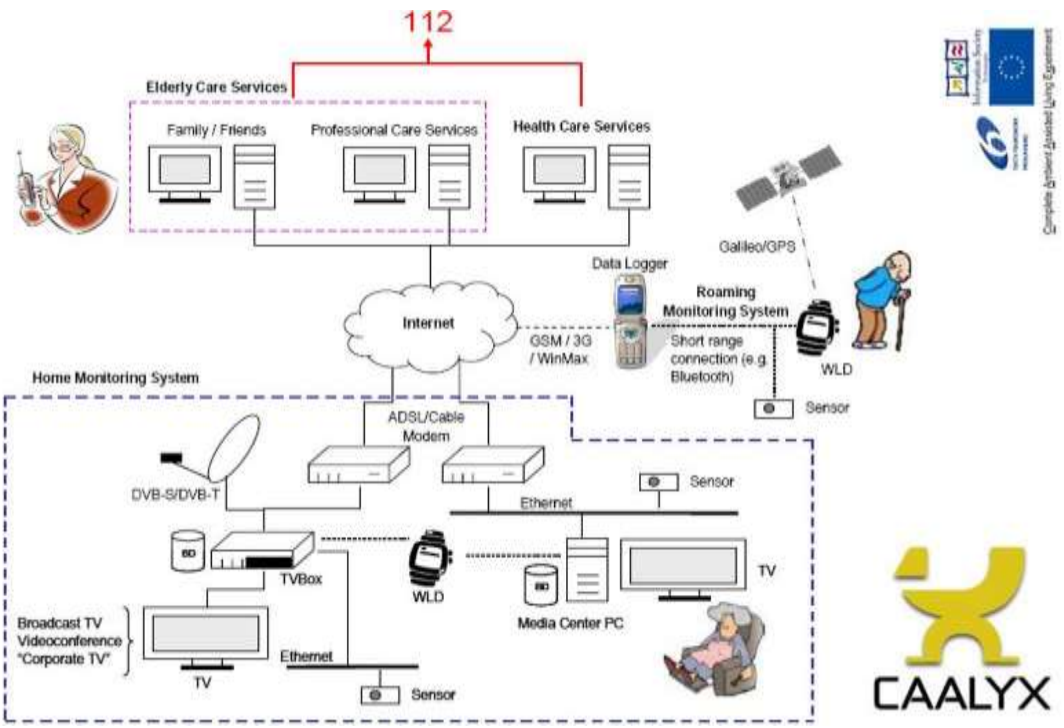

Figure 4: CAALYX system. (Kamel et al., 2009).

Interpretation: The figure 4 shows all layers of the AAL, featuring certain types of devices and picturing two main stakeholders: users with relatives and care providers.

eCAALYX is built on the Android platform and iOS application was considered. While smartphone role is important, battery life, inappropriate handling, unwanted updates and system reloads have to be considered.

Dem@Care.

Dem@Care is long term European AAL project for people with MCI and dementia, their relatives and involved healthcare professionals. The system is adapted for the specific needs of people with memory loss and cognitive impairment. At the same time, ambient intelligence (AmI) and pervasive computing allow ADL registration and partial analysis. Dem@Care collected enough information to present datasets online: http://www.demcare.eu/results/datasets

ADL is recognized primarily through the sensors: motion sensors, smart plugs, sleep monitor. There are also IR camera, a depth camera and wearable red-green-blue (RGB) camera. There is a number of typical scenarios, recognized by a depth camera, with

Complex Activity recognition (CAR), for example, standing, walking, sitting. Microcomputers in a number of nodes are attached to the camera. IR camera has Human Activity Recognition (HAR): eating, drinking, reading, watching TV, writing, taking medications. Information is recognized and compared with the normal/abnormal dataset. There is also a wearable wireless microphone. The speech is analyzed by Offline Speech Analysis (OSA) (Stavropoulos *et al.*, 2014).

Other Dem@Care dataset experiments are concentrated on the motion behaviour of patients with AD (Bian *et al.*, 2018). In addition to mentioned sensors, there are Gear4 Sleep Clock, Aura Sleep Sensor, UP24 wrist accelerator, tags. All are integrated into the DemaWare2 framework (Stavropoulos *et al*., 2017).

The Dem@Care project is an impressive application of ambient technology and IT for patients with AD and MCI. Datasets are the foundation for further research and development. However, there are some reservations in connection with extensive use of cameras and microphone, which can undermine the patient's privacy.

SAAPHO.

Secure Active Aging Participation and Health for the Old (SAAPHO) is AAL project with user-centered design (UCD). The Android-powered tablet is the dialogue entrepot for the user. Touch Screen is chosen for easy operation by tech novice. The decision is based on questionnaires. http://www.aal-europe.eu/projects/saapho/

The health monitoring data is stored in the Health Intelligent Server (HIS). There is a Historical Calculation Health Service, which allows to follow up changes in controlled parameters: blood pressure (BP). glucose level, weight. All fluctuations are registered, and those outside of the norm are indicated by the system. Besides the report to the healthcare stakeholder, the system can address these issues by the automatic recommendations for the medication intake or nutrition advice (Ahmed, 2017).

BelAmi.

Bilateral German-Hungarian Collaboration Project on Ambient Intelligence Systems (BelAmI) is an AAL for use in home care. The system is well conceptualized on a general level. The practical lab was run to prove the concept of the Ambient Home Care Systems

(AHCS). At the basis of the system are placed the number of principles, when AAL with AmI is: embedded, pervasive, invisible; context-aware; anticipatory; adaptive; mobile; heterogeneous and hierarchical (Kleinberger *et al.*, 2007).

The is a proposed element of the AAL, RFID-supplied system for the foo-freshness monitoring, smart refrigerator. Another application is a smart ECG system (Havasi and Kiss, 2008).

BelAmi AAL is oriented on enhancing comfort and autonomy, and at the same time able to handle emergency data. It can register activity, position and report about important events: change in the registered vital signs, security alert, medication non-compliance. As a system, it has the ability for the self-optimization, self-configuration and self-maintenance (Nehmer *et al.*, 2006).

Other AAL Projects.

AAL has been proposed decades ago, and in the last years, many frameworks and systems were put for scrutiny. While most of the projects are run in limited time settings, some of them, for example, CASAS, Dem@Care, UniversAAL are developing farther.

There is no scope to go through the all proposed schemes thoroughly, however, some of them can be mentioned, especially when they have certain notable solution or novel approach.

PersonAAL is an ongoing project, focused on the online applications, capable to assist the patient in the AAL environment. One of the directions for the project is End-User Development with frameworks such as “IF This Then That” (IFTTT) and TARE (Topology Adaptive Re-kEying scheme) platform for IoT (Corcella *et al.*, 2019). PersonAAL allows personalization and detection of the anomalous behavior (Manca *et al.*, 2017).

DOREMI is focused more on the social and psychological aspects. It monitors heart rate (HR), number of steps by DOREMI wristband, weight and balance by balance board, the position through the sensors and social activity with help of a smartphone. DOREMI developed synergy signatures monitoring to holistically register caloric balance, ADL and socio-psychological activity (Palumbo, Rosa and Ferro, 2016).

UbiCare is a low-cost AAL system, where contextual registration of ADL is made through the numerous sensors and IoT items. For privacy reasons, cameras and microphones are excluded. There are no PC, laptop or smartphone as computing units. All data and connections are handled by Arduino microcomputers and Xbee, ZigBee modules (Dasios *et al.*, 2015).

AMICA is a telemedical AAL project, concentrated on the home-based Congestive Obstructive Pulmonary Disease (COPD) patients. It features wearable sensors for the ECG and microphone for the pulmonary sounds registration (Gasparet *et al*., 2015).

gAALaxy is a current project, which bundles together existing solutions for AAL and Smart Home with cloud-based middleware. The project is market-oriented (Ates *et al.*, 2017).

There are different center points for AAL system. DynAMITE and SENSATION-AAL are recognized as agent-based, while EMBASSI, MAP, SmartKom are monolithic intelligent systems (Byrne, Collier and O'Hare, 2018).

AMIVital is oriented on the development of a business model for AAL, VAALID is concentrated on the computing and engineering tools, REMOTE is designed for people with chronic conditions, but living at a distance from the healthcare providers, and CogWatch is specifically focused on the group of patients, suffering from apraxia (Colomer *et al.*, 2014).

Wide range of European projects is listed at the portal http://www.aal-europe.eu/projects, while many AAL platforms are members of the national programs. Austrian ModuLAAr (A modular and scalable AAL system as lifestyle element for silver-ager up to assisted living), West-AAL, ZentrAAL, RegionAAL, WAALTeR and Smart VitAALity have regional division and some specific characteristics (Byrne *et al*, 2018).

Other projects are featuring some specific aims. ALICE is designed for patients with visual impairment, DIET4Elders on the ADL monitoring and support, EDLAH on the object location, ELF@Home on the fitness, FEARLESS – emergency situations, WIISEL is focused on the gate and ADL analysis, while MOBISERV is a personal robotic system (Nani *et al.*, 2010).

II.5. Summary and Analysis.

Principles of ubiquitous or pervasive computing are important for smart environment organization. The AAL system is a specialized application of a more universal Internet of Things. While smart manufacturing is industry-oriented IoT and smart cities are designed as a cyber-physical space for social and communal activities, seamless application for smart homes has several functions: security operation, utility service, microclimate regulation, domotics and smart devices management and control. Overall supervision of the system allows different modes of functioning. The flexibility of the architecture is convenient for customization and additional applications.

The healthcare extension for the IoT and smart home requires additional measures for functionality, safety, security and data protection. AAL system is mostly associated with technologically advanced healthcare. Automatic data registration, its transfer to Electronic Health Records (EHR), supportive health and administration applications, health and safety alarms form the background of specific features in the AAL system.

The internet of Things for a smart home has several layers. Every layer possesses specific technological “overtones” in the case of AAL. Sensors and actuators on the perception layer have to be unobtrusive, seamless and context-aware at the same time with fullness and time-sensitivity of data collection. Multi-sensor systems and wearables demand biocompatibility and end-user compliance conditions, the need for long battery life and effective computing capabilities for data minimization and encoding before transfer. The network layer technically must have high security, robustness, redundancy, consistency. The healthcare requirements add health safety, which moves options for connection in the direction of wireless communication, subject to power supply and coverage. Data protection is compatible with new developments of Fog and Edge computing, with data partial transformation, processing and encoding between gateways and actual processing layer.

The processing layer lies at the heart of the AAL system. It is home to Operational System and middleware. Main data transformation occurs at this stage. It handles principal management for other layers, data and applications. Technically the processing layer depends on the CPU performance and quality of software and architecture. It has to be balanced with power consumption, the price tag for acquirement and service and user-oriented specifications. While technical and healthcare stakeholders can formulate the list of demands, the first end-user, caretaker, is not always able to express their specific needs. User Interface/User Experience (UI/UX) modelling and surveys are a valuable source of the information. Comprehensive and intuitive UI is subject to usability for patients with physical and mental limitations. Besides that, the failure-proof power supply, secure data handling and ability to allow necessary applications through the API form the framework for the processing layer. Applications are often necessary for systems with high emergency awareness, reporting tools and Decision Support Systems (DSS). Cloud-based applications solve the problem for computer power, architectural complexity and the possibility to employ AI instruments. But the movement towards the cloud-based AAL applications is by some means not fully compatible with Fog and Edge computing environment.

In the AAL system, user-oriented architecture is interwoven with service-oriented architecture (SOA). The general medical requirements for vital signs registration and emergency reporting are supplemented with additional specifications, depending on the particular medical condition. The observational functions are amplified by supportive tasks and service provider obligations. Every health condition limits physical or mental capabilities for the patient and necessitates compensatory capacities for the AAL system. This put technical, medical, and administrative dictums into the position of higher sensitivity to private needs, including legal, social, psychological and emotional demands.

The high-performance AAL system tends to be relatively simple and be oriented on basic functions. The AAL environment for MCI may require a wider spectrum of duties in addition to the effective general AAL. Somatic health can be a matter of elevated concern due to the nature of the health condition. Simultaneously, tools for physical activity data collection, ADL automatic registration, sleep and wake pattern log, mental and memory tasks support are enhanced by cognitive and emotional observation and control. Currently, success frameworks are proposed in a number of AAL systems, and DemaWare and CASAS projects produced effective solutions and published data sets. There is an opportunity to conceptualize a modern AAL system for MCI patients on basis of previous research and practical work done in a number of relevant projects.

Chapter III: State of The Art of Questionnaire-based Assessment.

III.1. Assessments and Survey Methods for AAL

Existing and planned AAL system have to be evaluated, validated and tested. Several methods are used for surveys and assessments. There are also theoretical methods, modelling in silico and practice, prototyping, live-in lab experiments and dry runs. After the start of the practical use data from the system and stakeholders is routinely collected and assessed with help of analytical tools.

Conceptual Stage.

Health, WHO Quality of Life (WHOQOL) survey and questionnaires are used for patients (Queirós *et al.*, 2017). Healthcare specialists and caregivers formulate medical and social requirements and then the information is presented to technical specialists for conceptual validation, reference design and prototyping. The opinion of the social institutes and caretakers is also taken into account. At this stage, initial questionnaires are presented to stakeholders. The choice of every element in the system is based on the cross-section of requirements, from the skeleton to the user interface in later stages. Architecture is more influenced by technical standards.

Model.

An initial phase demands the formulation of functional requirements, based on stakeholders needs. ADL, IADL with help of prototype is envisaged with help of modeling, scenarios creation, personas and simulations. Data flow evaluation and model quality control are used, with analysis of acquisition, transmission and usage (Kara *et al.*, 2017). In the first stage, sensors are chosen and calibrated. In the second stage ways and periodicity of transmission are analyzed, as well as security. In the third stage storage, backup and potential recovery are envisaged. Personas are used and functional portraits of potential users are generated. Supplementary, narrowly focused questionnaires can be utilized together with expert reviews.

Prototype.

In the next stage, the prototype is tested for usability, functionality and interoperability by special tools or in living labs (Colomer *et al.* (2014). Experiments and questionnaires are instruments on this stage, as well as reviews (Salvi *et al.*, 2015). While technical and instrumental measures are more objective and based on external metrics, questionnaires tend to be more subjective instruments and require different instruments of analysis. Both approaches have to be balanced in every case. For example, in living labs, there are different approaches to the information presented for the actors or patients. Some can be informed about testing, and others are instructed afterwards. In every case, the nature of questionnaires and surveys may differ.

Impact Assessment.

Wider impact assessments include social, financial, industrial and political impacts, as demonstrated in the "Learning from the 2019 and 2020 AAL Impact Assessment Final report." by *http://www.aal-europe.eu* and Technopolis group. There are three main types of frameworks of impact evaluation: Re-AIM, MAST and UTAUT. (Østensen *et al.,* (2014).

Re-AIM is an acronym of “Reach”, “Effectiveness”, “Adoption”, “Implementation”, “Maintenance”. Reach speaks about the type and size of respondent's groups, inclusion and exclusion criteria. Effectiveness measures all effects, including positive and negative impacts. Adoption calculates the number of stakeholders, who adopted the scheme or system. Implementation registers social, financial, administrative and other costs. Maintenance is a measure of long-term adoption, level of institutionalization or routine practice change.

MAST is a Model for Assessment of Telemedicine. It is a multidomain approach to healthcare IT systems, which include AAL. It is divided into three stages: a preliminary assessment, multidisciplinary assessment and transferability assessment. At every stage multifaceted analysis of social, administrative, financial, ethical and other aspects is done. Safety, effectiveness, maturity, possibility to be practically adapted are surveyed.

The UTAUT stays for the Unified Theory of Acceptance and Use of Technology. It is a model framework, which consists of four elements: performance expectancy, effort expectancy, social influence and facilitating factors (Venkatesh *et. al*., 2012). There are also price value, hedonic motivation and habits in the extended model. The behavioral intention in the model is also influenced by age, gender and experience. All factors lead to user behavior. Every model can be used separately, partially or in full, with extensions, in combination with other models or provide elements fora specially constructed framework.

III.2. Questionnaires.

One of the widely employed methods is a questionnaire. Economical and policy institutions create a significant impact on the AAL provisions. At the same time stakeholders: technical service providers, medical service providers, e.g. institutions and workers, end-users, such as patients and family carers, are the most important immediate players in the field of AAL. Current, prospective and retrospective assessment of stakeholder opinion through the survey is an important tool, addressing various aspects of the AAL. The level of acceptance, satisfaction, informed opinion or professional view is significant in the design and exploitation of AAL system. Questionnaires can be subjective report tools but include objective information e.g. technical or biomedical parametric qualitative and quantitative data for comparison (Bethlehem, 2009.). Objective information can be obtained by other means than questionnaire. Psycho-social factors, such as subjective acceptance, readiness to learn new technologies or to be involved in services with extensive AAL components are also important. Results can be presented as qualitative data, but scaled questions and frequency tables allow formal non-parametric statistical analysis.

III.2.1. Methodology and Process.

The general framework depends on the questionnaire objectives and weights, attributed to certain metrics and variables. It is planned on the stages of conceptualization and questionnaire design (Brancato *et al*., 2006). Extensive literature review leads to the general understanding of the necessity, goals and the type of respondents the survey is targeting. While the concept influences every part of the questionnaire and every change in it, the nature of the expected category of interviewees is quite clearly split between the general population sample and the expert group. It affects the length of the survey and cognitive load, required from the respondents. The design depends on questionnaire structure, complexity, types of questions, wording, instructions, types of feedback and ways of administration. When the questionnaire is completed, it is tested, reevaluated, adjusted and implemented for data collection.

Types of Questionnaires.

There are several types of questionnaires (Saris and Gallhofer, 2014). They depend on the research goal, respondents group, type of questions, length and depth. Questions can be more qualitative or quantitative, open and closed, dichotomous, with simple dual answer options, or multiple options, factual or opinion-based. Scaled questions of several Likert types are also often used to measure level or degree. Complex questions can be designed with internal sub-questions and mixed options. Butteries of questions and specific batches can be arranged in sections or be spread randomly.

Questionnaires are used in a direct interview, by mail, phone, online application, mobile app. The obtained information is often analyzed with the help of statistical instruments. The separate complex research class is formed by multifaceted surveys, designed with axes for several stakeholders. AAL4ALL project (Cunha *et al*., 2013), run as an interdisciplinary, academic and industrial scheme. This project, for example, is created with a goal to answer questions about applicability, affordability and necessity to provide AAL as part of the communal healthcare program. It includes three major groups of respondents: patients as end-users, informal caregivers and healthcare and social care providers.

Another complex approach is to present the same type of questions to different stakeholders in iterations, known as Delphi Survey, named after a well-known historical oracle. Questions are iteratively updated by answers and re-presented to the “oracle” panel of experts (Spitalewsky, *et al*, 2013). Results are scaled, which helps to rank importance inside of the questions` groups.

Sampling.

The sample size depends on the level of desirable minimal margin error percentage. More selective sample and complex questionnaire structure and length can be instrumental for Computer-Assisted Data Input (CADI) (Bethlehem, 2009). The sampling frame is formulated on the basis of the plan and objectives. There are several types of sampling: randomized, which can be simple, systematic, stratified, disproportionate or cluster sampling (Mathers *et al*., 1998). Systematic is more connected to the study frame, stratified represents all necessary strata, disproportionate represents minor groups for comparison with general population and cluster is formed on the basis of random geographically selected clusters to represent wide population. Cluster sampling can be a two-stage process.

Non-random sampling includes quota sampling when a specific frame is applied. Two and multidimensional sampling depends on chosen variables. Sampling also can be dependent on space and time as frame dimensions (Bethlehem, 2009). Convenience sampling depends on the reaction of respondents and not suitable for most of randomized studies. However, it is acceptable for the specific categorical questionnaires (Mathers *et al*., 1998). Sample can be with or without replacement.

Respondent's groups in AAL questionnaires.

There are several major sections in most of the questionnaires, subject to the type of respondents they are presented for. Most of the surveys are concerned with physical, technological and psychological usability, privacy, medico-legal questions, security, perceived usefulness. Technical stakeholders are asked specific questions about design, architecture, middleware. Often are included questions about financial aspects, institutional support, availability, level of implementation. Public acceptance is weighted against professional advice and practical aspects of the implementation of AAL. Size, type, number, social position, role in AAL project, professional knowledge and education, common knowledge and education are important factors when referent groups of respondents are formed.

AAL4ALL (Cunha *et al*., 2013) found that every group is genuinely more concerned with a specific category of questions. While patients are concentrated on direct health benefits, usability and affordability, healthcare providers are aware of technical difficulties and lack of appropriate information and communication technology (ICT) skills, privacy and security issues, low level of AAL applications utilization, administrative and policy problems and insufficient public support.

Questions range from general ones, about the necessity to develop AAL and telemedicine in remote and rural areas, usability, legal issues, to medical and technical ones, about the importance of automatic diagnostic systems and platform interoperability.

Specific multi-collaborative AAL Service Description Tool is proposed as part of SOA to reconcile different requirements provided by the technical stakeholders, user-oriented professionals, social institutions and market specialists (Aquilano *et al*., 2012).

Another type of questionnaires are part of the developing AAL project and oriented on the feedback about certain aspects of design, usability, technical questions. The project is conducted in close collaboration with end-users and their relatives to co-design the most appropriate AAL tools (van Heek *et al.,* 2018).

Healthcare Stakeholders.

There is a significant difference between the opinions of stakeholders. Professional caregivers usually more specific about technological barriers, the intrusive character of some AAL technologies, e.g. camera usage vs simple sensors, and more critical about general acceptance, than other stakeholders (Haluza and Jungwirth, 2015). It is also found that caregivers are less optimistic when AAL implementation is discussed. In general, medical stakeholders are also more skeptical about ICT implementation in healthcare (Sprent and Smeeton, 2016).

Computer-Assisted Web Questionnaires.

There is difference by the way in which questionnaire is provided. Usual face-to-face techniques, on paper and letter type are more often replaced by the computer-based or internet-based surveys, such as CAWQ. There are several specific rules and principles, applied to the internet surveys (Hooley *et al*., 2012). Technical issues of accessibility and usability depend on the type of the platform, as well as integrated analytical tools and export file formats data security is also significant question.

The response rate in the self-administered web questionnaires depends on the complexity and length of the questionnaire. It can be in issue for deep survey and small sample sets. There are several ways to improve response rate (Madge *et al*., 2004): official credentials in the introductory letter, clear instructions, emphasis on the confidentiality, follow-up reminders.

The widely used list of standards for internet surveys is made by Don Dillman (Dillman, 2011). The particular focus is made on the technical matters. The advice is to keep questionnaire available in all widely used browsers on common computing devices, avoid switching screens or interact with a questionnaire in a complicated way or configuration computers and software. All instructions have to be placed exactly before necessary task. Another point is made about self-implementation of the questionnaire: there is no interviewer, no visual respondent control, processed information is textual or visual.

III.2.2. Types of Questions.

Operationalization is the translation of complex concepts into questions (Saris and Gallhofer, 2007). Question type and formulation is important for the survey results. There are several main types of questions used in the questionnaire. The classification includes multiple-choice questions, table questions, closed scale questions and open ones. Significant parts double as attention and consistency control questions. And there are also specific inclusions of so-called control “trap” questions.

There is more general division of questions on the basis of underlying concept. Concept-by-intuition is more obvious, intuitive and more obvious for the respondent, and concept-by-postulation, when potential answer is based on postulates and is less obvious (Saris and Gallhofer, 2014).

Multiple Choice Questions.

MCQs are quite convenient for classification when variants of answers are built from well-defined interrelated options. An MCQ is a question in which respondents are asked to select one alternative from a given list of alternatives in response to a “question stem.” (Carneson *et al.*, 1996). The number of potential answers in the stem can be minimal, two, or more. MCQs are easily designed, adjusted to the necessary level of competence. They can be applied for pointed clarification in the areas of knowledge. Information is easily collected and analyzed. They are also can be used to make reference points for future correlations between MCQs and other types of questions.

At the same time MCQs are limited in options to retrieve necessary information. There is not much freedom for respondent. Some questions may inadvertently include recall, which lessen the reliability of the data. MCQs are very sensitive to wording, even with restricted answer options.

Matrix Questions.

Matrix questions, grids or table questions are popular in the research for several reasons. They allow:

1) to shorten the length of the questionnaire;

2) to collect information in the interconnected manner;

3) to create feeling of the deep involvement;

4) to infuse the respondent with necessary information;

5) to shift the load from other parts of the questionnaire.

6) to analyze obtained data in relatively simple way

However, there is a mixed opinion between experts whether matrix questions are more acceptable than item by item questions or less acceptable (Couper *et al.*, 2013). Some authors see shortening the time and effort on grid questions, while others found that more time spend and higher cognitive load demanded. There is significant sensitivity of matrix questions to lengths of the options in the grid and number of items. Table questions can have one or more answer per row or per column, which can make it time and attention consuming.

Scale Questions.

Direct questions require options for answer. When MCQs often not very appropriate for the subjective and protective answers. The method to collect data is to use scales. These questions are often naturally longer, but are perceived as easier to answer. They have less restrictions in formulations of questions and can be comprehended as too direct ones, with no comparison except of neighboring questions.

Scale questions are usually direct closed questions with two options for answer, positive and negative, but with scale between two poles. The scale can be the simplest one, with two options. The third neutral option is often placed between the middle position to avoid polar answers. Additional intermediate points form the scale. There is a finding, when scales less than 7 can lose control of type I error" (Tempelaar *et al.*, 2020). Longer scales give more adequate scope of options for the suitable answer.

Open and Closed Questions.

Open questions give relative freedom for the answers. They facilitate the answer and allow to use own words of the respondents (Bethlehem, 2009). Open questions are relatively simple to ask for the interviewer. At the same time an answer can be incomplete, vague or unclear. Open answer can be a partial option in some more structured questions, together with potential alternatives "do not know" or "no suitable option". It gives some additional freedom to choose extra variant for the answer. Another way to use open questions is to implement filter questions, asking about other potential opinions not mentioned between answer variants.

Closed-ended questions limit the options and variations for answers. They are of several types: multiple choice with one possible answer, multiple choice "check all that apply" with several possible answers, rating scale questions.

Control Questions.

Small, but important part of the questionnaires is focused on respondents' attention and responses` consistency control. Not every respondent is able to keep a maximal level of concentration for the whole length of the questionnaire, especially the long one and loaded with information. For the extensive, complex and reach in new information questionnaire attention control have significant value.

The function of trap questions in the questionnaire can be clear for the respondent, but it is impossible to intentionally avoid it. It can be a directly or indirectly repeated question, request with inverted scale, an intuitively obvious question with several non-relevant answers. They are used for attention control, answer consistency control or honesty control. The problem arises when trap questions are used extensively. The control can be still not objective enough, but the mutual trust between interviewer and interviewee may be diminished. For example, in the case of intentionally loaded questions.

III.2.3. Structure of Questionnaires.

The structure depends on the questions construction, groups of questions, order and types of complex compositions and layouts.

Rules for Questions` Construction.

Questions` formulation and structure follows rules (Betlehem, 2009)

1) Familiar words are more acceptable than rare ones and intricate terminology. Words, less known to the interviewees or specific unfamiliar terms are better to avoid, as well as complex syntax.

2) Neutral wording. The position of the interviewer should not be explicit in questions with variants of answers. Expectations from answers have not to be clear, except completeness, honesty and effort.

3) Ambiguous questions should be avoided. The question has to be as clear and direct as possible if no other function is planned. Instructions have to be clear and precise and formulation consists of measurable or lucid, whit easy understanding of the question and no bias in answers, connected to the unclear wording. For example, when one answer is required, but wording allows more than one.

4) Questions are better to keep as short as possible. Long questions produce a less clear picture, can be inadvertently loaded or cover the shift of the concept. On the other side, modulating words can add precision.

5) Better to avoid recall questions. Recall bias is a source of errors in data and skews analysis.

6) Better to avoid leading questions, unknown topics, sensitive questions.

7) Negative form of the questions should be used only if necessary. Direct, positive form is preferable.

There are more details, important in question wordings. Complex sentences, as mentioned in point 4), can be a source of imprecision (Saris and Gallhofer, 2014). Assertion added as a condition for the situations in the question, embedded judgment, double-barreled questions, unbalanced questions can produce biased data.

Questions` Order.

Some researchers recommend (Saris and Gallhofer, 2014) recommend specifically use of question batteries. Similar questions or questions on the same topic are better for to group. It usually improves the results because of the smooth flow. Matrix question form can be used for the batteries of questions. At the same time potential, negative effects should be considered. There is an important rule, which is connected to questions order. Sometimes anchoring effect, when the previous question, even not close to the current question, influences the answer. It can be used in the case of educational and informational instruction for the interviewee but is undesirable in all other situations. Another effect is "carry-over" when emotional or other subjective impressions are transferred from the previous questions to the following. In these cases randomized placing of questions is preferable.

Sections Order.

Questionnaires with multiple questions are better to be divided into sections. They can be grouped on the basis of topic or type. The order of sections can depend on the informational load when instructions in previous sections affect answerability in the later ones. Depending on the goals and requirements, the section can be in a specific order or randomized. The latter approach is helpful when a specific section has a "drag" effect. The placement of sections in order can follow different strategies. It can have simple or complex branching architecture. In any case, there should be a smooth flow between sections and their parts.

There are typical orders for different types of sections (Brace, 2018). first is the exclusion section, which is followed by the screening section. The main questionnaire is presented for included respondents with certain credentials of eligibility. The main questionnaire usually starts with general sections and goes to specific ones. Sensitive topics are not asked in general sections and are moved to the later sections. The flow diagram is helpful for sections full cover. Some researchers recommend asking self-classification questions at the end sections to avoid the influence of intrusive information (Brace, 2018). Others

(Bethlehem, 2009; Saris and Gallhofer, 2014) strongly recommend starting the questionnaire with it, if they are considered neutral and not directly related to the topic of the questionnaire.

Length and Cognitive Load.

“Serial order can operate in at least three ways: by affecting motivation, promoting learning, and producing fatigue” (Krosnick, 2018). Most of the researchers' advise keeping online questionnaires short, with the required time to complete them no more than fifteen minutes. As mentioned above, the length and complexity depending on the type of survey and respondents. When the questionnaire is closer to the expert opinion, it has to be regarded as detailed and deep enough to satisfy the requirements. However, there are trades off in the structure, complexity and length of the questionnaire.

There are opinions about worse attention and accuracy at the start of filling the questionnaire, but not all researchers see the proof (Krosnick, 2018). For that reason, initial questions have to be easy, devoid of demographic or personal questions, with a strong connection with the topic. The effect is especially strong with self-administered surveys. It can have a negative effect in the case of necessity to start with inclusion and screen questions. The latter answers are also affected by fatigue, and there is a necessity to lessen load towards the latter sections in order to have completed the questionnaire, as there is “little or no reward to answer questions” (Krosnick, 2018).

Cognitive load and working memory also have to be considered (Lenzner *et al*., 2010). Complicated topics, complex questions, rare or special words, complex syntax, foreign language, extensive length all affect the result. The way to ease it is to address these issues. Clear and simple questions, normal questions and sections flow, comprehensible structure, a reasonable level of complexity and length can resolve it. At the same time for expert panels, there is no problem with special terms or specific information load.

Quality Control.

There are number of ways to validate and evaluate questionnaire before implementation. Methods to control implementation and filling procedures to obtain relevant data also used. Consistency of results is checked with help of statistical correlation and consistency tests.

Validity Criteria.

Several facets of validity are evaluated. Construct validity is first checked by experts, before being put to more scrutiny. Construct is compared to questionnaire content (American Psychological Association, 2014). Themes, wording, format and administration project are explored. Later it is compared with the response, with internal and external variables taken into account. Discriminant and convergent validity, predictive power and quality measures are checked. After all, results are obtained, Multitrait-Multimethod Matrix (MMTM) and other methods are used (Scherpenzeel and Saris, 1997). For example, content can be evaluated with a panel of experts by Lawshe`s Content Validity Ratio (CVR) (Lawshe, 1975). Subject Matter Experts, SME, rate every item in the questionnaire. A number of experts is calculated according to the formula: $CVR = (Ne - N/2)/N/2$ (1) where *Ne* is number of essential experts and *N* is number of all experts. Several panels are usually made.

Questions` Rout Control.

Internal questionnaire quality control includes pretests. The pretests have to include following topics (Converse and Presser, 1986):

1) Did any of the questions seem to make the respondents uncomfortable?

2) Was it necessary to repeat any questions?

3) Did the respondents misinterpret any questions?

4) Which questions were the most difficult or awkward for you to ask?

5) Have somebody come to dislike any questions? Why?

6) Did any of the sections in the questionnaire seem to drag?

Attention Control.

The level of concentration is often not permanent during the length of answering. There are points of control and lines of control:

1) Repeated questions in slightly different forms are not only a type of the registration of attention. It also helps to check consistency of answers and reliability of the information received.

2) Another instrument is examination of how instructions are followed. There is sometimes the tendency to ignore instructions or to use previous ones.

3) Opposite questions are an easy way to exclude automatic answers. Slightly more complex forms of opposite questions go in triples, when answer, partial answer, or opposite one all need to be appropriately balanced.

4) Directed questions and “loaded” questions demand active opposition from the respondent. Some statements are repeatedly wrong or partially wrong. Some are inclusive and go with part of other questions.

Consistency Control.

Attention level is directly and indirectly connected to the consistency. Low concentration may reflect problems in answers` consistency. There are some ways to register it:

1) Similar questions are repeated not only for the attention level reflection, but also for the similarity or dissimilarity in answers. Some questions are masked: part of them appear in other question sections or in slightly different focus, where the main question includes opinion as a prerequisite to answer.

2) Opposite closed directed questions show consistency in a simple way. Incoherent answers are easily detected if opposition is not appearing in the answer.

3) Balance of answers can be more complex, than simple following of the options in opposing questions. Questions about the same topic but in completely different format demand systematic understanding of the described point.

Error Types.

A number of typical errors can appear in surveys (Bethlehem, 2009).

1) The completeness error is more often for the questionnaires, where is possible not to

complete some questions or sections. To eliminate completeness error computer-based surveys are equipped with reminders and tools, which do not allow to move forward before the question or section are completed.

2) Domain error include all types of answers beyond the domain, framed by the question. It is more common with answers on open questions, but also possible in the case of extra options or fluid and not clearly marked answer boundaries. In computer-based questionnaires the problem is partially solved by technology.

3) Consistency error is the situation, when answers clearly contradict each other. There is a possibility to have more than one contradiction, and when one is resolved the other becomes more obvious.

4) Routing error appears, when the respondent fails to follow the routing instruction or skips on it for inattention or similarity reasons. In the branching questionnaires it can lead to the wrong path direction.

III.2.4. Statistical Methods

Statistical methods can be applied for the data, produced by the respondent positions, like age, gender, specialization etc. Normally distributed data is usually analyzed with help of Standard Deviation (SD), σ, or quadratic root of sums of squares of specific data item x_n and arithmetic mean μ, divided by number of measurements n (formula (2)). SD is widely used in a number of analytical formulas, as it will be seen below.

$$\sigma = \sqrt{\frac{\sum(x_n-\mu)^2}{n}} \quad (2),$$

Another area of the analysis is related to responses. Results are often discontinuous, discrete non-parametric data, which lacks normal distribution. Methods used for normally distributed random data are inappropriate in this case. Mean, SD, are not routinely used, as well as methods of normalization. Classical ANOVA, Analysis of Variance is also not suitable.

Most of the extensive questionnaires use scaled questions to apply quantitative analysis. It allows question ranking by the perceived level of importance. An expanded scale also allows statistical analysis by non-parametric order and rank statistical tests. In the case where no normal distribution is expected, standard analysis is replaced by ordinal data analysis methods and descriptive statistics. Inference statistics can be applied for samples, collected from big target groups` sets with the normal distribution of participants regarding all groups. In many cases, Delphi procedure of iterative specialists panel questioning is applied (Haluza and Jungwirth, 2015). A mixture of descriptive statistics, non-parametric statistics and qualitative methods are routinely employed.

Simple Rank Score Test. Student's T-test.

The simple ranking is achieved by dichotomous questions, which can be analyzed with T-test. It also allows simple comparison between two similar groups or sets, but usually used for normalized data. A distribution-free t-test is applied for non-parametric data.

$t = \frac{\mu_1 - \mu_2}{\sigma \times \sqrt{n^{-1}}}$ (3), where *t* is Student's test, μ_1 is one sample mean, μ_1 is second sample mean, *n* is number of values or set size, σ is standard deviation (SD)

A difference is statistically significant when the p-value of the result in the table for certain *n* for given α, usually 0.05 for standard confidence interval 95%. P-value can vary from generally accepted 0.001 to 0.01 and 0.05, depending on the level of demanded accuracy (Sprent and Smeeton, 2016).

Chi-square Test and Likelihood Ratio.

Non-parametric categorical data sets can be compared with help of constructed contingency tables (Sprent and Smeeton, 2016). Number of certain answers or values in two sets are matched in accordance with the formula:

$\chi^2 = \sum \frac{(O-E)^2}{E}$ (4), where χ^2 demonstrates interdependence, *O* is observed value, *E* is expected value. When observed and expected values are close, chi-square is low. This shows the closeness between sets. High chi-square indicates independence of two sets. P-value can be used, if it falls inside or outside of confidence interval.

Likelihood Ratio (LR) is an alternative to the chi-square. LR reflects likelihood of certain value by calculation ratio of probabilities of observed value *p(O)* and expected value *p(E)*. Its calculation is usually recommended for small samples sizes, with *N* less than 30 items. $LR = \frac{p(O)}{p(E)}$(5)

Consistency and Reliability.

Several well-established tests are applied for examination of internal consistency and reliability of the questionnaires. Split-half methods of different complexity are usually employed. Tabled results of the Likert scale responses undergone specific procedures. Cronbach`s Alpha (tau equivalent), Revelle`s beta, McDonald's omega, Guttman's lambda are described below. Test-retest reliability is checked by Cohen's kappa (Sideridis *et al*., 2018).

Cronbach`s Alpha.

Tau-equivalent or Cronbach`s alpha is a measure of covariance between elements of the questions group. This parameter counts "dimensions" of the questionnaire and their interrelation with the help of the covariance matrix. Every respondent result is compared with the entire count of each observation. The higher number of "dimensions" and a stronger correlation between them gives higher results for alpha. Cronbach`s alpha results are considered valid in the range of 0.8-0.9, with variations up and down. Alpha below 0.5-0.65 is considered to be a sign of low reliability, while higher than 0.9 shows redundancy or a high number of "dimensions".

$\alpha = \frac{N\bar{c}}{\bar{v}+(N-1)\bar{c}}$ (6), where N is set power, $\bar{c}$is average covariance for every element, $\bar{v}$ is average variance.

Revelle`s β.

Beta is minimum or lowest split-half type test estimate of internal reliability.

$\beta_{x_1} = \frac{c_{dp_1} - c_{dp_2} \times c_{p_1,p_2}}{1-c_{p_1,p_2}^2}$ (7)**,** where c is correlation/covariance, p_l and p_2 are predictors and d is dependable variable. Beta is supposed to be more conservative estimator, than alpha – the later has tendency to "overshoot".

McDonald's Omega.

Omega as a parameter is similar to alpha. Confirmatory Factor Analysis (CFA) of factor

F for *n* variables X_n are connected by load l_n and influenced by the error e_n.

$\omega = \frac{(\sum l_n)^2}{(\sum l_n)^2 + \left(\sum \sigma_{e_n}\right)^2}$ (8)

The additional level of factor analysis is added. The covariance matrix of results is obliquely rotated and then so-called Schmid-Leiman or S-L second transform is performed.

$C_m \approx \sum(FSS^T + D_m^2)$ (9) where C_m is square $p \times p$ correlation matrix, *F* is factors matrix $n \times n$, *S* is $n \times p$matrix, $D_m^2$is $n \times n$diagonal matrix. *F* is transformed to create F_m second-order correlation matrix.

McDonald's omega is supposed to be a more reliable coefficient than Cronbach`s alpha. Levels of 0.7-0.95 show reliability of the results.

Guttman's λ2.

Coefficient lambda is similar to alpha and tau-equivalent of reliability. It comes in several grades, starting from lambda 1. The difference is that for alpha is used more random algorithm, while lambda has a lower level of randomness. Covariance between sums of items and average variances are included into the formula:

$\lambda_2 = \left(1 - \frac{\sum C_i}{C_x}\right) + \sqrt{\left(\frac{n \times \sum \sum C_i^2,j}{C_x^2}\right)}$ (10), where $C_i^2,j$is covariance between results.

Lambda can be employed for more complex tasks. Lambda is usually higher than Cronbach's alpha. Values for reliable test are 0.8-0.95.

Correlation. Non-Parametric Methods.

There is a significant difference between parametric and non-parametric analysis. While parametric data is usually structured, with known equal steps between points, for example, kilograms, meters, seconds etc, non-parametric data consist of categories with less structured measurement scales. Usual statistical analysis is based on mean, variance, standard deviation, analysis of probability distribution and ANOVA, analysis of variance. Parametric methods often consider continuous data.

Non-parametric data does not have a usual tendency for normal distribution and often discrete ranks. Nominal data is presented by nominal categories, while ordered data is also scaled. In non-parametric methods, most important measurements are mode, median, quartiles and interquartile range (IQR) (Sprent and Smeeton, 2016). Sets of data can be compared between each other to trace independent or common sources of results (Kvam and Vidakovic, 2007).

Mann-Whitney-Wilcoxon Test.

Mann-Whitney-Wilcoxon (MWW) Test checks the equality of two ordinal sets of data. Sets can be of unequal size. MWW test calculates "unbiased" U parameter. It checks the equality of distribution and the supposed independence of sets.

$U = N_x N_y + N_x \frac{(N_x+1)}{2} - \sum R_x$ (11), where $N_x$is set X, $N_y$is set Y and R is the sum of ranks.

Precision of the test is lower with significant difference between sets there is a possibility for type II error in this case.

Wilcoxon Signed Rank Test.

This test is similar to MWW test. The test is used to compare two paired sets of ordinal data. Both sets have to be of the same size. It checks two dependent sets. Signed Rank (SR):

$SR = \sum_1^n R - \mu$ (12), where $\mu_{SR} = n \frac{(n+1)}{4}$ (13) then $\sigma_{SR} = \sqrt{\frac{n(n+1)(2n+1)}{24} - \frac{\sum T_n - \sum T}{48}}$(14), where T is number of occurrences for the value.

Kruskal–Wallis Test.

K-W test or one-way rank analysis of variance (ANOVA), calculates *H* parameter to test mutual dependency of data sets. KW test is designed for two or more sets. The size of data sets can be unequal, because the calculation does not involve paired comparison.

$H = \frac{12}{n(n+1)} \sum_{x=1}^{m} \frac{R_x^2}{n_x} - 3(n+1)$ (15), where *n* is certain data set power, *m* is number of groups, R_x is rank of x and x is number of the data set.

Two or more samples are compared. Big differences between sets can cause type I error, giving false positive results.

Spearman's Rho.

Spearman's Rho correlation coefficient is a rank analogue of Pearson coefficient. When Pearson coefficient is applied for continuous data, Spearman's Rho can be used for non-parametric ordinal data. Two sets of the same size, for example answers on two questions, are compared pairwise.

$\rho = 1 - \frac{6 \times \sum (R_x - R_y)^2}{n(n^2+1)}$ (16), where n is number of results.

Q-Q and P-P Plots.

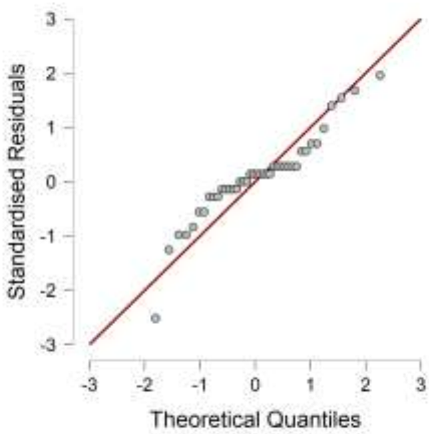

Figure 5: Q-Q plot. Example from the current work.

Interpretation: The relationship of the theoretical distribution and obtained data on the shown graph is linear

Quantile-Quantile plot allows analysis of data against theoretical normal distribution (Goss-Sampson, 2019). Any shift of the plot dots from the theoretical line shows a type of real data distribution (Figure 4). An assumption for the data set in this case under scrutiny is normality distribution or presumed non-normality. The variant of Q-Q plot is Probability-Probability plot, when two set probabilities are compared in similar manner.

Vovk-Sellke maximum p-ratio.

The p-value is not always linear for all continuity. There is non-linear probability distribution. Depending on the relationship of distribution for hypothesis 1 there is a possibility, when p-value is higher or lower than the expected value but still reliable.

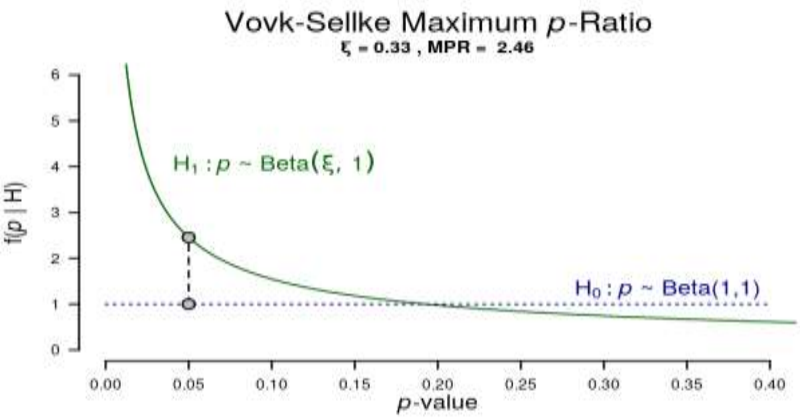

Figure 6: Vovk-Sellke Maximum p-value Ratio. Adopted from https://www.shinyapps.org

Interpretation: when p-value goes up, ratio non-linear goes down, and critical value is seen around 0.20.

Statistical Analysis Software.

The statistical analysis can be performed manually or with help of suitable software. There is a long list of other general and specialized statistical programs and online tools, suitable for specific types of research and projects. While Excel allows certain statistical operations, the R-language package is much more versatile. Programs like Jasp and Jamovi are front-end for R-language. Other popular statistical programs are proprietary SPSS from IBM, Matlab from Mathworks and GNU-licensed PSPP and Octave.

Qualitative Analysis.

Most of the longitudinal biostatistical reviews, such as Cochrane reviews, prefers quantitative data over qualitative. While qualitative questions can be to some extent arbitrary, the qualitative approach tends to minimize less rational, less controlled part of the studies, they also provide concrete numbers and statistical analytic to stick to.

However, the value of quantitative studies compared to the more qualitative path is, to some extent, exaggerated. The categories itself, even with scaling questions, are more qualitative than quantitative, Hence, the qualitative analysis is supposed to be not less important, than a quantitative and statistical one. At the end of the day, researches are constrained by the dual quantitative-qualitative nature of the data.

There are similar problems, as in any questionnaire or survey, where the significant part is played by the panel of those, providing their opinions. Besides recruiting the panelists, there is more focus on the categories, under which the interview is provided. The strictly statistical part is applied for the panelists` data in order to establish the most appropriate groups of respondents. But the categorical division of the questionnaires into parts, number and character of questions, form the questions, which gives the best way to answer open, semi-open or prompted questions with less than definite answers, put rigorous, but discussible frames on the questionnaires and surveys (Mayring, 2014).

There are several methods employed in qualitative questionnaire construction and its analysis. Question type and structure, its explicitness or implicitness, with or without implication. Contextual analysis can be applied for one question, group of questions or the whole survey. Reliability of the test does not imply validity. Validity is often a result of general qualitative analysis.

Qualitative analysis, especially made by an expert panel, is regarded as a high standard for the industry and bears a significant value tag (Haluza and Jungwirth, 2015) . Different panel answers can be weighed against each other (Siegel *et al.*, 2014). Moreover, a mixture of the qualitative and quantitative survey is often the best standard (Singh *et al.*, 2017).

The significant part of qualitative analysis depends on the paradigm web of fundamental axiomatic “beliefs” in terms of Duhem and Quain (DeWitt, 2018). Central hypothesis often depends on several “lesser” hypotheses, non-obvious at the time of direct approach. Ability to find these hypotheses can be crucial for the whole paradigm web.

III.3. Summary and Analysis

Demographic change in most of the population of developed and significant numbers of developing countries has a longer active life. At the same time, prolonged years of living create a situation, when the number and percentage of chronic health conditions will be higher than before. Advances in medical prophylaxis and treatment increase the level of survival for previously untreatable or serious conditions. Those, in turn, caused a significant growth of demand for long term treatment. Hospital and institutional care became more expensive in terms of quantity of patients and complexity of medical treatment methods employed today. Massive institutionalization also makes a notable impact on the social aspects of life for patients and society as a whole.

The alternative of home-based healthcare was proposed more than thirty years ago. Development of technical methods for data collection, communication and automatic reporting made it possible to create an AAL home environment for patients of advanced age with many chronic health conditions. One of the widespread illnesses is MCI, or MND. Successful application of AAL for groups of these disorders can be beneficial and will bring solutions for most of the associated problems.

AAL system requires extensive planning and evaluation. The conceptual stage requires assessment of the patient's needs, made with help of questionnaires for primary and secondary end-users. The approach for professional caregivers is formalized with help of instruments such as WHOQOL. The next stage is the creation of the model. The model is tested with scenarios, personas and technical evaluation: data flow, storage and backup. Model is physically embodied in the prototype. The prototype is often laboratory or equipped residential property. Actors or specially chosen patients are spending time in the living laboratory with scenarios or “normal” tasks providing measurement and architecture testing. At the same time and later more wide impact assessment is done. There are three main approaches: Re-AIM; MAST; UTAUT.

A significant part of the assessment for AAL is the questionnaire. It is used for all stakeholders on every stage of AAL evaluation. I can be a general acceptance measurement tool, specialized survey for professional stakeholders, Delphi procedure with stages or platform for the interaction between all stakeholders. Respondent's groups choice and sampling follow well-developed procedures. The questionnaire adheres to several rules for general composition and internal structures. For example, there is a recommendation to group questions on similar topics in sections. There are requirements for the design: the way explanations are given, for the wording of questions. Words have to be familiar, with neutral connotations. Questions have to be short enough, without ambiguity and negative forms, if possible. Better to avoid loaded questions, recall questions, leading, sensitive questions and questions about unknown topics without appropriate explanation.

Types of questions are also a matter of design and influence results. Open questions give more freedom, while binary choice, MCQs or scaled questions provide options for specific answers. MCQ is more strict, matrix questions are less restrictive when scaled questions can be quite sensitive in measurements with scales higher than seven points. The grouping of question types and very similar questions is also important. High similarity can lead to the “drag effect” when questions are not read properly or opinion about previous questions is transferred to the following ones. The same effect can appear for the sections. An appropriate order and smooth transition between sections are important. The strengths of these phenomenons also depend on the informational load and attention level. The common advice is to shift the complex part from the start. For longer questionnaires, the overall attention curve is considered, as well as question rout control.

Several ways exist to control attention, validity and consistency of the questionnaires. Validity and consistency are checked by experimental runs for small groups and by expert opinion, often on the basis of already on the basis of obtained information from the respondent's groups. Expert advice is frequently checked with help of MMTM. Typical errors to find out are: completeness error, domain error, consistency error and rout error. To avoid completeness error reminders are set in the computer-aided surveys. Domain error is lessened by avoidance of questions outside of the knowledge domain or with blurry answer boundaries. Consistency and routing errors require control.

Attention and understanding levels are evaluated with help of randomly spread control and “trap” questions. Sometimes the question is repeated in a slightly different form to evaluate the consistency of the answer. The question can be reformulated to take a negative form or be used in the different types of questions, matrix or scaled one with the ability to compare scores. The other instrument of attention control is a comparison of answers with instructions given before the question. Directed or intentionally “loaded” questions require an active position to avoid “drag”. The more complex balance of answers is analyzed with help of statistical methods.

Results are analyzed with the help of qualitative and quantitative tools. Consistency is measured with help of Cronbach`s alpha, Revelle`s beta, McDonald's omega and Guttman's lambda. Descriptive and comparative statistics use standard tools. Descriptive statistics apply methods with mean mode, median, standard deviation calculations, distributive analysis and quartiles. Matrix questions are evaluated with help of chi-square and Likelihood ratio. Scaled questions are often given non-parametric results without a normal type of distribution. Non-parametric tests are required for the analysis and comparison. The most employed tests are Mann-Whitney-Wilcoxon, Kruskal-Wallis and Spearman's rho. They can be applied for the comparative groups' analysis or, as Spearman's rho, for paired questions comparison. Significance in non-parametric is reflected by p-value, which is not linearly distributed and could be checked by Vovk-Sellke maximum p-ratio.

All analytical information can be presented in the form of numbers and reflected in the graphs. There is a difference in the perception of symbols and digits and for illustrative graphical information. The combination of both approaches guarantees an exhaustive examination of results.

"Measure what is measurable, and make measurable what is not so."

Galileo Galilei

"When you can measure what you are speaking about, and express it in numbers, you know something about it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts advanced to the stage of science."

William Thomson, 1st Baron Kelvin

Chapter IV: Research Preparation.

IV.1. Methodology

Research Goals.

MCI is a condition, which in most cases does not require hospitalization or institutionalization. Home-based MCI patients usually manage with home chores with some help from relatives or social and medical workers. AAL system for MCI patients can alleviate pressure on patients, families, social and healthcare systems. While elements of such a system are successfully implemented, there is no full-fledged AAL system for MCI patients. Moreover, any AAL system has general and specific elements. It is necessary to envisage common elements and specialized elements in AAL for MCI patients. AAL system design is a fundamental question, which can be divided into sub-questions:

1 The necessity of AAL system for the healthcare;
2 The place of the AAL system in the healthcare system today and in future;
3 The ability of the AAL system to provide basic healthcare functions;
4 The ability of the AAL system to provide an extensive range of functions;
5 Main design elements of AAL: computational devices, sensors, software, as seen by the healthcare specialists;
6 The capability of the AAL system to provide assistance for patients with MCI;
7 Main design features of the AAL system for patients with MCI;
8 Feasibility of AAL system for patients with MCI in contemporary healthcare.

Current research is focused on the preliminary conceptual model of AAL for MCI patients. It also considers more general questions as an unavoidable part of any AAL design and implementation.

Null Hypotheses.

The main null hypothesis could sound as: “AAL system for MCI patients is not necessary”. The reasons for such statement are: low effectiveness of the system, technical, financial, administrative or other obstacles for implementation. There is, however, the necessity to divide the null hypothesis into several categories, which produce the list of interconnected null hypotheses.

Null hypotheses, H0x, for every research question will be as follows:

H01. AAL is not necessary in the healthcare.

H02. The place of AAL is negligent and will remain so in future.

H03. AAL is unable to provide basic healthcare functions.

H04. AAL is not extendable and cannot provide extensive range of functions.

H05. Healthcare specialists cannot advice on rational design of AAL as a system or in detail.

H06. AAL system is incapable to provide assistance for the MCI patients.

H07. There are no significant features in special AAL system for MCI patients.

H08. AAL system for MCI patients is not feasible in contemporary healthcare.

Method.

Medical and social requirements for the AAL are formulated on the conceptual stage. There are several ways to find answers, theoretical and practical. Any route gives only partial vision. The needs of caretakers and healthcare stakeholders are collected by questionnaires and expert suggestions. The process can be iterative, mixed and include detailed recommendations. The best approach is to try to encompass all these raised problems in one research to weight and compare information between sub-questions. In the conditions of limited research complex questionnaire for healthcare stakeholders is the easiest way to obtain necessary preliminary answers. Web-based questionnaire is easy to deliver worldwide. In current research Google Forms-based questionnaire was used.

Respondent's Group.

The AAL system design has to be based on the opinion of the main stakeholders: healthcare professionals, technical stakeholders, administrative stakeholders and patients. Every opinion group is important, and the opinion has to be assessed appropriately.

Healthcare professionals represent a specific cross-section of society with a skilled understanding of patient's needs in specific conditions. Years of focused training and practice give a wealth of information about the needs and problems of home-based patients. Still, there is a range of possible opinions, dictated by the professional view, personal experience and wide scope of technical, social and organizational knowledge.

This study is based on a complex questionnaire. The questionnaire is presented to the healthcare workers, mainly medical doctors. In order to achieve the best possible combination, heterogeneous groups of medical professionals from different countries are included. In order to obtain as much and as wide information as possible and to keep the sample big enough despite complexity of the questionnaire all specialists with finished medical education or clinical psychology diploma were considered.

The respondents were reached via web of personal contacts and with help of social media. The main reason was to eliminate subjective element of self-report about profession and professional experience.

Principles.

There are several principles used in the questionnaire.

1 Online responses collection. The questionnaire was designed before COVID-19 pandemic, and it was planned to be international with the help of technical tools. In this case – Google Forms. The start of the pandemic made online responses only the way to answer.

2 Voluntary participation. There is a small probability to obtain answers, “expected” by the interviewers from the formed group of respondents, but the problem is solved by questionnaire design, relevant number of participants and statistical analysis of results.

3 Anonymity. Every respondent gave only the name of the medical profession, information about the medical and technical experience. There is a justified interest in obtaining data about the age, gender, country of the current residence of the respondent and country of education for future analysis. But rules of anonymity restricted available data. On the other hand, it helped respondents to give answers in a free, open manner. Emails were not collected, which made response control slightly less strict. However, the complex nature of the questionnaire made it much less attractive for the “fiddled” responses. There was no initiative to fill it in the name of the other person, and anonymity demonstrated “fair” intentions of the questioning side.

4 The full, extensive explanation was given at every step. Type, scope and goal of the research was explained. Instructions about possible spent time were given – 25-30 minutes to mark all answers. While it is the normal prerequisite for the questionnaire to be explained in an exhaustive manner, there are some additional cautions, which make explanations longer and more elaborated. The technologies used in AAL are quite novel and require detailed description for the novice as well as for more informed respondents. There are understandable limits for the lengths of possible comments. The explanation, perceived as too long and too complicated will potentially limit the number of respondents. Those, who see the response to such a questionnaire as a difficult task for reasons of being less technically proficient, overloaded with work or other chores, concerned about spent time or considering the topic as not more than a fancy exercise, would refuse to share their opinion. This can be an advantage of the sort, as in the case of the questionnaire complexity. Only willing, able and motivated respondents would answer them.

The complex structure is intentional. It covers more than one area of interest in one questionnaire and gives an opportunity for the complex analysis. Another reason is mentioned above: composite nature is filtering responses from less motivated and less focused respondents.

Lines of Investigation.

Lines of investigation are built in accordance with research questions and hypotheses. There are important points, which appear in main areas and thematic blocks, but consist of two or more correlated issues. Every point can be expressed as an intersection of two areas.

Medical areas of emergency reporting by AAL system, of continuous diagnostic and support, and specific topics of MCI intersect with technical issues. Another area open for investigation is personal knowledge and experience. There are possible correlations between medical knowledge and experience, IT knowledge and experience and vision of the AAL system in every medical and technical aspect.

Theoretically, there are multiple points, where groups of correlations will show consistency and interdependence. In practice, with an abundance of data, it will be enough to demonstrate the main axes and critical correlations, which connects it.

Results and Analysis.

Data is obtained from answers to multiple-choice questions, matrix questions and scaled item-by-item questions. Healthcare and IT experience is projected on questions about medical aspects of technology implementation. Results are assessed with the help of descriptive and analytical statistics. Google Forms provide not only an easy way for questionnaire implementation but also a preliminary analytical structure. Numerical data and percentages are presented for scales and frequency tables, graphs and histograms provide visual information. All data can be extracted as an XML file. Excel and analytical software help to analyze data. JASP package is used for data analysis.

Technical Aspects.

Google Forms is a convenient tool, with the ability to build a questionnaire and deliver it to the respondent. The completed form reports with a time stamp on it. there are specific points to address. First, an extensive questionnaire has to be loaded appropriately. It depends on the computer device, used by the respondent, internet speed, internet stream stability, type of browser, CPU load and other technical factors. Another limitation comes from the specific way questions can be designed. The variety of used questions is discussed below, but one specific point actually could influence the result. Tables can be answered only in a horizontal manner: every question in the table occupies a horizontal row, while options are placed in the column. When there are too many columns relatively to the questions, there is a natural tendency to switch rows with columns and place questions vertically. In this capacity the question works also as an attention control tool.

IV.2. Questionnaire Structure and Content.

The questionnaire was planned and constructed to allow qualitative and quantitative analysis. General guidelines for questionnaires recommend following a number of rules. The straightforward idea was to make the questionnaire clear, simple, easy to use and as short as practically reasonable. On the other hand, there is a necessity to obtain as much information as possible in more than one area. These, sometimes conflicting requirements, make the task less trivial than it is supposed to be from the first glance.

Medical knowledge and experience have to be placed in a technological framework. This requires medical questions and technical questions often to be combined together. Medical ones include general and emergency medicine topics, and MCI discussion as well. There are also important questions about the privacy of MCI patients, psychological aspects for relatives of MCI patients, administrative and financial questions. All of them come on the background of healthcare and technology requirements.

IV2.1. Questionnaire Design.

The questionnaire has a composite structure, which works as one system. This structure is important not only from the formal point of view but as working details of the complex instrument. The number of the parts, size of parts, the relationship between them, the order in which they are placed – everything is significant and may affect results.

There were several choices of design: simple ones and their combinations. Direct and simple design requires a similar type of questions for all areas of interest. The complex design depends upon a significant level of internal balance but gives robustness in data collection and allows more combinative analysis. The complex variant was chosen in current research for these abilities to extract voluminous and multi-structured data. In this case, the survey is a mixture of the expert preliminary report and classical questionnaire.

Thematic Blocks.

Thematic blocks encompass main areas but have a specific structure. The first block is about personal knowledge and experience. The second block is about personal opinion about the place of AAL in a healthcare system, medical education and personal prognosis about time and appropriately the implementation of AAL.

The third block asks general questions about the role of AAL in general and emergency medicine for home-based patients. This is a prerequisite for the massive fourth block, which asks questions about technical areas of AAL and the role of each main aspect, such as computing devices, sensors, network and software in the AAL. Medical projection on technical issues makes it easier to imagine the system and allows to mentally design every part of the system without going deep into technical issues. The questions of this block are relatively unfamiliar for many respondents, and for this reason, it had been placed in the middle, before the fifth block. The fifth one is about implementing the AAL system and its parts for the MCI patients. And the sixth block includes parts about privacy, psychology, relatives, administrative and financial questions. For the reason for shortening the questionnaire, these questions are kept short and simple.

Sections.

Structural elements include sections and their internal organization: parts of sections and specific groups of questions. Types of questions are important, as well as questions` flow. The list of sections is as follows.

1 Explanation and agreement

2 Personal information: profession, medical experience, experience with MCI patients

3 IT technologies experience

4 AAL implementation. General medical questions, present and future roles of AAL

in the healthcare system

5 Technical questions. Computing devices for AAL, sensors in AAL, smart devices in AAL, network, software. All questions are devised as 2D tables, allowing multiple answers

6 AAL solutions for patients with MCI.

7 Diagnostic soft requirements in the AAL system for patients with MCI.

8 Smart devices and software in the AAL system for patients with MCI

9 Sensors in the AAL system for patients with MCI.

10 Computing devices in AAL system for patients with MCI.

11 ADL and IADL.

12 Privacy of the patient with MCI in a home equipped with the AAL system.

13 Acceptance of the AAL system by patients with MCI and their relatives.

14 AAL system for patients with MCI. Administrative and financial questions.

15 An opinion about AAL for MCI patients.

The section 15 is an open directed question: “Reflect your opinion about Ambient A for patients with MC. “In my opinion, the AAL system for patients with MCI...”

Metrics.

The questionnaire is presented the first time and formulated for conceptual planning. These issues make metrics not easily manageable. While age is easy to measure, the medical profession, level of healthcare and IT experience are less measurable and more subjective. The international nature of the survey and limited abilities to recruit a significant number of participants restrict the possibility to use extensive evaluation and statistical tools. The main approach is a 10-point Likert scale, partially balanced by comparative analysis between questions and groups formed on the basis of profession and experience. Frequency tables, formed by answers on matrix questions also add a possible dimension for the comparison. The complex nature of the questionnaire allows several types of comparisons to be made. Further development of the method will allow more objective and measurable items to be included in the questionnaire.

IV.2.2. Questions.

Several types of questions are used in the questionnaire: simple directed closed item-by-item questions, multiple choice questions, matrix questions and open-end directed question. The type of the question used depends on the place in the questionnaire, type of the section, section flow and question flow between sections. Many questions are coupled or united by the line of investigation. Some questions double as a question and a control tool.

Every question has an instruction. General instructions and information for sections and groups of questions are given before it. Instructions for the question can be part of the question itself. Some instructions work as an attention measurement tool.

Types of Questions.

MCQs are used in the personal experience section. Some have one given option for an answer, others have more than one. Matrix questions are used in the technical section for reasons of compactness. There are matrix questions with one possible answer per line and several answers per line.

The main part of the questionnaire is formed by simple direct closed questions with a 10-point Likert scale. They are easy to comprehend and to answer. The ten-point scale allows some freedom of choice for the opinion if compared to shorter scales. The odd-number scale has a propensity to answer questions on the less familiar topics with the middle position. Even number partially eliminates this issue. However, there is still a tendency to treat number 5 as the middle point for the 10-point scale, while the real middle is at 5.5.

The last question in the questionnaire is open-ended with given direction in the incomplete phrase.

Form of Questions.

Most of the questions are direct statements with a closed end. When a scale or options are available it gives a clear way for the opinion. The less direct way to ask questions will end with a more extensive and nuanced version of the questionnaire. In some key points, several statements are available. One of the points is made in section 5, questions, A, B, C, D, E, F:

A) AAL system is the best solution for MCI patients;

B) AAL system is a good addition to the existing healthcare solutions for patients with MCI;

C) AAL system is helpful only for some patients with MCI;

D) AAL system is inconvenient for MCI patients;

E) AAL system is too complicated to be used for patients with MCI;

F) AAL system can help patients with dementia, not with MCI.

Besides personal statements, all questions are a projection of the professional opinion. Medical terms are used with compendium healthcare education and practice in mind. There are no complicated issues, not known to the respondents. MCI is explained in basic terms for those who have limited experience in everyday work. All technical questions have an explanation in advance as well.

Questions` Flow.

Questions on the same or close topic are united in one block, one section or part of the section. They are listed in such a manner, that the next question will be seen as a next step for the previous one or logical part of the group. Question flow between sections was also considered. The type of questions and form of questions also depend on the section and group to make it easier for the respondent to follow items in the questionnaire. Every question has reminder about the necessity to complete it.

Questions go from the personal statement about the medical profession and IT experience towards the projection of experience on general AAL issues, technical AAL issues and specific questions about the AAL system for MCI patients. The final part is dedicated to the non-medical and non-technical topics with an option for the general opinion about AAL for MCI patients.

Questions` Webs.

There is a necessity to organize questions in a more complex manner than simply applying order and flow measures. Some questions are repeating previous ones and are placed as familiar partial repetition for reasons of comparison and control. Questions can be in the same section or, often, in different sections. Some similar o repeated questions help to measure correlation and similarities, dissimilarities in the case of specific reasons of the topic, respondent's experience or drag by the previous questions. In more simple cases questions are with scale, while in more complex cases it also can be an element of matrix question.

For example, the question I) in section 3 is partially connected to the question L) in the same section:

I) AAL system can signal about psychiatric emergency;

L) AAL system is helpful in a chronic neuropsychiatric condition

At the same time these questions are part of the web of close questions in section 5 (A, B, C, D, E, F), section 6, questions in sections 7 and 8, section 10. All questions are asked about problems in psychiatry and special matters in the case of MCI and dementia patients. Similar question groups are made for topics in general medicine and about technical aspects. Some answers in these groups can be directly compared for correlation, others can show the tendency and direction.

Control.

Special measures are made for the control of attention, consistency and ability of the respondent to implement information from the descriptive instructions. Questions are repeated in some form, sometimes statements with an opposite meaning (scale) are used to extract more exact opinions. For one matrix question table is inverted, with columns and rows replacing each other, if to compare it to other matrix questions in the section. Paired control questions can be part of the groups for the specific topic. In this way potentially consistency can be measured for the topic or line of investigation.

IV.2.3. Sequencing Sections.

A significant part of the current questionnaire structure depends on the order of sections and internal build of every section. There is a necessity to present information in order of complexity and informational load. The other reason is to build relationships and hierarchy between topics. Structure appears before the respondent step by step. There are several reasons for the order: thematic, informational, logical, psychological and special. Information has to be not only obtained from the respondent, but also given in some sequence. It is a "natural" vision of the order by the interviewee. Psychological order requires taking into account concentration, emotions, sustainable "rapport" with questionnaire. Specific reasons relate to attention, consistency and concentration registration instruments. Sections flow goes from personal statements, which frame the future answers, through the general section, technical section, MCI sections towards the privacy, administration and financial questions. The load intensity is represented by the diagram: Figure 7

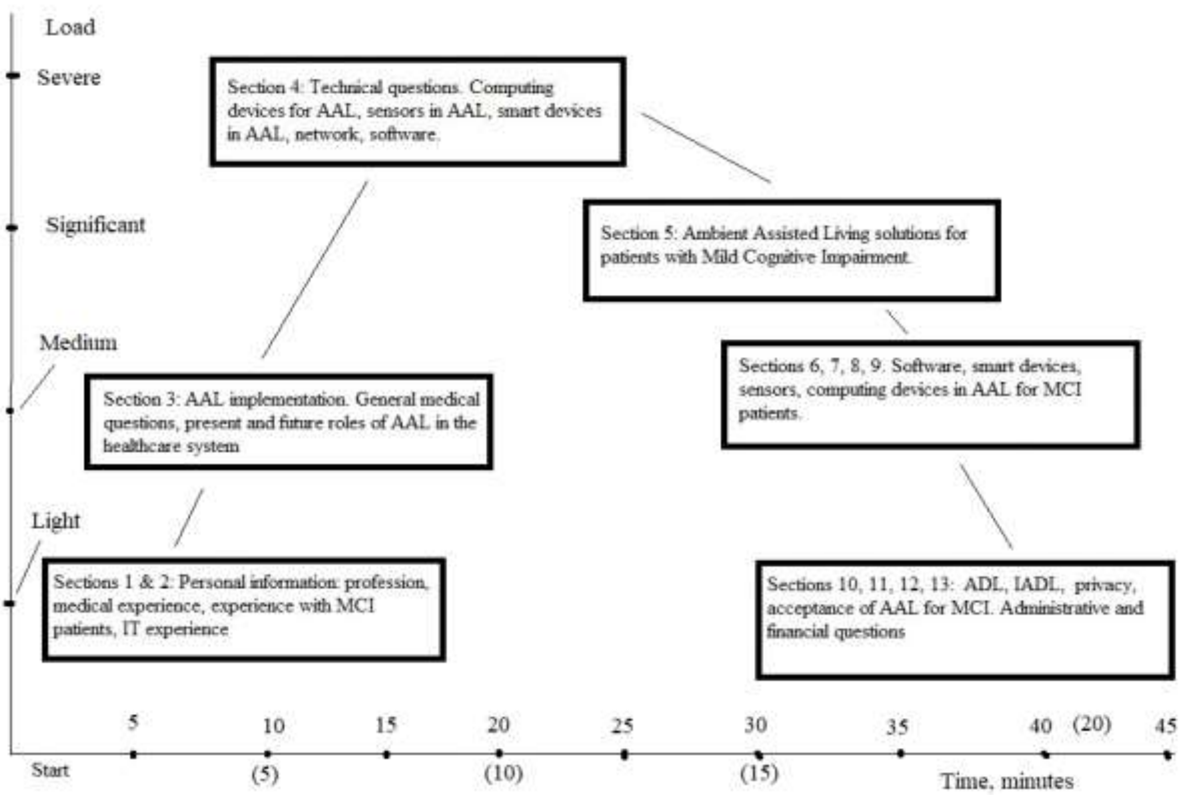

Figure 7: Questionnaire sections` flow and load

Interpretation: The load starts from the low position, grows quickly in the first half, achieving pick before the middle. Then the load gradually goes down, giving possibility for successful filling. There are two time limits lower, in brackets, and upper. The lower time spent on the questionnaire was reported or shown by no less than third of respondents, as well as the upper limit. An average time was 30-35 minutes.

Sections` Flow.

After the introduction explanatory section about the nature of research and the instruction come personal sections. They ask about medical and IT experience and help to build future lines of correlation. Personal sections are psychologically important and appear before other sections.

The next section has an informational preamble about the AAL system and its parts. Then follow scaled questions, the mixture of general and emergency medical questions in regard to AAL system effectiveness and its role in the healthcare system.

More technical questions are concentrated in one big section. Every table questions` part has a preliminary explanatory unit. Tabled questions ask opinions about the place and composition of hardware, sensors and software from the point of view of a medical specialist. This section is quite hard for the respondent, and appears relatively early.

It is important to inform the interviewee about technical details and to collect answers to these questions before one will feel too tired to do it. The next several sections are in fact extended repetitions of the same “technical” questions, but as specific ones for the AAL system for patients with MCI. It is simpler to work with, because of easiness to comprehend scaled questions and iteration of the same topics with slight turns and some additions. The final sections are non-technical and non-medical. A general open question, asking the opinion of the respondent about the AAL system for MCI patients is the last one. It finalizes the questionnaire. The respondent is already informed enough to form an opinion.

Every section has a reminder if one or more questions in it are not completed. Every section appears on separate page.

Relationship Between Sections.

Question flow is important not only inside of sections, but between them as well. Topics of neighboring sections are closely related, and there is a logical connection between them.

An order also includes an end-start relationship, when the last questions of the previous section, especially in blocks, have some sort of internal perceptual proximity to the starting questions of the next section. As was mentioned, some sections go together in one block, and others have axial closeness due to the discussion topics. These topics connect some parts of the questionnaire. There are several reasons for it. General AAL sections and MCI sections are naturally interrelated, and many aspects are shared. In addition, repetition of some themes in direct or slightly disguise form help to calibrate answers, check consistency, create the lines of correlative comparisons and evaluate specific opinions while question is asked in different block “environment”. Repetition of similar questions is expected to be seen by the respondent as more formal than metrical issue. To create more sensitive approach, some questions have opposite scales or give a space for more than one type of answer. Graduated by the level of categorical statement, they give more possibility for the opinion reflection.

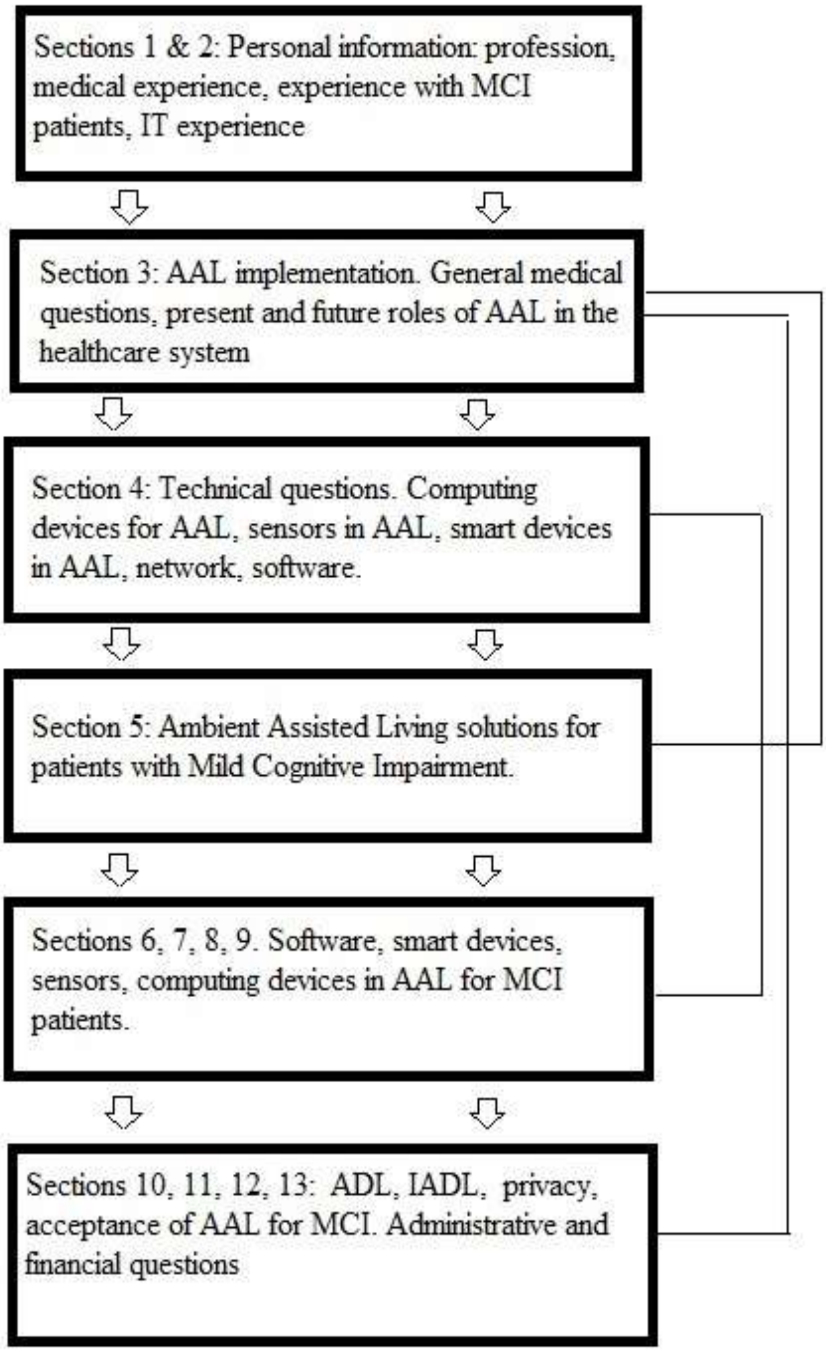

Figure 8: Relationship between sections of questionnaire

Interpretation: scheme shows sections` flow and relationship between sections in the questionnaire.

Specific loop is created, when the questionnaire starts with a personal section and ends with an open question, asking general opinion about AAL system.

Internal Order.

Every section has its own internal arrangement logic. There are some common rules. Sufficient information is given before. Then, questions start from general ones and afterwards focus on some particular points. Complicated questions tend to be at the start or in the first half to keep concentration in the new section. It also depends on the place of the section and topic itself.

The questionnaire has a more developed structure. First quarter is relatively simple, with a steep introduction towards the technical tabled questions. More loaded themes are in the second quarter of the questionnaire. In the third quarter questions tend to be on a “plateau”, with relatively smooth difficulty spread in the sections. Towards the end of the questionnaire sections are shorter, with more independent questions in a stand-alone manner. It might be the same weight for every question in the section, but they raise different points.

Generally, most of the sections are usually finished by the less difficult and easily answered questions. The rule is not applied only in the sections with table questions.

It will be discussed in more detail below.

Size of Sections.

It is a general recommendation to keep similar size of sections. When it works well for homogeneous questionnaires, the rule can be challenged in the case of complex ones.

The size depends on several parameters: importance of the topic, the place in the questionnaire, psychological ability of an average respondent to productively concentrate on the best possible answer. There is influence of previous and next sections on each other. For these reasons personal sections are small and easy to answer. The next section is bigger. It is informative and has questions about the place of AAL in healthcare. The biggest section is the following one, with extensive technical explanations and table questions. All the successive sections about MCI are relatively similar in size, with gradient going down towards the end, where some sections have no more than three questions.

IV.2.4. Questionnaire: Structure and Content.

Several aspects of the questionnaire structure require additional level of explanation.

Information About the Respondent.

Anonymity was recognized as one of the important elements of the questionnaire. Yet there was a necessity to obtain some information about respondents. One of the most important reasons – to build an opportunity for the future correlations between personal knowledge, experience and other answers.

1 The medical profession in the diploma, current medical position or further qualification document were mentioned. There was no place for the detailed questioning about the year of the qualification and years of experience for the necessity to keep the initial part shorter. The complexity and the length of other sections required the balance, especially at initial steps. There were respondents with more than one medical qualification, sometimes as distant as operating theater and laboratory, and the respondent mentioned only later one. But the medical experience was asked in other questions and was reflected there.

2 Area of medical experience included options for hospital, clinical and non-clinical positions, non-hospital family or district visiting healthcare, ambulance service, medical research, public medicine and option for another type of work or experience. Multiple choice questions allowed more than one answer.

3 "Most often contact with a patient" question requires information about the main mode of communication: personal clinical, personal technical (X-ray, ultrasound etc.), indirect (laboratory), administrative, direct or indirect and option with no contact at all. Type of professional practice is important for analysis.

4 Personal experience with patients, diagnosed with MCI or dementia. Options are: part of the medical routine, experience with institutionalized patients, experience with home-based patients, experience outside of medical duties, rare contact or no contact whatsoever. More than one answer is possible.

5 IT, computer or smartphone skills. Options in the MCQ were: professional, semi-professional, advanced IT user, normal IT user, occasional IT user and rare IT user.

Personal knowledge of elements of AAL was moved to the next section. An explanation is below.

General AAL Questions.

The reason for placement of this section was to separate two blocks, to focus the attentiveness of respondents. There was no previous explanation about the main elements of the AAL system in this section. Respondents were instructed to answer questions without the help of external sources of information. This section measured the level of previous knowledge about the subject.

1 Telemedicine. Practical and theoretical knowledge. This exact order is important. Theoretical knowledge is more formal and often depends on the year of obtaining the qualification, even though it was mentioned repeatedly in some form for decades. Biometry in space medicine or other types of biometry or telemetry were usually mentioned as a highly specialized area and could be easily forgotten. Practical knowledge usually is more recent, and better remembered. Options for practical use are: every day, periodic (1-4 times a month), occasional (1-2 times a year), never. Learning about telemedicine: recently (1-3 years ago), some time ago (3-9 years ago), a long time ago (more than 10 years ago), never.

2 Smart home. Four options: good theoretical and practical knowledge; familiar with a concept; heard about it, but not much; never heard about it.

3 Internet of Things. Four options: good theoretical and practical knowledge; familiar with a concept; heard about it, but not much; never heard about it.

4 AAL. There were two questions, about theoretical and practical knowledge. Here the order is “natural”. AAL is a quite recent development and theory is close in time to practical experience. Learning about the AAL system: recently (1-3 years ago), some time ago (3-9 years ago), a long time ago (more than 10 years ago), never. Options for practical use: every day, periodic (1-4 times a month),

occasional (1-2 times a year), never.

AAL. Technical Sections.

The most important questions were presented in the technical sections. For the necessity of keeping a balance between technical and medical aspects, which is important for the respondents, technical information at the same time goes in groups and spreads across sections.

In the section “AAL implementation” an explanation about the system is given with descriptions of elements. Since the respondent is informed, they are questioned about the vision of the role of AAL system. Scaled questions examine an opinion about the ability of AAL to solve problems of healthcare for home-based patients in situations of medical emergencies and chronic diseases. Somatic and mental problems were considered.

Scaled questions are followed by two tables. These tables allow one answer per row per column. Questions are grouped around the topic of the place the AAL system would take in the healthcare system today and in the projected future.

The most significant technical part is named explicitly: “Technical questions”. It consists of several tables of questions with multiple options and the possibility to mark more than one option. Before every table or group of tables, an explanation is given in the way, which allows any respondent to use this information guide to answer questions if it is necessary.

There are two tables with questions about computing devices, one table on sensors, one on smart devices, one on networks and one about medical software.

Technical questions are also asked in four sections about AAL for MCI patients: AAL diagnostic soft requirements for MCI patients, smart devices and software in AAL for MCI patients, sensors in AAL system for MCI patients, computing devices in AAL for MCI patients. These questions are scaled. They also allow comparison with results of tables.

AAL. General Medicine Sections.

General medicine is a basis for any AAL system requirements. It has to be placed prior to any questions on specialized areas. This part appears after personal information about medical and technological knowledge and experience in the section “AAL implementation. General medical questions, present and future roles of AAL in the healthcare system”. Every question asks about one of the most important emergencies or general medicine aspects.

General medicine also indirectly appears in the technical sections, where questions about specific measurements of vital signs and diagnostic soft are asked. The same type of technical questions are repeated for patients with MCI, but they bear the same message.

The section about ADL is much wider than just focused MCI sections. ADL and IADL are important for any home-based patient. On the other hand, ADL and IADL in some positions signify diagnostic changes for patients with MCI.

AAL for MCI Sections.

These sections have a specific mixture of technical, general medical, psychiatric and some other themes. Themes are grouped around theoretical and structural principles of AAL, potential problems and their solutions, practical technical questions – as seen from the medical, psychiatric, psychological point of view. “AAL for MCI” questions are spread between ten sections. The majority of these sections are about the main technical elements of the AAL system, as seen by medical professionals. Three sections are mixed with general care (ADL and IADL), social, psychological, administrative and financial themes (described below). And the last section is an open question: opinion of respondents about the AAL system for MCI patients.

AAL. Other Sections.

Four last sections are intentionally placed after the technical core and following repetition of technical themes, when asked specifically about patients with MCI.

Socio-psychological questions asked about privacy and acceptance of AAL by patients with MCI and their relatives. It is mostly projection, as far as AAL is more theoretical than a practical question for the majority of medical practitioners.

Important administrative and financial questions appear primarily in table form. The dedicated section itself was shortened as much as possible and placed at the end of the questionnaire.

The open question at the end finalizes the questionnaire.

IV.3. Sections: Questions Structure.

The whole questionnaire has 15 sections of uneven size (Please, see the Table below). The first section is the consent form. The second section has one space for the profession type with possibility to enter any small text and 4 multiple choice questions about healthcare and IT experience with single and multiple answer options. Section 3 holds 6 MCQs with single answer option about an experience in telemedicine and smart home technology. Section 4 consists of 13 scale questions and 2 matrix questions with on answer per row. Section 5 has 6 matrix questions with more than one answer option per row. Section 6 has 7 scale questions. Section 7 – 6 scale questions. Section 8 – 11 scale questions. Section 9 – 15 scale questions. Section 10 – 5 scale questions. Section 11 – 6, section 12 – 7, section 13 – 6, section 14 – 3. Section 15 has one open-ended item. There are 100 questions, 202 items (if to include every line in the matrix questions). Items in single-option MCQs can be calculated as one – is shown in the table in brackets.

Table 2: Characterization of the sections of the questionnaire

	Type of questions	**Number of questions**	**Number of items**
Section 1	Statement	1	2
Section 2	Short text, MCQ	5	0
Section 3	MCQ	6	0
Section 4	Scale, Matrix	15	37
Section 5	Matrix	6	47
Section 6	Scale	7	7

Section 7	Scale	6	6
Section 8	Scale	11	11
Section 9	Scale	15	15
Section 10	Scale	5	5
Section 11	Scale	6	6
Section 12	Scale	7	7
Section 13	Scale	6	6
Section 14	Scale	3	3
Section 15	Open-ended	1	1
Sum: 15	n/a	100	0

Interpretation: The table reflects formal structure with number and type of questions in sections. The load is not reflected.

Chapter V: Collected Data and Descriptive Statistics

V.1. Questionnaire reliability.

Questionnaire was tested on several runs before wide implementation.

Reliability of the questionnaire is checked in Jasp 0.14.0.0. – for scaled questions. Responses on 50 questions have McDonald's $\boldsymbol{\omega}$ = 0.899, Cronbach's $\boldsymbol{\alpha}$ = 0.911, Guttman's $\boldsymbol{\lambda}2$ = 0.921. The highest values in the questionnaire are: for Cronbach's $\boldsymbol{\alpha}$ is 0.920; for McDonald's $\boldsymbol{\omega}$ is 0.934; for Guttman's $\boldsymbol{\lambda}2$ is 0.932 (Table). Values above 0.9 may reflect a) redundancy of the test – there are specially added questions in some dimensions to recheck values of the responses b) multidimensionality of the test. 15 questions with opposite scales and negative results in the table were excluded from analysis.

In this section is presented simple analysis and comparative description analysis between sections and questions without group results comparison. In some cases Spearman's Rho pairwise correlation test is performed.

Table 3: Consistency of questionnaire according to results

	Cronbach's $\boldsymbol{\alpha}$	McDonald's $\boldsymbol{\omega}$	Guttman's $\boldsymbol{\lambda}2$
Consistency	0.920	0.934	0.932

Interpretation: Results are consistent according to three measurements. Numbers reflect redundancy and multidimensionality. 15 negative scale questions are excluded.

V.2. Information about participants.

V.2.1. Number of participants.

More than three hundred medical specialists were contacted in the USA, Canada, UK, Netherlands, Germany, Switzerland, Sweden, Greece, Israel, Armenia, Ukraine, Belarus and Russian Federation and asked to answer the questionnaire. Around 120 agreed to participate, of whom 60 answered all questions. Those who did not finish the questionnaire named several reasons for it: unknown topic, the length and complex nature of the questionnaire, heavy workload and shortage of time because of the COVID-19 pandemic.

Country name was removed from the questionnaire for reason of required anonymity. However, there was no informally registered difference in the approach of specialists, depending on the country of practice or residence.

Age and gender were collected for statistical necessities

V.2.2. Respondents. Age and gender structure.

Age and gender were collected for statistical necessities. The age is from 21 to 63, with average age 49.9 years.

Table 4: Age and gender of participants

	Number	Minimal-Maximal	Mean, years	Median	Mode
Age	60	21-63	49.9	50	50
Gender: F	29	21-60	49.0	50	50
Gender: M	31	42-63	50.7	50	49

Interpretation: results show relative homogeneity of the respondents` age by gender and near equal gender split, with age range not changing the general picture.

V.2.3. Medical profession.

There are 60 respondents. Of those who answered, there are 41 medical doctors, 10 nurses, 4 paramedics, 2 dental medicine doctors, 3 clinical psychologists. Some information is available about medical doctors` specialization. Limitations arose from wide options of the question about the medical profession, so some doctors did not mention their specialization. The additional matter is a possibility to have more than one profession and report only one, often the most recent.

Physician, MD – 14. Psychiatrist, narcologist – 9. Neurologist – 3. Geriatric consultant – 2. ONT consultant – 1. Gynecologist – 2. Surgeon – 1. Family doctor – 1. Anesthesiologist – 4. Hematologist – 1. Pediatrician – 1. Dentist, DMD – 2. Urologist – 1. Traumatologist, Orthopedist – 1. There was no option to learn nurses` specializations.

The age distribution by professional groups is presented below in the table.

Table 5: Age distribution for professional groups

	Age				
	DMD	**MD**	**Psychologist**	**nurse**	**paramedic**
Valid	2	41	3	10	4
Missing	0	0	0	0	0
Mean	49.500	50.951	48.667	45.900	50.250
Median	49.500	50.000	52.000	49.500	50.500
Mode	48.000	49.000	40.000	50.000	47.000
Variance	4.500	37.298	57.333	100.100	6.250
Range	3.000	32.000	14.000	35.000	6.000
Minimum	48.000	31.000	40.000	21.000	47.000
Maximum	51.000	63.000	54.000	56.000	53.000

Interpretation: age distribution by five professional groups. Main groups are medical doctors (MD) and nurses.

Age distribution for nurses is shown in the Figure 9 and for medical doctors – in Figure 10

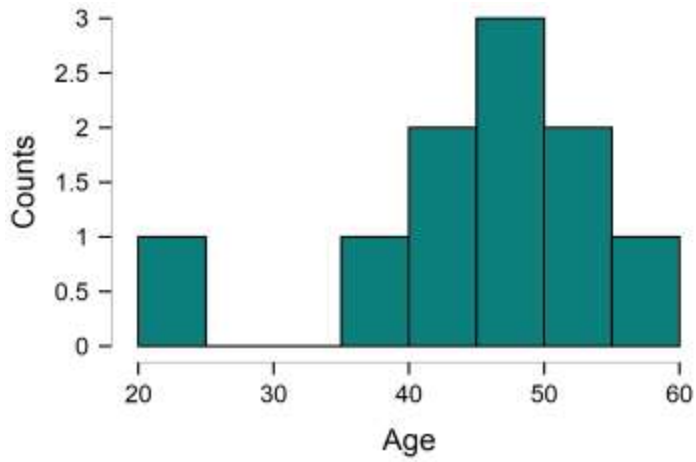

Figure 9: Age distribution, nurses

Interpretation: majority of respondents, who mentioned profession "nurse", has average age between 40 and 50, median 49.5, mode 50, as written in the table above.

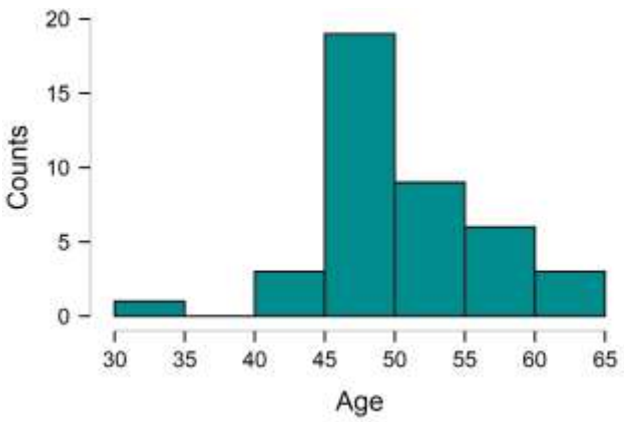

Figure 10: Age distribution, medical doctors

Interpretation: the age of doctors-respondents, mode is 49, median 50, from 31 to 63.

V.2.4. Medical experience.

The participants defined their medical experience as: hospital clinical – 37, 61.7%; hospital non-clinical – 4, 6.7%; visiting, family medicine 16, 26.7%; medical research – 15, 25%; non-medical – 7, 11.7%; public medicine – 1.

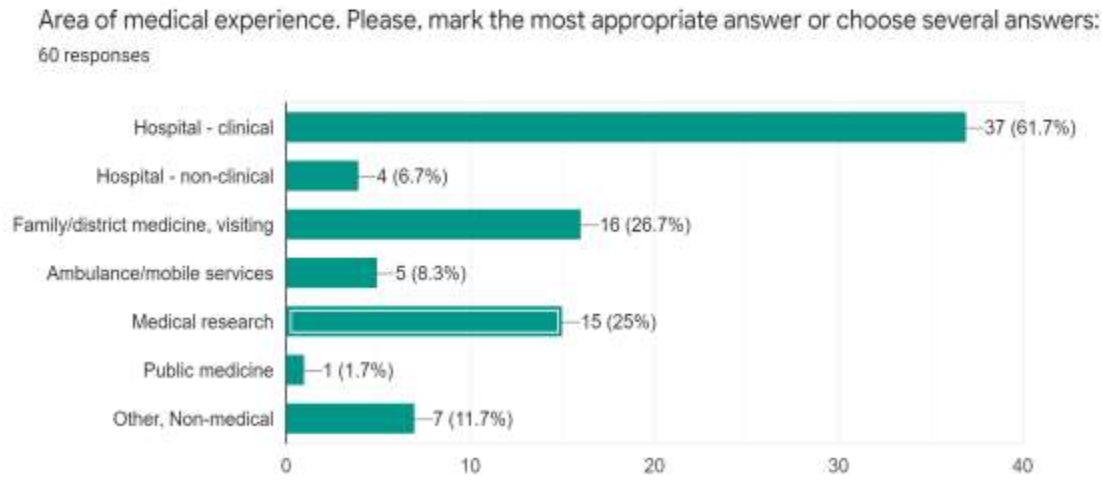

Figure 11: Area of medical experience. More than one answer per respondent.

Interpretation: more than one option was available. There are 61.7% of respondents who have or had hospital clinical experience, 26.7% has family/visiting medicine experience.

Altogether there are 80 responses combined, of which 53 are clinical. The number is higher than 60 because of the possibility to mark more than one option. The 53 out of 80 answers (more than one answer was allowed in this question), 66%. The 37 out of 60, 61.7%, mentioned hospital experience. Visiting, family medicine 16, 22.7% out of 60.

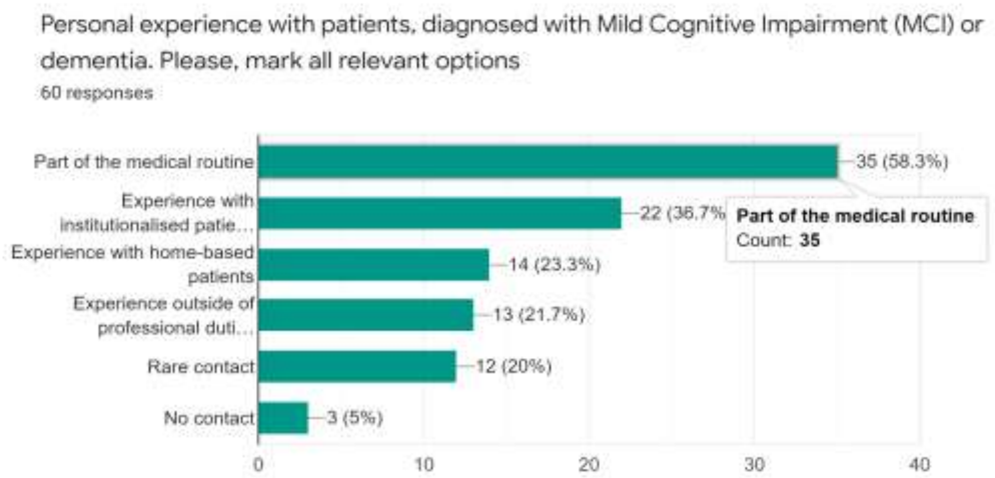

Figure 12: Personal experience with MCI patients. More than one answer per respondent.

Interpretation: more than answer was available. 35 respondents, 58.3%, contact patients with MCI or dementia during medical routine, while 22, or 36.7% have or had experience with hospitalized or patients placed in specialized institutions.

At the time of college or university studies, all respondents had clinical experience, but a limited one. Medical experience of three clinical psychologists is restricted mostly to the area of psychopathology. It is not very informative in the sections, which requires wide medical knowledge, but more relevant than the clinical experience of many medical specialists at the sections with questions about MCI patients.

Eight respondents marked clinical experience together with research. 6 reported clinical with non-clinical, and some reported clinical work, clinical research and non-medical work at the same time. Clear clinical research is mentioned 8 times, and clear non-medical 1 time. Out of 60 responses, 52 mentioned clinical experience, and 8 – only research or non-medical.

The other complication arouses from the complex experience. Some researchers, technical or laboratory workers had clinical experience before they moved to the research or non-clinical position. It could not be appropriately reflected in the current questionnaire without the creation of extensively elaborated preliminary questions. The picture is clear enough to see that most of the respondents have clinical experience with patients.

V.2.5. Contact with patients.

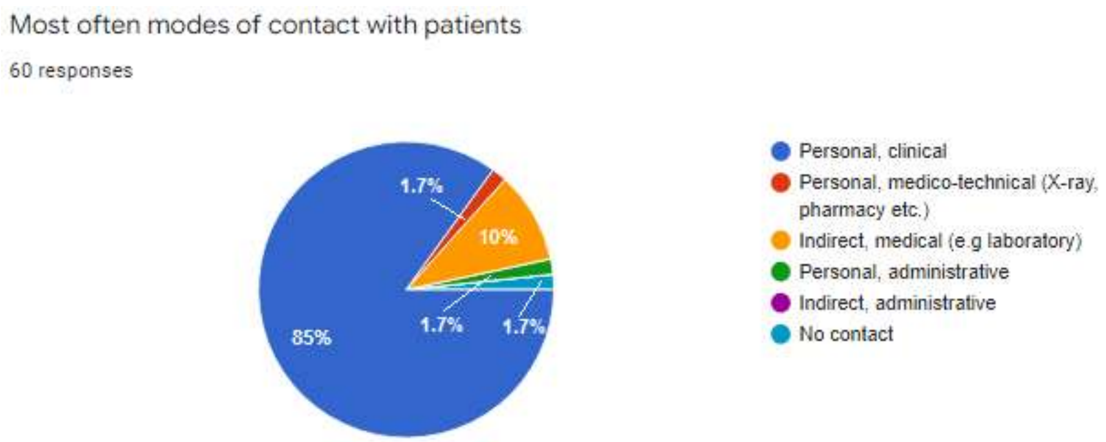

Figure 13: Most often mode of contacts with patients

Interpretation: majority, 85%, have or had personal clinical contact with patients.

Indirect, or contact as worker of laboratory or technician – 7 respondents, 11.7%.

The 51 respondents, or 85% have or had personal clinical contact with patients. The 7 respondents, or 11.7%, work in clinical diagnostic or laboratory, with only 1 person who has direct contact (US diagnostics). 1 respondent has direct contact on medical administrative positions, and 1 people currently have no clinical contact and no clinical work.

Personal experience with patients, diagnosed with MCI or dementia is described in the graph, Figure. Possible answer was to more than one option.

V.2.6. IT knowledge and experience.

The 38 respondents, 63.3% defined themselves as normal IT users; 2 or 3.3% as occasional users, 13, 21.7% as advanced users; 5 or 8.3% as professionals and 2 or 3.3% as semi-professionals.

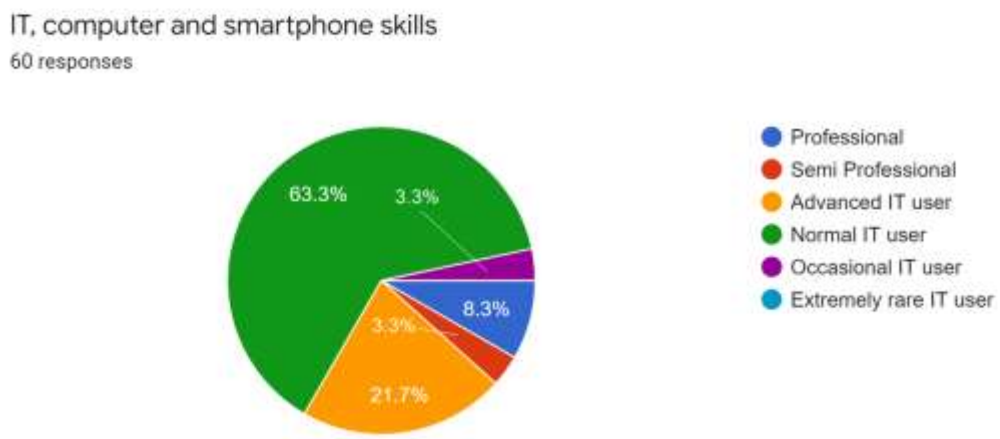

Figure 14: IT skills, groups of respondents

Interpretation: Majority of respondents have normal IT experience. More detailed description please, see above.

In accordance with claimed IT knowledge and experience it is possible to form four groups. One group is combined – see Table

Table 6: IT experience categories

User	Number, N	Percentage
Professional and semi-professional	7	11.7%
Advanced users.	13	21.7%
Normal and occasional IT users	40	66.7%

Interpretation: according to IT experience respondents can be divided into groups.

V.2.7. Practical experience of telemedicine.

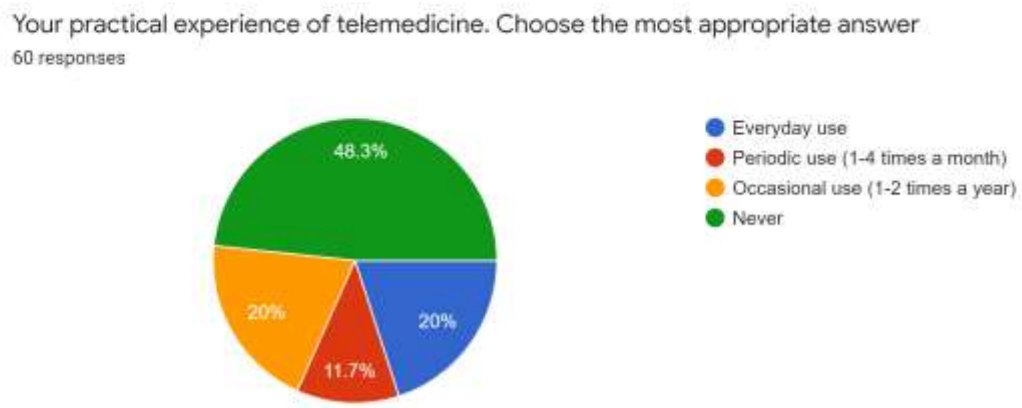

Figure 15: Practical experience of telemedicine

Interpretation: nearly half or the respondents have no practical experience of telemedicine

The 29, 48.3% – never used telemedicine. Twelve, or 20% – occasional use, 1-2 times a year. The 7, 11.7% – periodic use, 1-4 times a month, the 12 respondents or 20% – everyday use.

“I learned about telemedicine”: the 21, or 35% – never heard about it. The 3 or 5% --

more than 10 years ago. The 16 or 26.7% -- 3-9 years ago. The 20, or 33.3% learned recently, in the last 3 years.

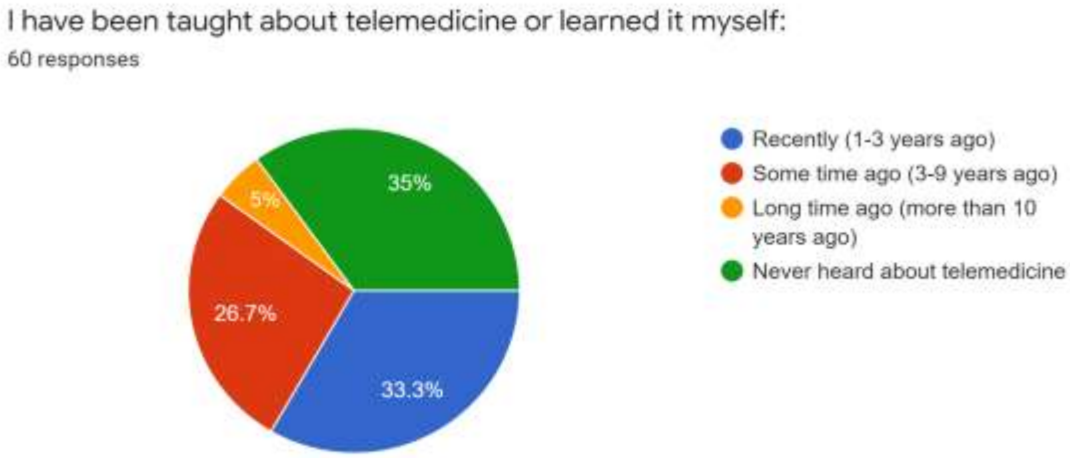

Figure 16: Theory knowledge about telemedicine

Interpretation: only third of respondents never heard about telemedicine.

Comparison of practical usage of telemedicine by groups of IT users is shown in the Table 7

Table 7: Comparison of practical usage of telemedicine by groups of IT users

Use	Number, N percentage	Everyday	1-4 times a month	1-2 times a year	Never used
Professional; Semi-Professional	7 11.7%	0 0.0%	1 10.7%	2 21.4%	4 57%
Advanced users	13 21.7%	4 31.0%	3 23.3%	1 7.7%	5 38.5%
Normal and occasional IT users	40 66.7%	8 20.0%	3 7.5%	9 22.5%	20 50.0%

Interpretation: there is no significant difference between IT group types of respondents in the telemedicine usage, with slight rise in periodic use for respondents, more advanced in IT.

V.2.8. Smart home technology.

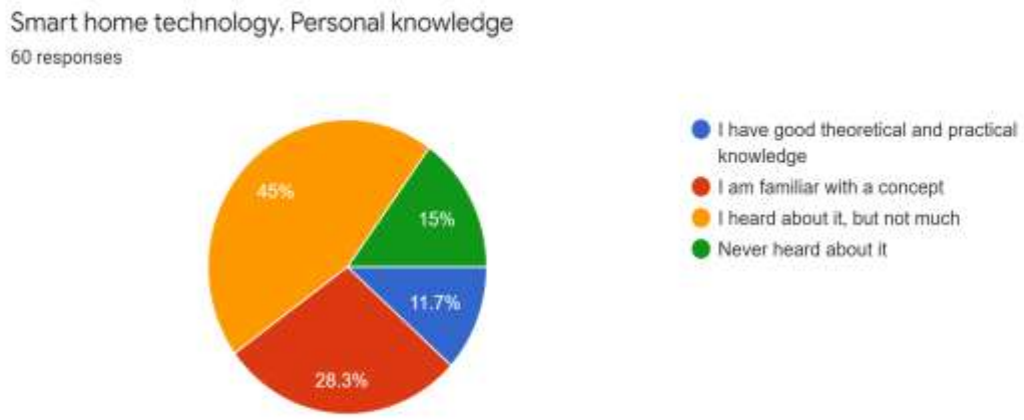

Figure 17: Smart home technology. Personal knowledge

Interpretation: almost 60% of respondents know little or nothing about smart home technologies, while only 11.7% have good theoretical and practical knowledge.

9, 15% never heard about it. Heard about it, but not much – 27, 45%. The 17, 28.3% – familiar with concept. The 7, 11.7% – have good theoretical and practical knowledge.

Table 8: Smart home technology knowledge by IT groups

Use	Number, N percentage	Good knowledge	Familiar with concept	Heard about it	Never heard
Professional; Semi-Professional	7 11.7%	3 42.9%	3 42.9%	1 14.2%	0 0.0%
Advanced users	13	2	5	6	0

	21.7%	15.4%	38.5%	46.1%	0.0%
Normal and occasional IT users	40 66.7%	2 5.0%	9 22.5%	20 50.0%	9 22.5%

Interpretation: There is a clear pattern of higher theoretical and practical knowledge in advanced and, especially, professional users groups.

V.2.8. Internet of Things.

Never heard about it – 24 respondents or 40%; familiar with a concept – 14 respondents or 23.3%; heard about it, but not much – the 15, 25%; good theoretical and practical knowledge – 7 respondents or 11.7%

Interpretation: the 65% of respondents have little or no knowledge of IoT. Only 11.7%

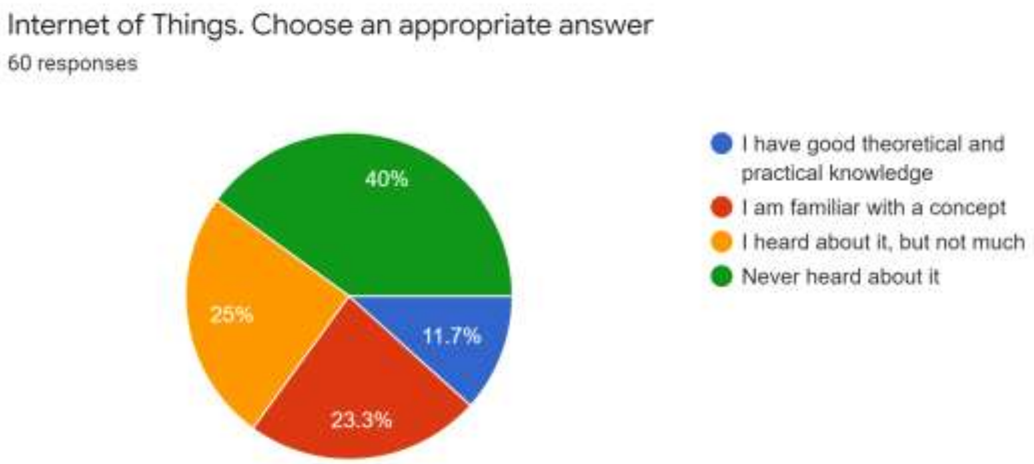

Figure 18: Internet of Things. Knowledge

have good theoretical and practical knowledge of IoT, same as for smart home.

Table 9: Internet of Things knowledge by IT groups

Use	Number, N percentage	Good knowledge	Familiar with concept	Heard about it	Never heard

Professional; Semi-Professional	7 11.7%	3 42.9%	3 42.9%	1 14.3%	0 0.0%
Advanced users	13 21.7%	3 23.1%	4 30.7	3 23.1%	3 23.1%
Normal and occasional IT users	40 66.7%	1 2.5%	7 17.5%	11 27.5%	21 52.5%

Interpretation: There is a clear pattern of higher knowledge in advanced and, especially, professional users groups.

V.2.9. AAL.

A) Learning.

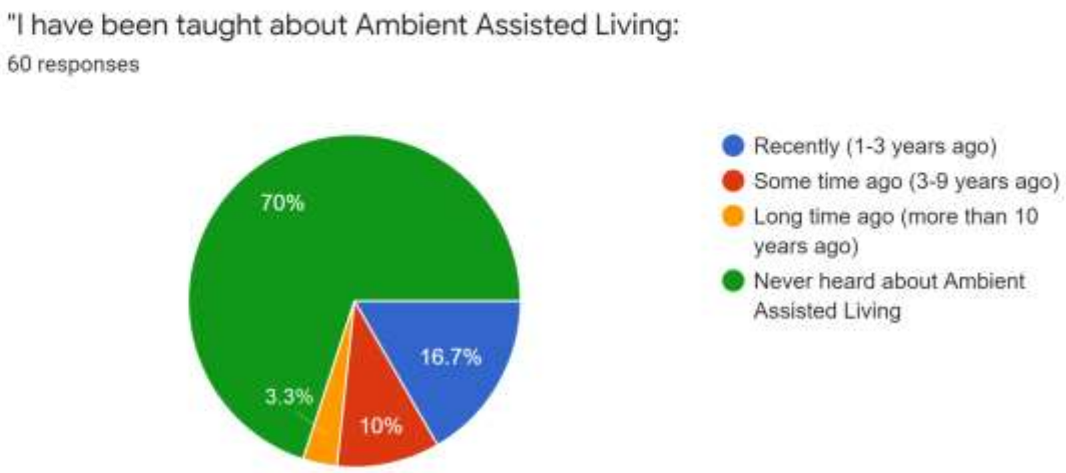

Figure 19: AAL theoretical knowledge

Interpretation: almost 70% of respondents never heard about AAL. At the same time 16.7% were taught about AAL recently.

The 70% of all respondents, or 42 interviewees, never heard about AAL. Learned more than 10 years ago: 2 respondents or 3.3%. 3-9 years ago 6 or 10%. Recently: 10 respondents or 16.7%.

Table 10: AAL system theoretical knowledge by IT groups

Use	Number, N percentage	1-3 years ago	3-9 years ago	More than 10 years ago	Never heard
Professional; Semi-Professional	7 11.7%	2 28.6%	2 28.6%	0 0.0%	3 42.9%
Advanced users	13 21.7%	2 15.4%	2 15.4%	1 7.7%	8 61.5%
Normal and occasional IT users	40 66.7%	6 15.0%	2 5.0%	1 2.5%	32 80.0%

Interpretation: There is higher theoretical knowledge in professional users` groups.

B) Practical knowledge of AAL.

13 respondents or 15% claimed some mode of use periodic of AAL, 7 of them, or 11.7% – everyday use. Periodic use, 1-4 times a month, 2, 3.3%. Occasional use, 1-2 times a year, 4, 6.7%. 47, or 78.3% – never used AAL technology.

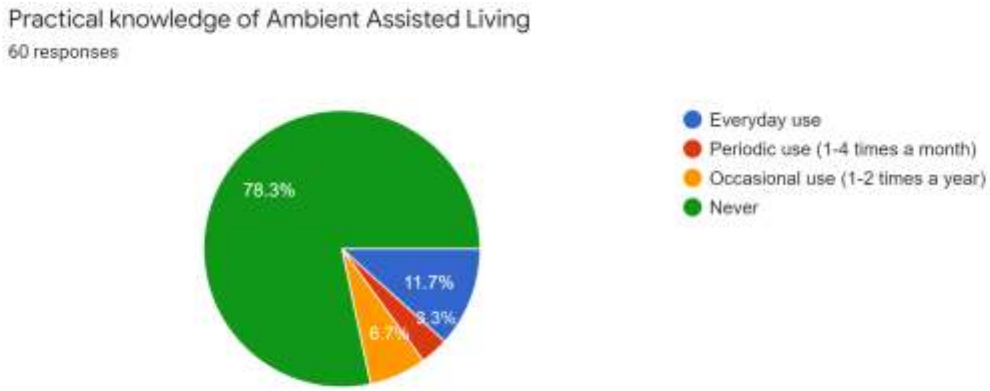

Figure 20: AAL, practical knowledge

Interpretation: Most of the respondents do not use or use very rarely AAL technology.

Only 11.7% use it every day.

Table 11: AAL practical knowledge by IT groups

Use	Number, N percentage	Everyday use	Periodic use 1-4 per month	Occasional, 1-2 a year	Never used
Professional; Semi-Professional	7 11.7%	0 0.0%	1 14.3%	1 14.3%	5 71.4%
Advanced users	13 21.7%	2 15.4%	1 7.7%	2 15.4%	8 61.5%
Normal and occasional IT users	40 66.7%	5 12.0%	0 0.0%	1 2.5%	34 85.0%

Interpretation: There is a slight, but not significant difference between groups.

V.2.10. IT and AAL Knowledge. Conclusion.

There is a clear difference in theoretical and practical knowledge of Internet of Things (IoT) and Smart Home technologies for respondents with professional, semiprofessional and advanced IT knowledge. Generally higher IT skills are reflected in higher knowledge. This pattern is less visible, when we look at telemedicine and AAL technologies. There are several respondents in normal IT users group who claim knowledge and use of AAL technologies, 6 and 5 interviewees respectively. It might signify deficiency of the self-report IT proficiency skills.

V.3. Medical aspects of AAL Implementation.

There are 13 statements in this section. Descriptive statistics is presented in the table below.

A) “AAL system is the only solution for the ageing crisis”.

B) “AAL system can help the family doctor or visiting nurse to monitor the patient's condition between visits”.

C) “AAL system can help to diagnose deterioration of the patient”.

D) “AAL system can help to register medical emergency”.

E) “AAL system can signal about heart emergency”.

F) “AAL system can signal about pulmonary and airways emergency”.

G) “AAL system can signal about the neurological emergency”.

H) “AAL system can signal about acute infection”.

I) “AAL system can signal about psychiatric emergency”.

J) “AAL system can help to signal about fall or trauma at home”.

K) “AAL system is helpful in chronic somatic conditions”.

L) “AAL system is helpful in a chronic neuropsychiatric condition”.

M) “AAL system implementation will ease the load of the healthcare system”.

Table 12: Descriptive statistics by statements of questionnaire

Statement	Likert 6-10	Likert 8-10	Likert 10	Mean	Median	Mode	Quartiles	IQR
A)	41; 68.3%	18; 30.0%	5; 8.3%	6.2	6.5	7	5; 6.5; 8	3
B)	58; 96.7%	53; 88.3%	26; 43.3%	8.8	9	10	8; 9; 10	2
C)	56; 93.3%	38; 63.3%	19; 31.7%	8.3	8	8	8; 9; 10	2
D)	59; 98.3%	47; 78.3%	22; 36.7%	8.6	9	10	8; 9; 10	2

E)	58; 96.7%	48; 80.0%	21; 35.0%	8.6	9	10	8; 9; 10	2
F)	58; 96.7%	47; 78.3%	19; 31.7%	8.5	9	10	8; 9; 10	2
G)	49; 81.7%	30; 50.0%	11; 18.3%	7.5	7.5	7	7; 7.5; 9	9
H)	44; 73.3%	15; 25.0%	5; 8.3%	6.5	7	7	5; 7; 7.3	2.3
I)	38; 63.3%	22; 36.7%	9; 15.0%	6.5	6	5	5; 6; 8	3
J)	56; 93.3%	49; 81.6%	21; 35.0%	8.6	9	10	8; 9; 10	2
K)	47; 78.3%	35; 58.3%	11; 18.3%	7.4	8	8	6; 8; 9	3
L)	39; 65.0%	23; 38.3%	9; 15.0%	6.6	6	5	6; 8; 9	3
M)	48; 80.0%	36; 60.0%	16; 26.7%	7.4	8	10	6; 8; 10	4

Analysis and conclusion: Predominant part of the respondents agree with the positive role of the AAL system. While a significant majority suppose the AAL system to be effective in the case of somatic emergency, mostly cardio-pulmonary, fall or injury, respondents are less sure about psychiatric emergency, acute infection or change in chronic condition.

V.4. AAL in healthcare.

Two matrix questions results are presented in two tables below. Only one answer per row is possible.

A) Present and future of AAL in healthcare system

Table 13: Future of AAL in healthcare system, answers` percentage

	Today	Nearest future, 5-	Future,	Distant future, 50 or	Never

		10 years	10-50 years	more years	
AAL will replace part of the non-hospital healthcare	8 13.3%	35 58.3%	14 23.3%	3 8.3%	0 0.0%
AAL will replace most of the non-hospital healthcare	2 3.3%	13 21.7%	21 35.0%	10 16.7%	14 23.3%
AAL replaces all the non-hospital healthcare	1 1.7%	8 10.0%	13 21.7%	8 13.3%	32 53.3%
AAL has to be integral part of electronic healthcare system	16 26.7%	22 36.7%	19 31.7%	3 5.0%	0 0.0%
All homes have to be built with AAL option	16 23.3%	17 28.3%	14 23.3%	6 10.0%	9 15.0%
AAL has to be taught in medical schools	38 63.0%	18 26.7%	5 8.3%	1 1.7%	0 0.0%

***Interpretation*:** Most of the respondents are moderately optimistic about the role of AAL in the non-hospital healthcare, but see it as mainly a supplementary system and not complete replacement.

B) Healthcare professionals and AAL system implementation. Tables with one possible answer per question/per option.

Table 14: AAL system implementation, answers` percentage

	Today	Nearest future, 5-10 years	Future, 10-50 years	Distant future, 50 or more years	Never
Every home-visiting medical practitioner has to know AAL	34 56.7%	20 33.3%	5 8.3%	0 0.0%	1 1.7%
Every medical practitioner has to know AAL	27 45.0%	26 43.3%	6 10.0%	0 0.0%	1 1.7%
AAL has to be covered by general healthcare	27 45.0%	27 45.0%	6 10.0%	0 0.0%	0 0.0%
AAL is financially affordable	8 13.3%	20 33.3%	22 36.7%	5 8.3%	5 8.3%
AAL is technically feasible	15 25.0%	27 45.0%	14 23.3%	3 5.0%	1 1.7%
AAL is administratively easy to organize	8 13.3%	29 48.3%	15 25.0%	4 6.7%	4 6.7%

AAL system in healthcare. General analysis conclusion.

Respondents have a positive outlook on the role of AAL system in non-hospital healthcare and are mostly sure it is important today and in the nearest future as an essential complementary element. Medical workers are slightly less optimistic about AAL integration by agencies and institutions outside of the healthcare system.

V.5. AAL system. Technical questions.

There are four thematic table questions with more than one answer per question option. The sum of percents for one question is more than 100%.

V.5.1. Computing Units in AAL. Practical Usefulness.

Table 15: Computing units practical usefulness, answers` frequency table

	Server	PC	Laptop	Tablet	Smartphone	Microcomputer
High Usability	10 16.7%	31 51.7%	30 50.0%	42 70.0%	45 75.0%	14 23.3%
High Computer power	49 81.7%	39 61.7%	17 28.3%	2 3.3%	4 6.7%	0 0.0%
High Information Security	39 65.0%	31 51.7%	17 28.3%	14 23.3%	14 23.3%	10 16.7%
Convenient Interface	8 13.3%	35 58.3%	32 53.3%	40 66.7%	36 60.0%	8 13.3%
Affordable Price	5 8.3%	15 25.0%	21 35.0%	38 63.3%	46 76.7%	19 31.7%
High Technical versatility	23 38.3%	40 66.7%	24 40.0%	23 38.3%	31 51.7%	8 13.3%

High Technical Service Convenience	14 23.3%	27 45.0%	30 50.0%	34 56.7%	40 66.8%	15 25.0%
Convenient for the patient	3 5.0%	10 16.7%	28 46.7%	45 75.0%	52 86.7%	14 23.3%
Energy efficient	11 18.3%	19 31.7%	22 36.7%	34 56.7%	44 73.3%	28 46.7%

***Interpretation*:** Smartphone is considered by respondents to be one of the best devices in usability, price, service convenience, energy efficiency; but low in computer power and average in security. Tablet is close behind. Server is considered possessing the highest computer power and security. Microcomputer is perceived as relatively cheap and energy efficient, but not as an important computing device with valuable characteristics.

V.5.2. Computing Devices in AAL. Importance.

Table 16: Computing devices importance, answers` frequency table

	Server	PC	Laptop	Tablet	Smartphon e	Microcomp uter
Most important computing device in AAL	37 61.7%	28 46.7%	15 25.0%	19 31.7%	27 45.0%	17 28.3%
This device must be in AAL	31 51.7%	23 38.3%	15 25.0%	25 41.7%	34 56.7%	20 33.3%
This device is not necessary for AAL	11 18.3%	27 45.0%	26 43.3%	17 28.3%	8 13.3%	17 28.3%

These devices are the best combination for the AAL	30 50.0%	33 55.0%	13 21.7%	31 51.7%	48 80.0%	25 41.7%
This device is convenient for wearable sensors	5 8.3%	5 8.3%	8 13.3%	22 36.7%	49 81.7%	23 38.3%
This is the cheapest possible configuration of devices	12 20.0%	12 20.0%	5 8.3%	25 41.7%	46 76.7%	26 43.3%
I would like to see these devices in AAL.	23 38.3%	19 31.7%	17 28.3%	33 55.0%	42 70,0%	19 31.7%

Interpretation**:** Smartphone and tablet remain the most popular options, especially for patient use. Server and PC are perceived as potentially important, but obviously not necessary. Microcomputer remain not a very popular option in most of the answers. It might reflect the level of knowledge about AAL and IT technologies.

V.5.3. Sensors in AAL.

Table with more than one possible answer per question per option.

Table 17: Sensors in AAL, answers` frequency table

	Video camera	Microphon e	Infrared Positionin g sensor	Mechanical pressure sensors	Wearable sensors	Temperatu re, air sensors
Most important sensors in AAL	38 63.3%	35 58.3%	38 63.3%	33 55.0%	49 81.7%	14 23.3%

The best combination of sensors in AAL	38 63.3%	34 56.7%	41 68.3%	35 58.3%	48 80.0%	18 30.0%
These sensors are not necessary for AAL	18 30.0%	14 23.3%	8 13.3%	10 16.7%	4 6.7%	35 58.3%
These sensors are too invasive to be switched on 24 hours a day/7 days a week	20 33.3%	14 23.3%	12 20.0%	11 18.3%	28 46.7%	6 10.0%
These sensors can be switched on only in emergency	29 48.3%	21 35.0%	15 25.0%	14 23.3%	10 16.7%	21 35.0%
These sensors can be used for communication	43 71.7%	49 81.7%	6 10.0%	4 6.7%	7 11.7%	3 5.0%
These sensors are most informative	27 45.0%	21 35.0%	28 46.7%	28 46.7%	44 73.3%	10 16.7%
These sensors are least informative	8 13.3%	16 26.7%	13 21.7%	12 20.0%	8 13.3%	33 55.0%
These sensors are important for security	41 68.3%	29 48.3%	23 38.3%	11 18.3%	19 31.7%	11 18.3%
These sensors can help to prevent abuse	45 75.0%	30 50.0%	14 23.3%	9 15.0%	17 28.3%	7 11.7%

Interpretation**:** Wearable sensors are recognized as most important medically, while the role of video camera and microphone is also high. Air quality and temperature sensors are seen as least important.

V.5.4. Smart Devices in AAL.

Remark: This table was used as an attention measurement block. For this reason columns and rows replaced each other. It led to the situation, when some questions were answered by a number of respondents not in full, on a basic level only.

Table 18: Smart devices in AAL, answers` frequency table

	These smart devices must be included into AAL	This device is not necessary in AAL	These devices are the best combination for the AAL	This device has to be designed especially for specific AAL	This device can be COTS (Commercial-Off-The-Shelf) to be included into AAL
Smart Body thermometer	43 71.7%	6 10.0%	16 26.7%	6 10.0%	27 45.0%
Smart Blood pressure machine	49 81.7%	0 0.0%	22 36.7%	5 8.3%	23 38.3%
Smart Pulse oximeter	43 71.7%	4 6.7%	20 33.3%	13 21.7%	19 31.7%
Smart ECG	43 71.7%	5 8.3%	18 30.0%	9 15.0%	22 36.7%
Smart tablet dispenser	32 53.3%	11 18.3%	10 16.7%	13 21.7%	19 31.7%

Smart electricity meter	11 18.3%	34 56.7%	7 11.7%	5 8.3%	18 30.0%
Climate control	15 25.0%	27 45.0%	9 15.0%	10 16.7%	22 36.7%
Robotic carer	11 18.3%	27 45.0%	9 15.0%	24 40.0%	13 21.7%
Smart furniture	19 31.7%	18 30.0%	12 20.0%	19 31.7%	13 21.7%
Smart refrigerator	15 25.0%	24 40.0%	6 10.0%	18 30.0%	16 26.7%
Smart vacuum cleaner	8 13.3%	35 58.3%	6 10.0%	15 25.0%	18 30.0%

***Interpretation*:** There is clear preference in AAL of smart devices, responsible for vital signs. Also, in the answers is registered moderately positive outlook on use of COTS devices.

V.5.5. Networks in AAL.

Table with more than one possible answer per question per option. This part of the questionnaire created most of the problems for the respondents, and they reported more random answers, than in other parts.

Table 19: Networks in AAL, answers` frequency table

	Special cable	Cables and wires	Wireless	Internet	Mobile phone network	Special wireless connection
The best connection inside of the home	16 26.7%	9 15.0%	36 6.00%	20 33.3%	16 26.7%	18 30.0%
The best type of external connection in AAL	18 30.0%	10 16.7%	15 25.0%	28 46.7%	23 38.3%	20 33.3%
Most secure connection in AAL	30 50.0%	13 21.7%	7 11.7%	6 10.0%	10 16.7%	24 40.0%
Can interfere with other devices	7 11.7%	19 31.7%	24 40.0%	19 31.7%	28 46.7%	9 15.0%
Health and safety issue at home	23 38.3%	46 76.7%	7 11.7%	6 10.0%	8 13.3%	4 6.7%
Most affordable connection	11 18.3%	19 31.7%	17 28.3%	24 40.0%	23 38.3%	2 3.3%

***Interpretation*:** There is preference for wireless connection in home with AAL, and one of the reasons – health and safety issues from wires and cables. There is some preference for internet and mobile network for external connection, if the problem of higher security is not involved.

V.5.6. Medical Software for AAL System.

Table with more than one possible answer per question per option.

Table 20: Medical software in AAL, answers` frequency table

	Automatic Health diagnostic soft	Communication soft	Activity and day organizer	Memory training soft	Automatic reminder
Most important for the healthcare specialist	49 81.7%	34 56.7%	21 35.0%	8 13.3%	18 30.0%
Most important for the patient	25 41.7%	34 56.7%	26 43.3%	22 36.7%	45 75.0%
Unimportant for the patient	20 33.3%	8 13.3%	17 28.3%	20 33.3%	5 8.3%
Important medically	52 86.7%	27 45.0%	19 31.7%	13 21.7%	18 30.0%
Important socially	13 21.7%	45 75.0%	25 41.7%	12 20.0%	29 48.3%
Important for the aged patients	23 38.3%	35 58.3%	27 45.0%	40 66.7%	47 78.3%
Important for patients with memory and cognitive	15 25.0%	27 45.0%	38 63.3%	48 80.0%	51 85.0%

Interpretation**:** answers reflect medical and social necessity with common sense. Medically recognized role of the automatic diagnostic soft. Communication software is perceived as significant for healthcare specialists and patients as well. Automatic reminders and memory training software are acknowledged as important for aged patients, especially for those with cognitive and memory problems.

V.5.7. AAL. Technical questions. General Analysis and Conclusion.

There is generally a positive vision of smartphones and tablets in AAL. Wearable sensors are recognized as most important medically, with important role of video camera and microphone. There is clear preference in AAL of smart devices, responsible for vital signs. There is preference for wireless connection in the AAL. Diagnostic and communication soft is most important.

V.6. AAL System for Patients with MCI.

Statements:

A) “AAL system is the best solution for MCI patients”.

B) “AAL system is a good addition to the existing healthcare solutions for patients with MCI”.

C) “AAL system is helpful only for some patients with MCI”.

D) “AAL system is inconvenient for MCI patients”.

E) “AAL system is too complicated to be used for patients with MCI”.

F) “AAL system can help patients with dementia, not with MCI”.

G) “AAL system is a good support for relatives of patients with MCI”.

Table 21: AAL for MCI patients. Descriptive statistics by statements

Statement	Likert 6-10	Likert 8-10	Likert 10	Mean	Median	Mode	Quartiles	IQR
A)	54; 90.0%	35; 58.3%	16; 26.7%	7.6	8	8	6; 8; 10	4
B)	59; 98.3%	49; 81.7%	26; 43.3%	8.8	9	10	8; 9; 10	2
C)	36; 60.0%,	24; 40.0%	6; 10.0%	6.1	6	8	5; 6; 8	3
D)	13; 21.7%	8; 13.3%	2; 3.3%	3.8	3	1	1.5; 3; 5	3.5
E)	21; 35.0%	7; 11.7%	2; 3.3%	4.1	4	1	2.5; 4; 6.5	4
F)	15; 25.0%	8; 13.3%	2; 3.3%	3.8	3	1	1; 3; 5.5	4.5
G)	55; 91.7%	43; 71.7%	21; 35.0%	8.4	9	10	7; 9; 10	3

***Interpretation*:** majority of respondents consider the AAL system to be a good addition and one of the best solutions for home-based patients with MCI, but not with dementia. AAL system is recognized by the significant majority of respondents as a serious supportive measure for relatives of patients with MCI.

V.6.1. Diagnostic Soft Requirements.

Statements:

A) “AAL system must send the immediate report in the case of somatic emergency”.

B) “AAL system must send an immediate report about psychiatric emergency”.

C) “AAL system has to diagnose the level of cognitive deterioration”.

D) “AAL system has to report about the strange and unusual behavior”

E) “AAL system has to recognize sleep disturbance”.

F) “AAL system has to include specific software for a regular memory check**”.**

Table 22: Diagnostic soft requirements. Descriptive statistics by statements

Statement	Likert 6-10	Likert 8-10	Likert 10	Mean	Median	Mode	Quartiles	IQR
A)	60; 100.0%	55; 91.7%	47; 78.3%	9.6	10	10	10; 10; 10	0
B)	56, 93.3%	51; 85.0%	42; 70%	9	10	10	9; 10; 10	1
C)	52, 86.7%	33; 55.0%	24; 40.0%	7.8	8	10	6; 8; 10	4
D)	57, 95.0%	48; 80.0%	27; 45.0%	8.7	9	10	8; 9; 10	2
E)	49; 81.7%	33; 55.0%	19; 31.7%	7.6	8	10	6.5; 8; 10	3.5

Remark about results of question B) “AAL system must send an immediate report about psychiatric emergency”. There is a remarkable difference with answers on a similar question I) in the chapter 3, “General medical aspects of AAL implementation”, where 63.3% agree with the statement. and 15% strongly agree. It might be explained by the assumption that the general AAL system differs from the AAL system adapted for MCI patients, and the last one is more sensitive towards psychiatric emergencies. The Spearman's Rho still shows statistically significant association between two sets of answers on these questions: the value of rs = 0.41059, p-value = 0.00112.

Interpretation**:** Any AAL system has to register somatic emergencies. The answer is the same as for unspecific AAL. Respondents also generally agree that the AAL system for MCI patients has to register unusual behavior, sleep disturbances and, most important, psychiatric emergencies. There is generally a predisposition, that AAL system for AAL patients is more sensitive to these signals, than general AAL, and includes instruments, registering the level of the memory of the patient.

V.6.2. Smart Devices and Software.

A) “AAL system for MCI patients has to include memory training soft”.

B) “AAL system for patients with MCI has to include an organizer with an automatic reminder”.

C) “AAL system for MCI patients has to include an electronic tablet dispenser with an automatic reminder”.

D) “AAL system for patients with MCI has to report about irregularities with medicines` intake”.

E) “AAL system for patients with MCI has to report about open water tap”.

F) “AAL system for patients with MCI has to collect information automatically from an electronic thermometer, blood pressure machine, pulse oximeter, glucometer and other vital signs measuring devices”.

G) “AAL system has to remind about the necessity to measure blood pressure or blood glucose”.

H) “AAL system for patients with MCI elements and devices have to be fully designed by a specially designated engineering company”.

I) “AAL system for patients with MCI is better to build from ready Commercial-Off-The-Shelf (COTS) elements and devices”.

J) “Devices in the AAL system for patients with MCI have to be only or mostly wireless”.

Table 23: Smart devices and software. Descriptive statistics by statements

Statement	Likert 6-10	Likert 8-10	Likert 10	Mean	Median	Mode	Quartiles	IQR
A)	49; 81.7%	31; 51.7%	15, 25.0%	7.5	8	10	6; 8; 9.5	3.5

B)	58; 96.7%	47; 78.3%	32, 53.3%	8.9	10	10	8; 10; 10	2
C)	58; 96.7%	45; 75.0%	27; 45.0%	8.6	9	10	7.5; 9; 10	2.5
D)	58; 96.7%	51; 85.0%	35; 58.3%	9	10	10	9; 10; 10	1
E)	56; 93.3%	48; 80.0%	35; 58.3%	8.8	10	10	9; 10; 10	1
F)	56; 93.3%	47; 78,3%	33; 55.0%	8.7	10	10	8; 10; 10	2
G)	60, 100.0%	48; 80.0%	33; 55.0%	9	10	10	8; 10; 10	2
H)	51; 85.0%	37; 61.7%	24; 40.0%	7.7	8	10	6; 8; 10	4
I)	45; 75.0%	26; 43.3%	13; 21.7%	7	7	10	5.5; 7; 9	3.5
J)	52; 86.7%	46; 76.7%	24; 40.0%	8.4	9	10	8; 9; 10	2
K)	40; 66.7%	27; 45.0%	18; 30%	6.7	7	10	5; 7; 10	5

Remarks: 1) There is an element of contradiction between answers to questions H) and I). Spearman's Rho rs = -0.00161. P-value is 0.99029.

2) There is an element of contradiction between answers on questions J) and K). Spearman's Rho rs = 0.16996. P-value is 0.19418.

Interpretation**:** There is general consensus about the necessity for the AAL system for MCI patients to include mechanisms of memory training and support. Most of the respondents overall agree with higher convenience of wireless devices in the AAL system for MCI patients, which correlates with similar questions about general AAL, described in the part 5.4. A supposed contradictory answers on questions about wired and wireless connection of devices has to be adjusted with additional requirement of battery charge for MCI patients, who suffer from memory loss, which prevents timely battery change or accumulator charge.

There is also some alleged incongruity in two blocks of answers about usage in AAL devices, specially designed by engineering company, or built from COTS devices. While the majority prefer special design, and it is supported by answers on similar questions in 5.3, there is an understanding of strong positive option of COTS devices in AAL. It is not comprehended as a completely polar contradiction by a significant part of respondents.

V.6.3. Sensors.

A) “The video camera is the best sensor in the AAL system for patients with MCI”.

B) “Microphones are very important in the AAL system for patients with MCI”.

C) “The video camera and microphones are too invasive to be used 24 hours a day/7 days a week as AAL sensors for patients with Mild Cognitive Impairment”.

D) “Video cameras and microphones can be used in AAL only for emergency”.

E) “Video camera and microphone can be used in AAL for patients with MCI for communication only”.

F) “Motion registration by infrared sensors is very important in AAL for patients with MCI”.

G) “Gesture recognition by active infrared sensors is very important in AAL for patients with MCI”.

H) “Wearable vital signs` sensors must be part of the AAL system for patients with MCI”.

I) “Wearable vital signs` sensors are inconvenient for patients with MCI”.

J) “Pressure sensors have to be part of smart furniture and have to be mounted on beds, couches, chairs for the position registration of patients with MCI”.

K) “Entrance door and windows have to be with sensors, to report about the open or closed status in AAL system for patients with MCI”.

L) “Smart electricity meters have to report about electricity usage pattern: day and night, unusual peak activities in AAL system for patients with MCI.”

M) “Smart water meters are necessary in the AAL system for patients with MCI”.

N) “Temperature and climate regulation sensors are a very important part of AAL for MCI patients”

O) “Gas leak chemical sensors have to control air quality in homes with gas stoves in AAL system for patients with MCI.”

Table 24: Sensors in the AAL for MCI patients. Descriptive statistics by statements

Statement	Likert 6-10	Likert 8-10	Likert 10	Mean	Median	Mode	Quartiles	IQR
A)	43; 71.7%	26; 43.3%	9; 15.0%	6.6	7	7	5; 7; 9	4
B)	41; 68,3%,	27; 45.0%	8; 13.3%	6.6	7	8	5; 7; 8	3
C)	39; 65.0%	26; 43.3%	11; 18.3%	6.5	7	10	4; 5; 7	4.5
D)	38; 63.3%	25; 41.7%	11; 18.3%	6	7	10	3; 7; 9	6
E)	35; 58.3%	23; 38.3%	6; 10.0%	6	6	1	3.5; 6; 8.5	5
F)	46; 76.7%	31; 51.7%	12; 20.0%	7.3	8	10	6; 8; 9	3
G)	17; 28.3%	43; 71.7%	7; 11.7%	7.7	7	8	5; 7; 8.5	3.5
H)	52; 86.7%	40; 66.7%	18; 30.0%	7.9	8	10	7; 8; 10	3
I)	31; 51.7%	17; 28.3%	6; 10.0%	5.6	6	6	3; 6; 8	5
J)	43; 71.7%	28; 46.7%	9; 15.0%	6.8	7	9	5; 7; 9	4
K)	56; 93.3%	43; 71.7%	26; 43.3%	8.5	9	10	7; 9; 10	3

L)	47; 78.3%	32; 53.3%	20; 33.3%	7.5	8	10	6; 8; 10	4
M)	50; 83.3%	32; 53.3%	19; 31.7%	7.5	8	10	6; 8; 10	4
N)	44; 73.3%	26; 43.3%	14; 23.3%	7	7	7	5; 7; 9	4
O)	57; 95.0%	53; 88.3%	37; 61.7%	9.2	10	10	9; 10; 10	1

***Interpretation*:** Vitally important sensors have to be part of AAL for MCI patients according to most of the opinions. This includes wearable sensors, door and windows' sensors, smart water and gas leak sensors. There is less consensus about invasive ones', such as video camera and microphone, or sensors, controlling positioning and gestures, and smart electricity sensors. While nearly two thirds of respondents generally support use of all these sensors, there is significant disagreement. No difference is registered with answers on similar questions in the part 5.4. Support for video camera and microphone use is quite significant. There is a vision of necessity to use it not only for communication, even though it might be switched on 24/7 mode.

V.6.4. Computing Devices.

A) “The server for the healthcare stakeholder side and server in the patient's home side is the best configuration in AAL system for patients with MCI”.

B) “The server for the healthcare stakeholder side and personal computer on the patient's home side is the best configuration in AAL system for patients with MCI”.

C) “The laptop is the most convenient computing device on the patient's home side in AAL system for patients with MCI”.

D) “Computer tablet is the most convenient computing device on the patient's home side in AAL system for patients with MCI”.

E) “A smartphone is the most convenient computing device on the patient's home side in AAL system for patients with MCI”.

Table 25: Computing devices. Descriptive statistics by statements

Statement	Likert 6-10	Likert 8-10	Likert 10	Mean	Median	Mode	Quartiles	IQR
A)	29; 48.3%	17; 28.3%	8; 13.3%	5.6	5	6	3; 5; 8	5
B)	41, 68.3%	25; 41.7%	9; 15.0%	6.7	7	6	5; 7; 9	4
C)	37; 61.7%	19; 31.7%	6; 10.0%	6	6	6	5; 6; 8	3
D)	45; 75.0%	32; 53.3%	7; 11.7%	7.1	8	8	5.5; 8; 9	3.5
E)	48; 80.0%	39; 65.0%	12; 20.0%	7.6	8	9	6.5; 8; 9	2.5

***Interpretation*:** There is a tendency, already appearing in table about computing devices (see part 5.4) for smartphones to be seen as the best device on the patient side, with tablet closely behind. Laptop is also acceptable, but less, with PC below it.

V.6.5. ADL and IADL.

A) “AAL system has to measure ADL automatically”.

B) “AAL system can measure ADL and IADL automatically”.

C) “It is important to register automatically day and night routine activity and find out abnormalities”.

D) “Registered unusual night activity can point on the mental deterioration”.

E) “AAL has to register signs of unusual emotions”.

F) “AAL can register signs suicide risk”.

Table 26: ADL and IADL. Descriptive statistics by statements

Statement	Likert 6-10	Likert 8-10	Likert 10	Mean	Median	Mode	Quartiles	IQR
A)	49; 81.7%	34; 56.7%	15; 25.0%	7.8	8	10	6; 8; 9.5	3.5
B)	48; 80.0%	26; 43.3%	14; 23.3%,	7.6	8	10	7; 8; 9	2
C)	47; 78.3%	41; 68.3%	17; 28.3%	7.6	8	10	6; 8; 10	4
D)	53; 88.3%	44; 73.3%	21, 35%	8	8	10	7; 8; 10	3
E)	42;, 70.0%	31; 51.7%	12; 20.0%	7	8	10	5; 8; 9	4
F)	43; 71.7%	37; 62.0%	22; 36.7%	7.5	9	10	5; 9; 10	7

Interpretation**:** Majority of respondents see AAL system able to register ADL and IADL automatically. They also recognized the necessity to register day and night routine, with the option to report about unusual night activities as a potential sign of mental deterioration. Most of the respondents also suppose AAL system able to signal about suicide risks.

V.6.6. Privacy of the Patient.

A) “Patient's health is more important than privacy issues in AAL”.

B) “Privacy is more important than the patient's health in AAL”.

D) “Privacy issues in AAL can harm the mental health of patients with MCI”.

E) “Patients with paranoid thoughts are not advised to live in a home with the AAL system”.

F) “Emotionally sensitive patients are not advised to live in a home with the AAL system".

G) "AAL system is not more invasive than traditional healthcare".

Table 27: Privacy of the patients. Descriptive statistics by statements

Statement	Likert 6-10	Likert 8-10	Likert 10	Mean	Median	Mode	Quartiles	IQR
A)	41; 68.3%	27; 45.0%	15; 25.0%	7	7	10	5; 7; 9.5	4.5
B)	13; 21.7%	7; 11.7%	3; 5.0%	4.1	3.5	3	2; 3.5; 5	3
C)	35; 58.3%	26; 43.3%	14; 23.3%	6.5	7	10	5; 7; 9	4
D)	36; 60.0%	18; 30.0%	5; 8.3%	6	6	8	5; 6; 8	3
E)	32; 53.3%	15; 25.0%	3; 5.0%	5.7	6	5	5; 6; 7.5	2.5
F)	21; 35.0%	9; 15.0%	2; 3.3%	4.8	5	5	3; 5; 7	4
G)	36; 60.0%	20; 33.3%	6; 10.0%	6	6	8	4.5; 6; 8	3.5

***Interpretation*:** There is a tendency to put health problems before privacy problems, even though a significant part of respondents disagrees with this less balanced, by their opinion, view. There is also no consensus about the danger of AAL system for emotionally sensitive patients or those with paranoid thoughts. At the same time more than half of respondents see AAL system more invasive, than traditional healthcare system. There is correlation between answers to questions A) and G). Spearman's Rho r_s = 0.34036. P-value is 0.00779. There is also correlation between answers to questions E) and G). Spearman's Rho rs = -0.25529. P-value is 0.049.

V.6.7. Acceptance of the AAL System by Patients and Relatives.

A) "Most of the patients with MCI are favorably disposed towards home AAL".

B) “Some of the patients with MCIs are skeptical about home AAL”.

C) “Majority of the patients with MCI have a negative attitude towards home AAL”.

D) “Majority of the relatives are positively disposed towards home AAL”.

E) “Some of the relatives are concerned about a number of specific problems in home AAL”.

F) “Majority of the relatives have a negative attitude towards the home AAL”.

Table 28: Acceptance of AAL for MCI patients. Descriptive statistics by statements

Statement	Likert 6-10	Likert 8-10	Likert 10	Mean	Median	Mode	Quartiles	IQR
A)	43; 71.7%	24; 40.0%	8; 13.3%	6.7	7	5	5; 7; 8	3
B)	36; 60.0%	17; 28.3%	5; 8.3%	6.3	6	5	5; 6; 8	3
C)	17; 28.3%	11; 18.3%	0; 0.0%	4.6	5	5	3; 5; 6	3
D)	46; 76.7%	35; 58.3%	12; 20.0%	7.4	8	9	6; 8; 9	3
E)	37; 61.7%	19; 31.7%	5; 8.3%	6.4	6	5	5; 6; 8	3
F)	8; 13.3%	0; 0.0%	0; 0.0%	3.4	3	3	2; 3; 5	3

Interpretation**:** Majority of respondents expect a positive attitude towards AAL system by patients and their relatives. There is a strong correlation between answers on questions A) and D). Spearman Rho rs = 0.5324. P-value is 0.000001.

V.6.8. Administrative and Financial Questions.

A) “AAL for patients with MCI is difficult to organize”.

B) “AAL for MCI patients is expensive”.

C) “AAL for patients with MCI is easy to organize and finance”.

Table 29: Administration and finance. Descriptive statistics by statements

Statement	Likert 6-10	Likert 8-10	Likert 10	Mean	Median	Mode	Quartiles	IQR
A)	36; 60.0%	23; 38.3%	9; 15.0%	6.1	6	3	3; 6; 8	5
B)	49; 81.7%	40; 66.7%	20; 33.3%	7.9	9	10	7; 9; 10	3
C)	17; 28.3%	11; 18.3%	2; 3.3%	4.4	4	3	2.5; 4; 6	3.5

Interpretation**:** There is general consensus that the AAL system for MCI patients is quite difficult to organize and finance. These answers are significantly more skeptical, than about the general AAL system, described in 4. The results can reflect an impression that the AAL system for MCI patients is more complicated than AAL for general purposes.

V.6.9. AAL for MCI Patients. Analysis and Conclusion.

Majority of respondents see the AAL system as a good addition to the healthcare solutions for home-based patients with MCI. Any AAL system has to register somatic emergencies. AAL system for MCI patients has to register unusual behavior, sleep disturbances and psychiatric emergencies. The AAL system for MCI patients has to include instruments for memory training and support. Most of the respondents consider higher convenience of wireless devices. Smartphones and tablets are the best computing devices on the patient's side. In addition to usual sensors there is necessity to add controlling sensors for doors, windows, smart control of water flow and gas leaks. Majority of respondents see AAL system able to register ADL and IADL automatically, with necessity to register day and night routine. The unusual night activities can be a potential sign of mental deterioration. Most of the respondents also suppose AAL system should be able to signal about suicide risks. There is a tendency to put health problems before privacy problems.

Most of the respondents expect positive attitude of patients and relatives. However, there is general consensus that the AAL system for MCI patients is quite difficult to organize and finance.

V.7. Opinions about AAL System for Patients with MCI.

There are 60 commentaries, built as completion of the sentence: “In my opinion, the AAL system for patients with MCI (please, write down your answer)”. An open-ended question leaves enough room for the unconfined answer ending.

Forty-one (41) respondents demonstrated various levels of positive reaction, from measured one to an absolute and full support. Many of respondents pointed to the possibility of implementing AAL immediately and part of them declared that it should be done as soon as possible.

Two (2) of respondents declared insufficient expertise to say anything. One of them guessed that AAL for MCI might be a good idea.

Four (4) respondents think the idea is hard to develop and implement technically and financially, it is too expensive and too complicated.

Four (4) respondents see the proposal in positive light or call the idea “great”. But, according to their opinion, it is not practical today. Possibly it could be implemented in the far future. In some countries, not wealthy enough to spend resources on the AAL, it will appear in a hundred years. Two (2) mentioned insufficient educational level of patients to use such systems.

Another five (5) mentioned positive development, but mentioned the necessity to work more on it. Some respondents believe that AAL for MCI patients is feasible only in wealthy states.

Two (2) respondents mentioned good and timely reasons for AAL implementation: usefulness, higher safety for home-based patients, but reminded about “mild privacy invasion”, inability of the system to work in an autonomous state and potential dangers.

Short, one word or phrase – 33 answers.

Medium length, one sentence – 20 answers.

Long and detailed opinion – 7 answers.

All but one long commentary are positive vision and strong sides of AAL for MCI patients. One commentary is more skeptical: the respondent keeps the opinion, that AAL system is not suitable for MCI patients – it is hard for them to comply. But the system will be useful for relatives of patients.

Qualitative, conceptual evaluation of the AAL system for MCI patients in current research is made mostly by people without experience of AAL in practice. Nevertheless, a significant majority see the future of the system positively. The main areas of concern are: appropriate structure, adequate engineering solution, accurate assessment of the patient before using the system, adequate management, information security, proper combination of automatic care and traditional healthcare.

Negative commentators mention mainly technical difficulties and financial limitations. Some respondents do not believe it can be administered properly.

There is correlation between positive and negative reflections and answers on other questions in the questionnaire.

V.8. AAL. General Analysis and Conclusion.

The questionnaire is reliable. Cronbach's is $\boldsymbol{\alpha}$ is 0.920; McDonald's $\boldsymbol{\omega}$ is 0.934; Guttman's $\boldsymbol{\lambda}2$ is 0.932. Values above 0.9 may reflect redundancy and multidimensionality of the test with control functions of dimensions. There are 60 participants, who completed the questionnaire. The average age is 50. Gender structure is nearly even, with 29 females and 31 males. There are 43 doctors, of whom two are dental doctors. 17 other specialists are nurses (10), clinical psychologists (3) and paramedics (4). Medical experience is mostly hospital – 61%. Family, district or visiting mode is applied for 27%, while 25% are involved in research. An experience with MCI patients is typical for most of the respondents. Only 25% have rare or no experience. At the same time, 85% have or had some form of direct contact with general patients. Technological skills are mostly declared as “normal” for 63%, 67% together with occasional IT users. Proficient and advanced users take 33%. At the same time, 48% of respondents never used telemedicine and 35% never heard about telemedicine. Only 40% have some sort of knowledge about smart home technologies. 40% never heard about the Internet of Things and 70% never heard about AAL.

The predominant part of the respondents agrees with the generally positive role of the AAL system. A significant majority suppose the AAL system to be effective in the case of somatic emergency, mostly cardio-pulmonary, fall or injury. At the same time, respondents are less sure about psychiatric emergencies, acute infection or changes in chronic condition. Most of the respondents are moderately optimistic about the role of AAL in non-hospital healthcare but see it as mainly a supplementary system and not a complete replacement. Respondents have a positive outlook on the role of AAL system in non-hospital healthcare and are mostly sure it is important today and in the nearest future as an essential complementary element. They are slightly less optimistic about AAL integration by agencies and institutions outside of the healthcare system.

The technological sections were the most laborious part of the questionnaire for the respondents. In computing units smartphone is considered by respondents to be one of the best devices in usability, price, service convenience, energy efficiency; but low in computer power and average in security. Tablet is close behind. Server is considered possessing the highest computer power and security. Microcomputer is perceived as relatively cheap and energy efficient, but not as an important computing device with valuable characteristics. Smartphone and tablet remain the most popular options, especially for patient use. Server and PC are perceived as potentially important, but obviously not necessary. Microcomputer remain not a very popular option in most of the answers. It might reflect the level of knowledge about AAL and IT technologies. General conclusion: There is generally a positive vision of smartphones and tablets in AAL, with less optimism about some other computing devices, e.g. servers and microcomputers. Most probably It shows a personal experience of respondents, not the practical AAL experience.

Wearable sensors are recognized as most important medically, while the role of video cameras and microphone is also high. Air quality and temperature sensors are seen as least important. There is also a clear preference in AAL of smart devices, responsible for vital signs. In the answers is registered moderately positive outlook on the use of COTS devices. There is a preference for wireless connection in the home with AAL, and one of the reasons – health and safety issues from wires and cables. Internet and mobile network are chosen for external connection if the problem of higher security is not involved. Software: medically recognized role of the automatic diagnostic soft. Communication software is perceived as significant for healthcare specialists and patients as well. Automatic reminders and memory training software are acknowledged as important for aged patients, especially for those with cognitive and memory problems.

The majority of respondents consider the AAL system to be a good addition and one of the best solutions for home-based patients with MCI, but not with dementia. AAL system is recognized by the significant majority of respondents as a serious supportive measure for relatives of patients with MCI. Functionality, respondents believe any AAL system has to register somatic emergencies. The answer is the same as for unspecific AAL. Respondents also generally agree that the AAL system for MCI patients has to register unusual behavior, sleep disturbances and, most important, psychiatric emergencies. There is generally a predisposition, that the AAL system for AAL patients is more sensitive to these signals, than general AAL, and includes instruments, registering the level of the memory of the patient. There is general consensus about the necessity for the AAL system for MCI patients to include mechanisms of memory training and support. Most of the respondents overall agree with the higher convenience of wireless devices in the AAL system for MCI patients.

Vitally important sensors have to be part of AAL for MCI patients according to most of the opinions. This includes wearable sensors, door and windows’ sensors, smart water and gas leak sensors. There is less consensus about invasive ones’, such as video camera and microphone, or sensors, controlling positioning and gestures, and smart electricity sensors. A visible disagreement is about the privacy and invasivity of the AAL system for MCI patients. There is a tendency, already appearing in the table about computing devices for smartphones to be seen as the best device on the patient side, with tablets closely behind. The laptop is also acceptable, but less, with a PC below it. The majority of respondents see the AAL system able to register ADL and IADL automatically. They also recognized the necessity to register day and night routines, with the option to report unusual night activities as a potential sign of mental deterioration. Most of the respondents also suppose the AAL system is able to signal about suicide risks. The majority of respondents expect a positive attitude towards AAL system from patients and their relatives. There is a general consensus that the AAL system for MCI patients is quite difficult to organize and finance. These answers are significantly more skeptical, than about the general AAL system. The results can reflect an impression that the AAL system for MCI patients is more complicated than AAL for general purposes.

Chapter VI: Evaluation and Assessment Based on Data Analysis.

VI.1. Comparative Data Analysis.

Descriptive analysis of the whole set results gives sufficient information for the following analysis and preliminary conclusions. A more profound way is to divide the set into groups and make a comparative analysis. For comparison descriptive and correlation analysis is informative. Correlation for non-parametric data can be found with help of Mann-Whitney-Wilcoxon test, MWW, Kruskal–Wallis test, KW and Spearman's ρ test. Mann-Whitney-Wilcoxon Test checks the equality of two ordinal sets of data. Sets can be of unequal size. MWW test calculates “unbiased” U parameter. It checks the equality of distribution and the supposed independence of sets. Kruskal–Wallis test or one-way rank analysis of variance (ANOVA), calculates H parameter to test the mutual dependency of data sets. KW test is designed for two or more sets. The size of data sets can be unequal because the calculation does not involve paired comparison. Spearman's Rho correlation coefficient is a rank analogue of the Pearson coefficient. When the Pearson coefficient is applied for continuous data, Spearman's Rho can be used for non-parametric ordinal data. Two sets of the same size, for example, answers to two questions, are compared pairwise.

VI.1.1 Groups.

There are several principles of group formation The main idea is an ability of comparative analysis with potential counterpart groups in accordance with created thematic axes. In the current research Potential groups for comparative analysis are listed below. Details of every group will be discussed in related parts.

1 The groups of respondents, who are psychiatrists, neurologists, geriatricians, family doctors, medical psychologists, and their counterparts. There are groups of: psychiatrists (Psy); psychiatrists, neurologists, geriatricians (PNG); psychiatrists, neurologists, geriatricians, family doctors, medical psychologists, or associated professionals (PNG&AP). The counterpart groups are other than PNG (Non-PNG) and other than PNG&AP (Non-PNG&AP).

2 The groups of respondents who have professional experience with MCI dementia

and patients: routine medical experience (RME); institutional experience and experience with home-based patients (IE); medical and institutional (MIE) experience; rare or no experience (NoE); any experience (Ex) with MCI patients, including non-clinical. Counterpart groups are respondents who have: no institutional experience (No-IE); no medical or institutional experience (No-MIE); no experience whatsoever (NoE).

3 The groups of respondents with hospital work experience and combinations with family and visiting specialists: hospital experience only (HEO); hospital experience plus, including work outside of hospital (HEP); hospital experience united, combining first two groups (HEU). The counterpart groups are: non-hospital main clinical experience only (NoH); non-clinical or hospital non-clinical main experience only, (NoCP); non-hospital main experience plus (NoHP), combining two previous counterpart groups.

4 The group of mentioned clinical experience (CLEXP) and counterpart group (NoCLEXP).

5 The groups of respondents, which have: professional and semi-professional IT skills (PROF); advanced IT skills (ADV); combined group of proficient and advanced IT users (PROFADV). The counterpart group consists of respondents with normal IT skills and occasional use of IT (NORMOC).

6 The group of respondents with university educated medical specialists (UNIM) and those, who has other university degree or non-university degree (Non-UNIM): paramedics, nurses and clinical psychologists.

VI.1.2. Psychiatrists and Related Specialists.

There are 9 psychiatrists and narcologists, 3 neurologists, 2 geriatric consultants, 1 family doctor and 3 clinical psychologists between respondents. It would be reasonable to unite them as most competent in understanding and treatment of MCI condition. The following groups are formed:

1) Psychiatrists only (Psy), N=9;

2) Psychiatrists, neurologists and geriatricians (PNG), N=14;

3) Psychiatrists, neurologists, geriatricians and associated professionals such as clinical psychologists and GP (PNG&AP) N=18;

4) Counterpart respondents group, who are not psychiatrists, neurologists or geriatricians (Non-PNG), N=46;

5) Another counterpart group, which excludes associated professionals (Non-PNG&AP), N=42.

Table 30: Groups of specialists with psychiatric and associate experience

Members of the group	Size of the group	Abbreviated name	Average age, years	Main counterpart group
Psychiatrists, Neurologists and Geriatricians	N=14	PNG	52.2	Non-PNG
All respondents other than PNG	N=46	Non-PNG	49.2	PNG
Psychiatrists	N=9	Psy	53.1	Non-PNG Non-PNG&AP
Psychiatrists, Neurologists, geriatricians and associated professionals such as Psychologists and GP	N=18	PNG&AP	52.0	Non-PNG&AP
All respondents other than PNG&AP	N=42	Non-PNG&AP	49.0	PNG&AP PNG Psy

Interpretation**:** Age distribution in formed groups is relatively similar, with average age from 49 to 53.

Q-Q plot shows age distribution in every group. They are comparable on the basis of the age distribution.

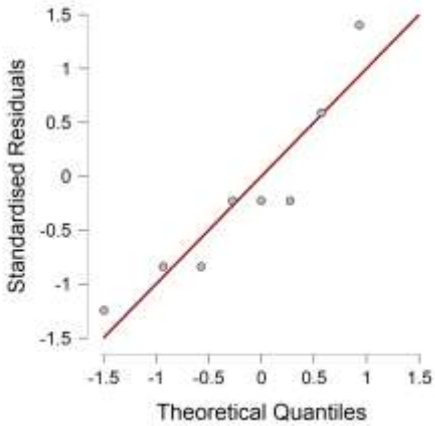

Figure 21: Age distribution Q-Q - plot for PSY group

Interpretation: The Psy group is small, but distribution is relatively close to the line

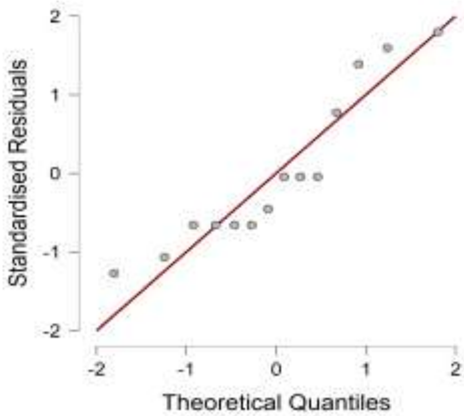

Figure 22: Age distribution Q-Q plot for PNG group

Interpretation: The age values of PNG group are around the line

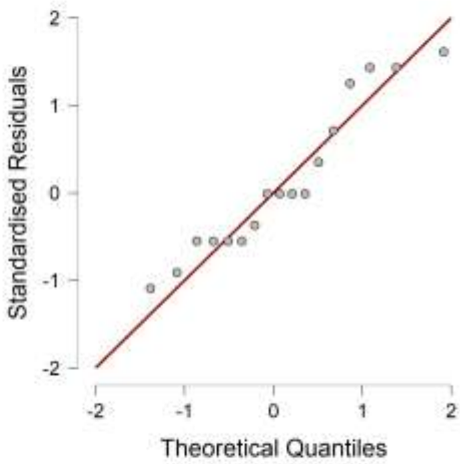

Figure 23: Age distribution Q-Q plot for PNG&AP group

Interpretation: Age distribution in the combined group PNG&AP is around the line

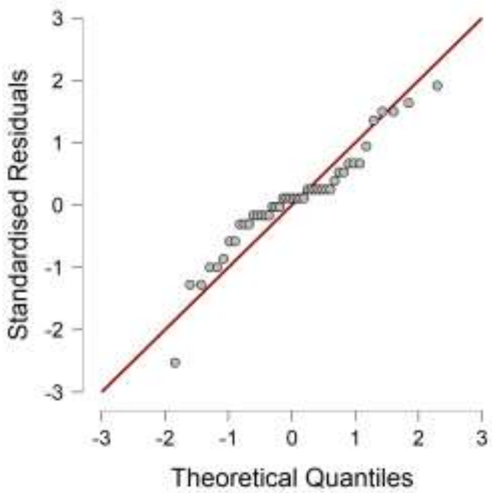

Figure 24: Age distribution Q-Q plot for Non-PNG group

Interpretation: Age distribution for Non-PNG group is relatively stable around the line

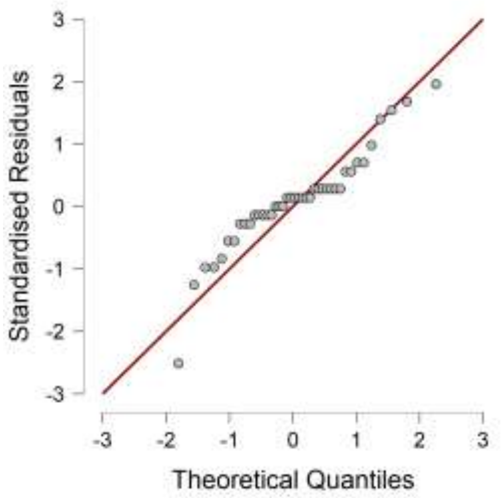

Figure 25: Age distribution Q-Q plot for Non-PNG&AP group

Interpretation: Age distribution for Non-PNG&AP group is around the line

VI.1.2/1. Relevant Statements.

There are number of statements, on which these groups MWW test p-value is less than 0.05, with Vovk-Sellke maximum p-ratio (MPR) 2.46 and above. There are also statements with p-value for MWW from 0.05 to 0.1 and KW p-values often less than 0.05. Statements with p-values between 0.05 and 0.1 for MWW test and higher than 0.05 for KW test are excluded from further investigations.

1) Section 6, statement D) “AAL system is inconvenient for MCI patients“.

2) Section 6, statement E) “AAL system is too complicated to be used for patients with MCI”.

3) Section 7, statement B) “AAL system must send an immediate report about psychiatric emergency”.

4) Section 7, statement C) “AAL system has to diagnose the level of cognitive deterioration”.

5) Section 7, statement F) “AAL system has to include specific software for a regular memory check”.

6) Section 8, statement F) “AAL system for patients with MCI has to collect information

automatically from an electronic thermometer, blood pressure machine, pulse oximeter, glucometer and other vital signs measuring devices”.

7) Section 9, statement E) “Video camera and microphone can be used in AAL for patients with MCI for communication only”.

8) Section 9, statement L) “Smart electricity meters have to report about electricity usage pattern: day and night, unusual peak activities in AAL system for patients with MCI”.

9) Section 10, statement E) “A smartphone is the most convenient computing device on the patient's home side in AAL system for patients with MCI”

10) Section 11, statement C) “It is important to register automatically day and night routine activity and find out abnormalities”.

11) Section 12, statement C) “Patient’s health and privacy are equally important in AAL”.

12) Section 12, statement F) “Emotionally sensitive patients are not advised to live in a home with the AAL system”.

VI.1.2/2. Psychiatrists vs Non-PNG and Non-PNG&AP groups.

The table shows main descriptive for Psy group and MWW&KW results for Psy vs Non-PNG (p- value 1) and Psy vs Non-PNG&AP (p-value 2).

Table 31: Descriptive statistics and MWW&KW comparative results for Psy group

Statement	Mean Psy	Median Psy	Mode Psy	MWW p-value 1	KW p-value 1	MWW p-value 2	KW p-value 2
1)	1.9	2	2	0.042	0.017	0.024	0.023
2)	3	3	1	0.053	0.049	0.073	0.063
3)	7.4	9	10	0.059	0.016	0.062	0.023

4)	5.9	7	7	0.028	0.008	0.021	0.012
5)	4.9	6	2	0.025	0.011	0.018	0.011
6)	8	9	9	0.048	0.191	0.068	0.131
7)	4.1	3	1	0.067	0.041	0.083	0.123
8)	6.6	7	5	0.031	0.113	0.062	0.067
9)	5.7	4	3	0.037	0.007	0.055	0.002
10)	6.2	8	8	0.046	0.088	0.056	0.085
11)	4.2	5	2	0.009	0.006	0.007	0.008
12)	3	2	2	0.034	0.037	0.024	0.051

***Interpretation*:** respondents from the group Psy are positively disposed towards the AAL system for MCI patients. In some statements, 1), 2) and 7) they have a more positive outlook with fewer limitations. In statements 3), 4), 8), 10) they are more skeptical, but still in the area above 6 in the Likert scale. However, there is significant skepticism about the technological abilities or necessities of the AAL system, demonstrated in statements 5), 6), 9). Statement 11) shows primary concerns with patients' health, which is seen as more important than privacy. Statement 12 reflects skepticism in the ability of the healthcare system to implement AAL for MCI patients.

VI.1.2/3. PNG vs Non-PNG.

In the table used statements from the previous section.

Table 32: PNG vs Non-PNG

Statement	Mean	Median	Mode	MWW	KW

	PNG	PNG	PNG	p-value	p-value
1)	2.4	2	2	0.046	0.026
2)	3.3	3	3	0.039	0.037
3)	8.3	10	10	0.227	0.131
4)	6.8	7	7	0.091	0.059
5)	5.7	6	2	0.056	0.029
6)	8.3	9	9	0.084	0.277
7)	4.3	3	1	0.038	0.033
8)	6.5	6.5	5	0.032	0.051
9)	6.6	8	9	0.307	0.073
10)	6.9	8	8	0.164	0.249
11)	4.9	5	2	0.018	0.013
12)	5.4	5	4	0.860	0.253

Interpretation**:** the PNG group shares with Psy group differences with Non-PNG specialists on statements 1), 2), 5), 7), 8), 11) while all other statements are more in line with non-PNG group.

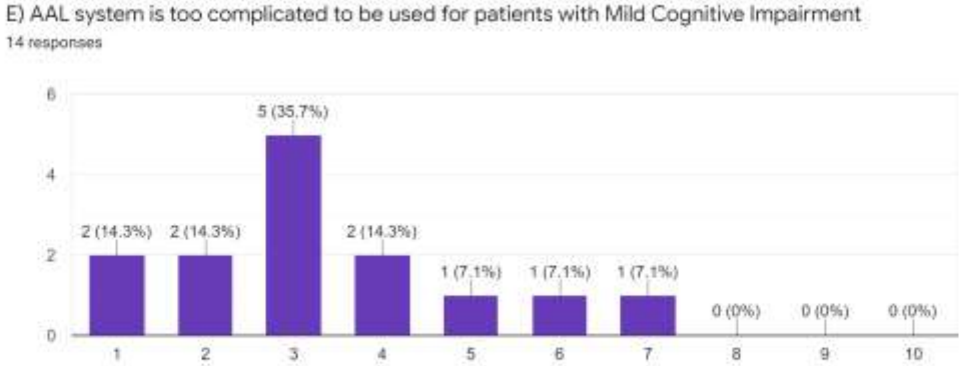

Figure 26: Histogram, statement 2) for PNG group

***Interpretation*:** majority of answers is lower than 5.

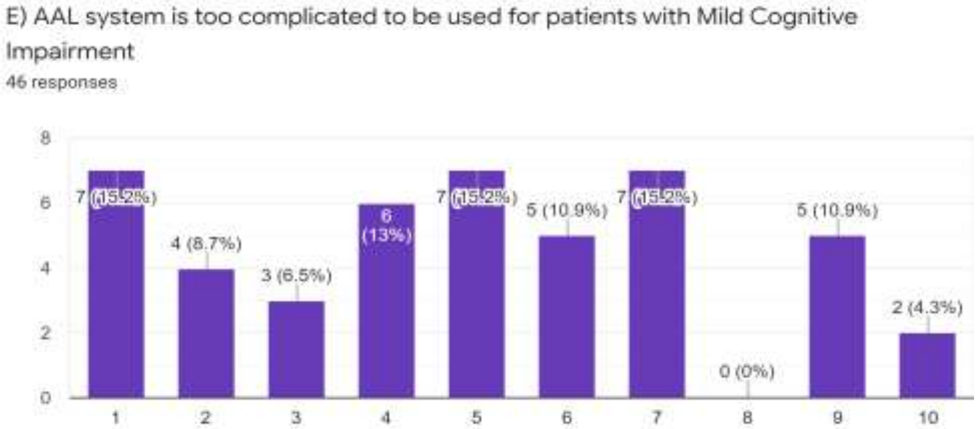

Figure 27: Histogram, statement 2) for Non-PNG group

Interpretation: while answers are distributed relatively equally across the scale, the tendency is more towards more skeptical options.

Neurologists and geriatricians make a difference in those opinions. Artificially created paired groups where halves of PNG and Non-PNG groups were mixed, did not show any significant p-value in the listed statements besides statement 10), which is not presented in the original PNG vs Non-PNG comparison.

VI.1.2/4. PNG & AP.

PNG&AP vs Non-PNG&AP.

Associated professionals include GP and clinical psychologists.

Table 33: PNG&AP vs Non-PNG&AP

Statement	Mean PNG&AP	Median PNG&AP	Mode PNG&AP	MWW p-value	KW p-value
1)	3	2.5	2	0.211	0.131
2)	3.8	3.5	3	0.164	0.165
3)	8.6	10	10	0.349	0.272
4)	7.2	7	7	0.283	0.211
5)	6.3	7	7	0.267	0.185
6)	8.2	9	10	0.045	0.103
7)	5	4	1	0.153	0.123
8)	6.3	5.5	5	0.003	0.006
9)	6.4	7.5	9	0.065	0.009
10)	7	8	8	0.114	0.220
11)	5.4	5	5	0.065	0.059
12)	4.8	4.5	2	0.896	0.920

Interpretation**:** the PNG& AP group shares with Psy group differences with Non-PNG&AP only on statements 9). There is outstanding value for statement 8), which demonstrates skepticism of clinical psychologists and GP about the possibility to use smart electricity meters to register day and night activity. Still, the Likert scale in this answer shows middle numbers.

VI.1.2/5. Analysis of Statistics for PNG&AP Group.

Psychiatrists and close professionals show positive attitude towards the AAL system for MCI patients. Psychiatrists do not see specific clinical limitations for these patients to use AAL system, even in the case of additional psychiatric complications. However, they show skepticism about technical abilities to register intellectual decline or suicidal risks. These statements are taken less skeptically by associated specialists, besides the possibility of activity measurement by electricity smart meter, where skepticism of associated specialists is higher. There is a tendency for psychiatrists and, to lesser extent, associated specialists, to be concerned more with health issues, than with privacy of the patients.

VI.1.3. Matrix Questions. AAL Role in a Healthcare.

Some table questions demonstrate difference between groups with chi-square p-value lower than 0.1. The Likelihood Ratio is also used as an additional measure for small sets. Psy group is excluded from the analysis because of the small size. Technology table questions have more than one option per line and also excluded from chi square and Likelihood ratio analysis.

VI.1.3/1. Psychiatrists vs Non-PNG.

1)

Table 34: Psy vs Non-PNG matrix question. AAL replaces most of the non-hospital

healthcare

AAL replaces most of the non-hospital healthcare	Non-PNG	PSY	Total
Distant future (50 and more years)	7	2	9
Future (10-50 years)	20	0	20
Nearest future (5-10 years)	9	2	11
Never	9	5	14
Today	1	0	1
Total	46	9	55

Table 35: Psy vs Non-PNG matrix question. AAL replaces most of the non-hospital healthcare. Chi-square and LR

Interpretation: there is general skepticism about quick implementation of AAL as a replacement of most of non-hospital healthcare, with some technical difference between groups

	Value	df	p
X^2	8.191	4	0.085
Likelihood ratio	10.807	4	0.029

Interpretation: the difference between groups is shown in the results

2) Table 36: Psy vs Non-PNG matrix question. All homes have to be built with AAL option

All homes have to be built with AAL option	Non-PNG	PSY	Total
Distant future (50 and more years)	6	0	6
Future (10-50 years)	7	4	11
Nearest future (5-10 years)	16	1	17
Never	5	3	8
Today	12	1	13
Total	46	9	55

Interpretation: Non-PNG groups I more optimistic

Table 37: Psy vs Non-PNG matrix question. All homes have to be built with AAL option. Chi-square and LR

	Value	df	p
X^2	9.079	4	0.059
Likelihood ratio	9.359	4	0.053

Interpretation**:** the difference between groups in opinion is quite significant

Commentary: group Psy in comparison with Non-PNG group demonstrates skepticism about future implementation of AAL system.

VI.1.3/2. Psychiatrists vs Non-PNG&AP.

1)

Table 38: Psy vs Non-PNG&AP. AAL replaces part of the non-hospital healthcare

AAL replaces part of the non-hospital healthcare	Non-PNG&AP	PSY	Total
Distant future (50 and more years)	3	0	3
Future (10-50 years)	7	5	12
Nearest future (5-10 years)	27	3	30
Today	5	1	6
Total	42	9	51

Interpretation: Psy group is more skeptical

Table 39: Psy vs Non-PNG&AP. AAL replaces part of the non-hospital healthcare. Chi-square and LR

	Value	df	p
X^2	6.618	3	0.085
Likelihood ratio	6.320	3	0.097

Interpretation: p-ratio is less than 0.1

2)

Table 40: Psy vs Non-PNG&AP. AAL replaces most of the non-hospital healthcare

AAL replaces most of the non-hospital healthcare	Non-PNG&AP	PSY	Total
Distant future (50 and more years)	6	2	8
Future (10-50 years)	18	0	18
Nearest future (5-10 years)	9	2	11
Never	8	5	13
Today	1	0	1
Total	42	9	51

Interpretation: Non-PNG&AP group is significantly more optimistic

Table 41: Psy vs Non-PNG&AP. AAL replaces most of the non-hospital healthcare. Chi-square and LR

	Value	df	p
X^2	8.247	4	0.083
Likelihood ratio	10.780	4	0.029

Interpretation: p-ratio shows difference between views of groups

3)

Table 42: Psy vs Non-PNG&AP. All homes have to be built with AAL option

All homes have to be built with AAL option	Non-PNG&AP	PSY	Total
Distant future (50 and more years)	5	0	5
Future (10-50 years)	5	4	9
Nearest future (5-10 years)	15	1	16
Never	5	3	8
Today	12	1	13
Total	42	9	51

Interpretation: Psy group is more skeptical

Table 43: Psy vs Non-PNG&AP. All homes have to be built with AAL option. Chi-square and LR

	Value	df	p
X^2	10.005	4	0.040
Likelihood ratio	10.049	4	0.040

Interpretation: p-ratio for chi-square and LR is close and shows significance below 0.1

4)

Table 44: Psy vs Non-PNG&AP. AAL is administratively easy to organize.

AAL is administratively easy to organize	Non-PNG&AP	PSY	Total
Distant future (50 and more years)	4	0	4
Future (10-50 years)	12	1	13
Nearest future (5-10 years)	20	5	25
Never	0	3	3
Today	6	0	6
Total	42	9	51

Interpretation: Psy group is consistently skeptical

Table 45: Psy vs Non-PNG&AP. AAL is administratively easy to organize. Chi-square and LR

	Value	df	p
X^2	17.125	4	0.002
Likelihood ratio	15.461	4	0.004

Interpretation: p-ration is really significant for chi-square and LR

Commentary: group Psy in comparison with Non-PNG&AP group demonstrates skepticism about future implementation of AAL system, but very optimistic in the vision of administrative easiness of its organization.

VI.1.3/3. PNG vs Non-PNG.

1)

Table 46: PNG vs Non-PNG. AAL replaces part of the non-hospital healthcare

AAL replaces part of the non-hospital healthcare	Non-PNG	PNG	Total
Distant future (50 and more years)	3	0	3
Future (10-50 years)	8	6	14
Nearest future (5-10 years)	30	5	35
Today	5	3	8
Total	46	14	60

Interpretation: PNG group is more skeptical

Table 47: PNG vs Non-PNG. AAL replaces part of the non-hospital healthcare. Chi-square and LR

	Value	df	p
X^2	6.395	3	0.094
Likelihood ratio	6.778	3	0.079

Interpretation: p-value is less significant, than in the case of Psy group

2)

Table 48: PNG vs Non-PNG. All homes have to be built with AAL option.

All homes have to be built with AAL option	Non-PNG	PNG	Total
Distant future (50 and more years)	6	0	6
Future (10-50 years)	7	7	14
Nearest future (5-10 years)	16	1	17
Never	5	4	9
Today	12	2	14
Total	46	14	60

Interpretation: PNG group is more skeptical

Table 49: PNG vs Non-PNG. All homes have to be built with AAL option. Chi-square and LR

	Value	df	p
X^2	13.168	4	0.010
Likelihood ratio	14.330	4	0.006

Interpretation: p-ratio is significant

Commentary: PNG group shows less differences than Psy against Non-PNG, but still more reserved about future of AAL.

VI.1.3/4. PNG&AP vs Non-PNG&AP.

1)

Table 50: PNG&AP vs Non-PNG&AP. All homes have to be built with AAL option

All homes have to be built with AAL option	Non-PNG&AP	PNG&AP	Total
Distant future (50 and more years)	5	1	6
Future (10-50 years)	5	9	14
Nearest future (5-10 years)	15	2	17
Never	5	4	9
Today	12	2	14
Total	42	18	60

Interpretation: PNG&AP is more skeptical

Table 51: PNG&AP vs Non-PNG&AP. All homes have to be built with AAL option. Chi-square and LR

	Value	df	p
X^2	13.577	4	0.009
Likelihood ratio	13.484	4	0.009

Interpretation: p-value is significant

2)

Table 52: PNG&AP vs Non-PNG&AP. AAL is administratively easy to organize.

AAL is administratively easy to organize	Non-PNG&AP	PNG&AP	Total
Distant future (50 and more years)	4	0	4
Future (10-50 years)	12	3	15
Nearest future (5-10 years)	20	9	29
Never	0	4	4
Today	6	2	8
Total	42	18	60

Interpretation: PNG&AP group is more skeptical

Table 53: PNG&AP vs Non-PNG&AP. AAL is administratively easy to organize. Chi-square and LR

	Value	df	p
X^2	11.872	4	0.018
Likelihood ratio	13.370	4	0.010

Interpretation: p-value is significant

3)

Table 54: PNG&AP vs Non-PNG&AP. AAL is technically feasible.

AAL is technically feasible	Non-PNG&AP	PNG&AP	Total
Distant future (50 and more years)	3	0	3
Future (10-50 years)	11	3	14
Nearest future (5-10 years)	21	6	27
Never	0	1	1
Today	7	8	15
Total	42	18	60

Interpretation: PNG&AP is relatively less skeptical

Table 55: PNG&AP vs Non-PNG&AP. AAL is technically feasible. Chi-square and LR

	Value	df	p
X^2	8.776	4	0.067
Likelihood ratio	9.424	4	0.051

Interpretation: p-value has significance less than 0.1

Commentary: the PNG&AP group is generally more skeptical in questions of implementation of AAL system. At the same time respondents demonstrate more sureness in administrative and technical possibilities to implement it today.

VI.1.3/5. Analysis and Conclusion.

Psy, PNG and PNG&AP groups show a mixture of skepticism and optimism about the implementation of the general AAL system and AAL for MCI patients. Skepticism is shown in the statements about specific technical abilities of the system to register a change in the condition or necessity to have it. An optimistic part is demonstrated about the potential technical and administrative implementation of the general AAL system and the suitability of AAL for MCI patients.

VI.1.4. Experience of Contact with MCI and Dementia Patients.

Responses were allowed on more than one option. groups are formed in accordance with the sole answer or first answers in the table. There are:

1. 49 respondents who have professional or outside duties contact with MCI or dementia patients. This number includes 35 respondents with routine contacts, 11 with main experience in the specialized institutes and 3 respondents with main experience outside of duties.

2. 11 respondents have primarily rare or no contact.

3. 35 respondents have contact as part of a medical routine.

4. 11 respondents have claimed main experience with institutionalized or home-based patients.

3 respondents primary experience as outside of duties.

The following groups are formed:

1) Routine medical experience (RME) with MCI patients, N=35;

2) Institutional experience and with home-based patients (IE), N=11;

3) Medical and institutional (MIE) experience, N=46 (RME+IE, 35+11);

4) Rare or No experience with MCI patients (NoE), N=11;

5) Experience (any) with (Ex) MCI patients, N=49.

Table 56: Respondents with experience of contact with MCI and dementia patients.

Groups

Members of the group	Size of the group	Abbreviated name	Average age	Main counterpart group
Routine medical experience	N=35	RME	50.5	NoE No-MIE
Institutional Experience	N=11	IE	48.8	Non-IE NoE
Medical and institutional experience	N=46	MIE	50,1	No-MIE
Rare or No experience with MCI patients	N=11	NoE	48.8	IE Ex
Experience (any) with MCI patients	N=49	Ex	50.1	NoE
No Medical and institutional experience	N=14	No-MIE	49.2	RME MIE
No Institutional Experience	N=49	Non-IE	50.1	IE

Interpretation: average age is close for all the groups

Q-Q plot shows age distribution in every group. They are relatively comparable on the basis of the age distribution.

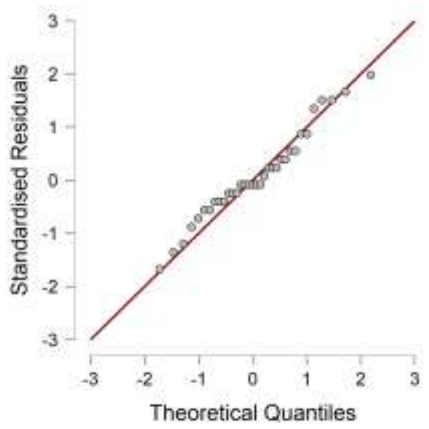

Figure 28: Age distribution for RME group

Interpretation: age distribution of RME is close to the line

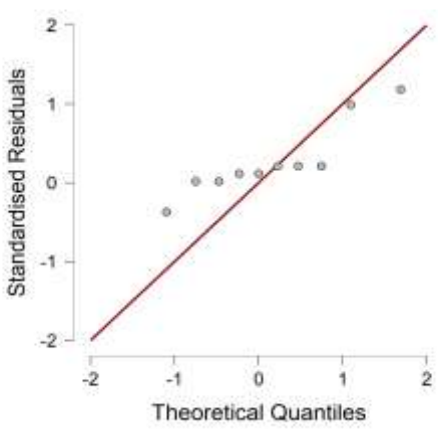

Figure 29: Age distribution Q-Q plot for NoE group

Interpretation: age in NoE group is distributed around the line with some shift demonstrating lesser age unity

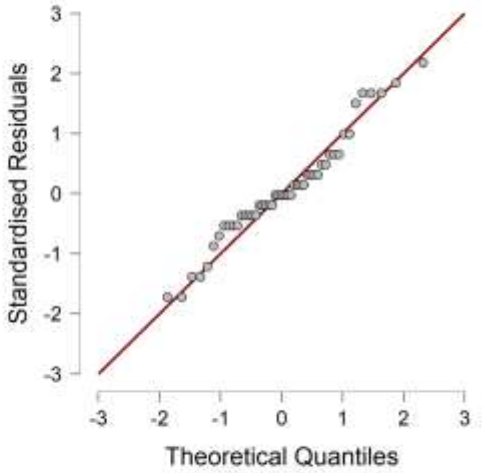

Figure 30: Age distribution Q-Q plot for Ex group

Interpretation: age distribution of Ex group is close to the line

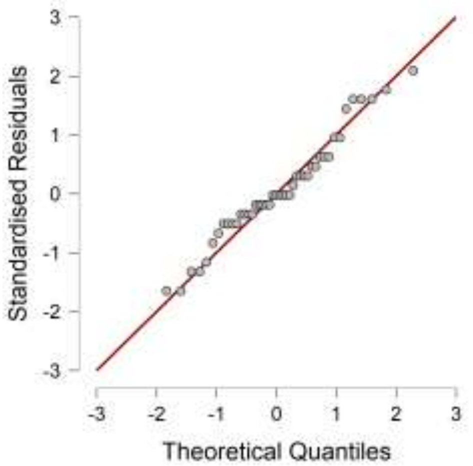

Figure 31: Age distribution Q-Q plot for MIE group

Interpretation: age distribution in MIE is close to the line, very similar to RME with small differences

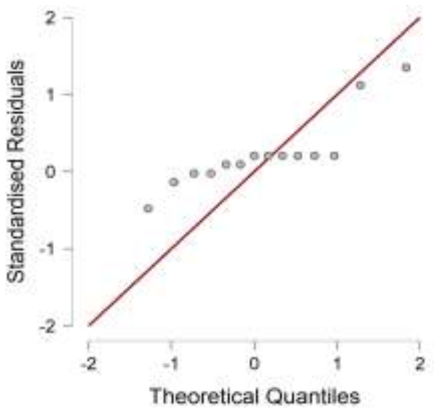

Figure 32: Age distribution, Q-Q plot for No-MIE group

Interpretation: age distribution in No-MIE group shows some spread

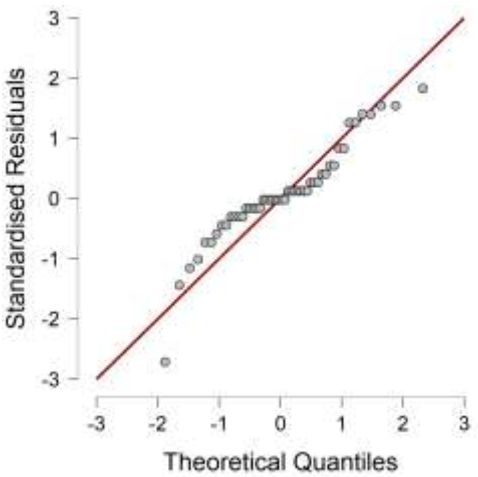

Figure 33: Age distribution, Q-Q plot for Non-IE group

Interpretation: age distribution in Non-IE group is relatively close to the line

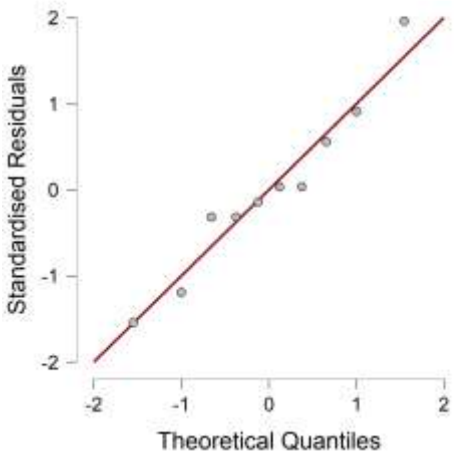

Figure 34: Age distribution, Q-Q plot for IE group

Interpretation: age distribution in IE is close to the line

VI.1.4/1. Relevant Statements.

There are number of statements, on which these groups MWW test p-value is less than 0.1, with Vovk-Sellke maximum p-ratio (MPR) 1.6 and above. Every statement showed the required p-value at least once in one paired comparison.

1) Section 6 G) "AAL system is a good support for relatives of patients with MCI".

2) Section 8 C) AAL system for MCI patients has to include electronic tablet dispenser with an automatic reminder

3) Section 8 G) "AAL system has to remind about the necessity to measure blood pressure or blood glucose".

4) Section 10 A) "The server for the healthcare stakeholder side and server in the patient's home side is the best configuration in AAL system for patients with MCI".

5) Section 10 E) "A smartphone is the most convenient computing device on the patient's home side in AAL system for patients with MCI".

6) Section 12 A) "Patient's health is more important than privacy issues in AAL".

7) Section 12 F) "Emotionally sensitive patients are not advised to live in a home with the AAL system".

8) Section 13 B) Some of the patients with MCI are skeptical about home AAL

9) Section 13 F) “Majority of the relatives have a negative attitude towards the home AAL”.

10) Section 14 A) “AAL for patients with MCI is difficult to organize”.

11) Section 14 B) “AAL for MCI patients is expensive”.

12) Section 14 C) “AAL for patients with MCI is easy to organize and finance”.

VI.1.4/2. MWW Paired Comparison Results.

In the table is shown MWW p-value for every paired comparison.

Table 57: MWW paired comparison results.

	RME vs NoE	Ex vs NoE	MIE vs No-MIE	RME vs No-MIE	IE vs Non-IE	MIE vs NoE	IE vs NoE	Pairs with p-value > 0.1
1)	0.046	0.039	0.034	0.047	0.414	0.034	0.089	RME vs NoE Ex vs NoE MIE vs No-MIE RME vs No-MIE MIE vs NoE IE vs NoE
2)	0.115	0.219	0.115	0.068	0.523	0.171	0.743	RME vs No-MIE
3)	0.063	0.219	0.136	0.053	0.343	0.165	0.798	RME vs No-MIE

4)	0.577	0.878	0.945	0.701	0.074	0.909	0.270	IE vs Non-IE
5)	0.979	0.831	0.248	0.509	0.025	0.659	0.108	IE vs Non-IE
6)	0.106	0.145	0.052	0.052	0.952	0.109	0.313	MIE vs No-MIE RME vs No-MIE
7)	0.128	0.133	0.036	0.068	0.424	0.080	0.072	MIE vs No-MIE RME vs No-MIE MIE vs NoE IE vs NoE
8)	0.206	0.083	0.749	0.847	0.904	0.135	0.102	Ex vs NoE
9)	0.446	0.876	0.715	0.359	0.048	0.826	0.197	IE vs Non-IE
10)	0.138	0.053	0.423	0.564	0.412	0.084	0.070	Ex vs NoE MIE vs NoE IE vs NoE
11)	0.395	0.126	0.367	0.755	0.034	0.157	0.014	IE vs Non-IE IE vs NoE
12)	0.491	0.275	0.412	0.661	0.106	0.278	0.070	IE vs NoE

Interpretation: statements with significant difference for groups are discussed in commentaries.

Table 58: Significant groups` paired comparison by statements.

Statement	Pairs with p-value > 0.1	MWW p-value	KW p-value	Relevant Mean	Relevant Median	Relevant Mode
1)	RME vs NoE	0.046	0.044	8.6	9	10
1)	Ex vs NoE	0.039	0.038	8.6	9	10
1)	MIE vs No-MIE	0.034	0.033	8.6	9	10
1)	RME vs No-MIE	0.047	0.046	8.6	9	10
1)	MIE vs NoE	0.034	0.033	8.6	9	10
1)	IE vs NoE	0.089	0.083	8.7	9.5	10
2)	RME vs No-MIE	0.068	0.066	8.8	10	10
3)	RME vs No-MIE	0.053	0.052	9.3	10	10
4)	IE vs Non-IE	0.074	0.072	7	8	10
5)	IE vs Non-IE	0.025	0.025	6.5	7	7
6)	MIE vs No-MIE	0.052	0.051	6.6	6	5
6)	RME vs No-MIE	0.052	0.051	6.5	6	5
7)	MIE vs No-MIE	0.036	0.036	4.4	4	4

7)	RME vs No-MIE	0.068	0.066	4.5	4	5
7)	MIE vs NoE	0.080	0.079	4.4	4	4
7)	IE vs NoE	0.072	0.067	4.1	4.5	6
8)	Ex vs NoE	0.083	0.082	6.5	6	5
9)	IE vs Non-IE	0.048	0.047	4.4	4.5	5
10)	Ex vs NoE	0.053	0.052	6.4	7	3
10)	MIE vs NoE	0.084	0.082	6.3	7	3
10)	IE vs NoE	0.070	0.065	6.8	6.5	6
11)	IE vs Non-IE	0.034	0.034	9.2	10	10
11)	IE vs NoE	0.014	0.013	9.2	10	10
12)	IE vs NoE	0.070	0.064	3.2	3	3

Interpretation: statements with significant difference for groups are discussed in commentaries

Analysis:

a. Most of the groups with experience support the statement 1) “AAL system is a good support for relatives of patients with MCI”.

b. Group with institutional experience, IE, less sure that “A smartphone is the most convenient computing device on the patient's home side in AAL system for patients with MCI”, statement 5).

c. Majority of groups with relevant medical and institutional experience give less support to the statement 7) “Emotionally sensitive patients are not advised to live in a home with the AAL system”. The group with an institutional experience more agree with statements: 9) “Majority of the relatives have a negative attitude towards the home AAL” and 11) “AAL for MCI patients is expensive”.

d. Most other statements in comparisons usually have a p-value higher than 0.05 for the MWW test and KW test. Artificial groups, created from halves of paired groups did not produce any significant p-value for all numbered statements but one. Statement 5) “A smartphone is the most convenient computing device on the patient’s home side in AAL system for patients with MCI” received an unusual p-value less than 0.0001 in several mixtures.

e. Even though selected groups with experience include respondents from previous groups with psychiatric and associated professions there is a difference in many statements and answers.

VI.1.4/3 Matrix Questions. AAL Role in a Healthcare.

Only results with p-value less than 0.1 for chi-square and Likelihood ratio are shown. There is no significant difference in the pair Ex vs NoE, RME vs NoE, RME vs No-MIE, IE vs Non-IE, IE vs NoE.

MIE vs No-MIE.

Table 59: MIE vs No-MIE. AAL is administratively easy to organize

AAL is administratively easy to organize	MIE	No-MIE	Total
Distant future (50 and more years)	1	3	4
Future (10-50 years)	11	4	15
Nearest future (5-10 years)	24	5	29
Never	4	0	4

AAL is administratively easy to organize	MIE	No-MIE	Total
Distant future (50 and more years)	1	3	4
Future (10-50 years)	11	4	15
Today	5	3	8
Total	45	15	60

Interpretation: No-MIE is more skeptical

Table 60: MIE vs No-MIE. AAL is administratively easy to organize. Chi-square and LR

	Value	df	p
X^2	8.287	4	0.082
Likelihood ratio	8.337	4	0.080

Interpretation: p-value is less than 0.1 for chi-square and LR

Analysis: MIE group demonstrates more optimism about administrative organization of general AAL system.

VI.1.5. Hospital and Non-Hospital Experience.

11 respondents marked visiting or family medicine as the only option. 2 – ambulance service only. 8 – medical research or other activities. 2 hospital non-clinical. 22 hospital clinical only. 15 – hospital clinical experience with other experience. groups can be formed as follow:

1) Hospital experience only (HEO), N=22 respondents.

2) Hospital experience plus (HEP), N=15 respondents.

3) Hospital experience united (HEU), N=37 respondents, 1)+2)

4) Non-hospital main clinical experience only (NoH), N=13 respondents.

5) Non-clinical or hospital non-clinical main experience only (NoCP) N=10 respondents.

6) Non-hospital main experience plus (NoHP), N=23 respondents, 4)+5)

Table 61: Hospital and non-hospital experience. Groups

Members of the group	Size of the group	Abbreviated name	Average age	Main counterpart group
Hospital experience only	N=22	HEO	49.1	HEP NoH
Hospital experience plus	N=15	HEP	50.3	HEO NoH
Hospital experience united	N=37	HEU	49.6	NoHP NoCP
Non-hospital main clinical experience only	N=13	NoH	51.3	HEO HEP
Non-clinical or hospital non-clinical main experience only	N=10	NoCP	49.2	HEU
Non-hospital main experience plus	N=23	NoHP	50.4	HEU

Interpretation: average age in groups is from 49.1 to 51.3.

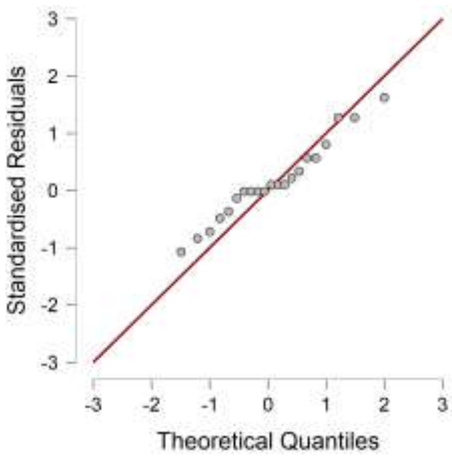

Figure 36: Age distribution, Q-Q plot for HEO group

Interpretation**:** age distribution for HEO group is relatively close to the line

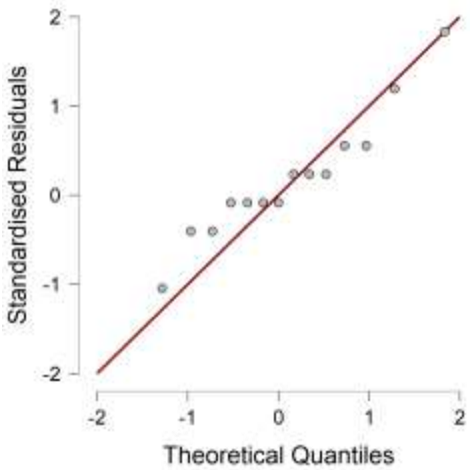

Figure 35: Q-Q plot for age distribution in the group HEP

Interpretation**:** age distribution in HEP group is along the line

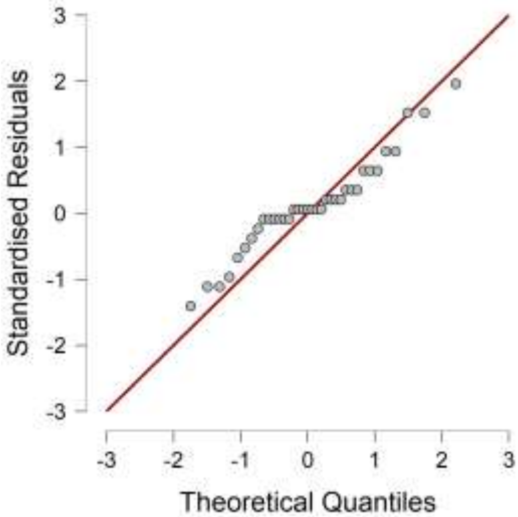

Figure 37: Q-Q plot for age distribution in the group HEU

Interpretation**:** age distribution in HEU group is along the line, similar to HEP

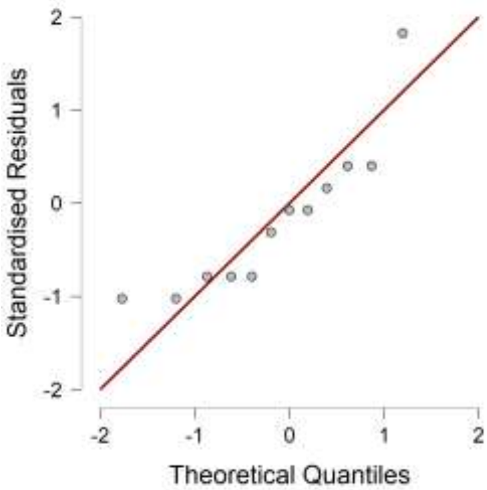

Figure 38: Q-Q plot for age distribution in the group NoH

Interpretation**:** age distribution in NoH group is formed around the line

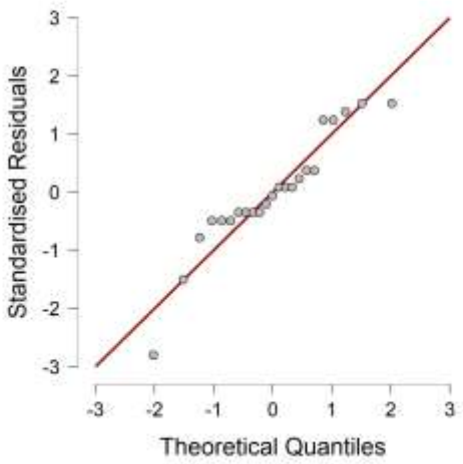

Figure 39: Q-Q plot for age distribution in the group NoHP

***Interpretation*:** age distribution is along the line

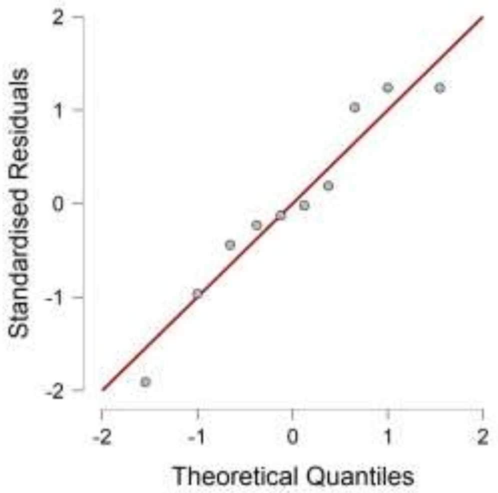

Figure 40: Q-Q plot for age distribution in the group NoCP

***Interpretation*:** age distribution in NoCP group is close to the line

VI.1.5/1. Relevant Statements.

There is a significant number of statements, on which these groups MWW test p-value is less than 0.06, with Vovk-Sellke maximum p-ratio (MPR) 2.18 and above. A level slightly higher than 0.05 is chosen for the KW test p-value differences. Every statement showed the required p-value at least once in one paired comparison.

Section 4:

1) Section 4 F) “AAL system can signal about pulmonary and airways emergency”.

2) Section 4 H) “AAL system can signal about acute infection”.

3) Section 4 I) “AAL system can signal about psychiatric emergency”.

4) Section 4 J) “AAL system can help to signal about fall or trauma at home”.

5) Section 4 L) “AAL system is helpful in a chronic neuropsychiatric condition”.

Section 6:

6) Section 6 A) “AAL system is the best solution for MCI patients”.

7) Section 6 D) “AAL system is inconvenient for MCI patients”.

8) Section 6 F) “AAL system can help patients with dementia, not with MCI”.

9) Section 6 G) “AAL system is a good support for relatives of patients with MCI”.

Sections 7&8:

10) Section 7 F) “AAL system has to include specific software for a regular memory check”.

11) Section 8 G) “AAL system has to remind about the necessity to measure blood pressure or blood glucose”.

12) Section 8 H) “AAL system for patients with MCI elements and devices have to be fully designed by specially designated engineering company”.

13) Section 8 K) “Devices in the AAL system for MCI patients have to be only or mostly wired because it is hard to remember about charging all the batteries”.

Section 9:

14) Section 9 E) “Video camera and microphone can be used in AAL for patients with MCI for communication only”.

15) Section 9 G) “Gesture recognition by active infrared sensors is very important in AAL for patients with MCI”.

16) Section 9 I) “Wearable vital signs` sensors are inconvenient for patients with MCI”.

17) Section 9 J) “Pressure sensors have to be part of smart furniture and have to be mounted on beds, couches, chairs for the position registration of patients with MCI”.

18) Section 9 M) “Smart water meters are necessary in the AAL system for patients with MCI”.

19) Section 9 N) “Temperature and climate regulation sensors are a very important part of AAL for MCI patients”.

Sections 11-14:

20) Section 11 A) “AAL system has to measure ADL automatically”.

21) Section 11 B) “AAL system can measure ADL and IADL automatically”.

22) Section 11 D) “Registered unusual night activity can point on the mental deterioration”.

23) Section 12 A) “Patient’s health is more important than privacy issues in AAL”.

24) Section 12 B) “Privacy is more important than the patient’s health in AAL**”.**

25) Section 12 C) “Patient’s health and privacy are equally important in AAL”.

26) Section 12 E) “Patients with paranoid thoughts are not advised to live in a home with the AAL system”.

27) Section 13 C) “Majority of the patients with MCI have a negative attitude towards home AAL”.

28) Section 14 A) “AAL for patients with MCI is difficult to organize”.

VI.1.5/2. Groups Comparison.

Table 62: MWW p-values for paired hospital experience groups in given statements.

	HEU vs NoHP	HEO vs HEP	HEO vs NoHP	HEU vs NoH	HEU vs NoCP
1)	1.000	0.034	0.422	0.335	0.260
2)	0.079	0.304	0.040	0.013	0.947
3)	0.673	0.035	0.139	0.147	0.332
4)	0.377	0.485	0.681	0.642	0.040
5)	0.628	0.017	0.127	0.183	0.470
6)	0.400	0.040	0.917	0.725	0.310
7)	0.841	0.051	0.452	0.669	0.392
8)	0.208	0.975	0.307	0.047	0.875
9)	0.199	0.551	0.388	0.945	0.023
10)	0.842	0.054	0.456	0.729	0.958
11)	0.531	0.854	0.523	0.021	0.146
12)	0.027	0.210	0.010	0.036	0.179
13)	0.113	0.434	0.110	0.780	0.018
14)	0.055	0.023	0.430	0.009	0.824

15)	0.032	0.719	0.082	0.022	0.338
16)	0.030	0.303	0.134	0.199	0.028
17)	0.029	0.520	0.076	0.347	0.009
18)	0.994	0.021	0.306	0.274	0.195
19)	0.595	0.044	0.730	0.485	0.082
20)	0.011	0.214	0.084	0.127	0.011
21)	0.053	0.438	0.153	0.120	0.141
22)	0.530	0.059	0.852	0.945	0.245
23)	0.497	0.017	0.093	0.557	0.643
24)	0.590	0.016	0.169	0.078	0.256
25)	0.159	0.181	0.054	0.091	0.683
26)	0.442	0.791	0.505	0.630	0.059
27)	0.799	0.024	0.489	0.452	0.181
28)	0.534	0.047	0.854	0.460	0.854

Remark: all significant findings are discussed below.

Table 63: Groups paired comparison with p-value less than 0.06 in MWW.

	Pair with p-value less than	MWW	KW	Relevant	Relevant	Relevant

Statement	0.06	p-value	p-value	Mean	Median	Mode
1)	HEO vs HEP	0.034	0.030	8.8	8	8
2)	HEO vs NoHP	0.040	0.038	6	6	7
2)	HEU vs NoH	0.013	0.012	6.2	6	7
3)	HEO vs HEP	0.035	0.034	5.7	5.5	5
4)	HEU vs NoCP	0.040	0.039	8.6	9	10
5)	HEO vs HEP	0.017	0.017	5.6	6	6
6)	HEO vs HEP	0.040	0.038	7.3	7	6
7)	HEO vs HEP	0.051	0.049	3	2	2
8)	HEU vs NoH	0.047	0.046	4	3	3
9)	HEU vs NoCP	0.023	0.022	8.6	9	10
10)	HEO vs HEP	0.054	0.052	6.3	7	7
11)	HEU vs NoH	0.021	0.020	8.9	10	10
12)	HEU vs NoHP	0.027	0.026	8.3	9	10
12)	HEO vs NoHP	0.010	0.010	8.8	10	10
12)	HEU vs NoH	0.036	0.035	8.3	9	10
13)	HEU vs NoCP	0.018	0.017	7.2	7	10

14)	HEU vs NoHP	0.055	0.054	6.4	8	8
14)	HEO vs HEP	0.023	0.022	5.6	6.5	8
14)	HEU vs NoH	0.009	0.009	6.4	8	8
15)	HEU vs NoHP	0.032	0.032	7	8	9
15)	HEU vs NoH	0.022	0.022	7	8	9
16)	HEU vs NoHP	0.030	0.029	6.1	6	6
17)	HEU vs NoHP	0.028	0.029	7.4	8	9
17)	HEU vs NoCP	0.009	0.009	7.4	8	9
18)	HEO vs HEP	0.021	0.020	6.8	7	7
19)	HEO vs HEP	0.044	0.042	6.5	6.5	8
20)	HEU vs NoHP	0.011	0.011	8.3	9	9
20)	HEU vs NoCP	0.011	0.011	8.3	9	9
21)	HEU vs NoHP	0.053	0.052	8	8	10
22)	HEO vs HEP	0.059	0.057	7.9	8	10
23)	HEO vs HEP	0.017	0.016	6	5	5
24)	HEO vs HEP	0.016	0.016	5	5	5
25)	HEO vs NoHP	0.054	0.053	7.5	8.5	10

26)	HEU vs NoCP	0.059	0.057	5.5	5	5
27)	HEO vs HEP	0.024	0.023	5.2	5	5
28)	HEO vs HEP	0.047	0.045	6.7	7	8

Analysis:

a. 50% of formally significant pairs comparisons consist of HEO vs HEP testing. The hospital experience only (HEO) group usually holds a more skeptical position. Statements 1), 3), 5), 6), 10), 14), 18), 19), 22), 23) demonstrate less sureness in the proposed approach. In statement 7) the HEO group disagree with a statement about the inconvenience of AAL for MCI patients in a more pronounced manner. Statements 24), 27), 28) are negative, and the HEO group supports them more. The group with hospital and external medical experience is more positively disposed towards AAL system and AAL system for MCI patients in most of the statements, besides statement 7).

b. All groups with hospital experience are more medically astute and positive towards AAL system and AAL system for MCI patients, than groups without hospital o clinical experience, as shown in statements 8), 9), 14) 15). They are also less skeptical in negative statements 4), 13), 26). Technically these groups are also more on the side of fully-fledged technical development in the AAL system, as shown in statements 12), 17), 20), 21). Answers on statement 25) appears more balanced than in the case of groups with psychiatric and associated medical experience.

VI.1.5/3 Matrix Questions. AAL Role in a Healthcare.

Statements with p-value 0.1 and lower for chi-square and Likelihood ratio are included. No significance is shown for HEO vs NoHP, HEO vs HEP, HEU vs NoCP.

HEU vs NoHP.

1)

Table 64: HEU vs NoHP. AAL has to be integral part of electronic healthcare system.

AAL has to be integral part of electronic healthcare system	HEU	NoHP	Total
Distant future (50 and more years)	1	2	3
Future (10-50 years)	8	11	19
Nearest future (5-10 years)	15	7	22
Today	13	3	16
Total	37	23	60

Interpretation: group HEU is more optimistic

Table 65: HEU vs NoHP. AAL has to be integral part of electronic healthcare system. Chi-square and LR.

	Value	df	p
X^2	7.085	3	0.069
Likelihood ratio	7.234	3	0.065

Interpretation: p-ratio for group HEU is less than 0.1 for chi-square and LR

2)

Table 66: HEU vs NoHP. All homes have to be built with AAL option.

All homes have to be built with AAL option	HEU	NoHP	Total
Distant future (50 and more years)	1	5	6
Future (10-50 years)	9	5	14
Nearest future (5-10 years)	12	5	17
Never	4	5	9
Today	11	3	14
Total	37	23	60

Interpretation: group HEU is more optimistic, than NoHP

Table 67: HEU vs NoHP. All homes have to be built with AAL option. Chi-square and LR

	Value	df	p
X^2	8.575	4	0.073
Likelihood ratio	8.714	4	0.069

Interpretation: p-ratio for chi-square and LR is less than 0.1

Analysis: respondents with hospital experience are more confident about the integration of the AAL system into the general electronic healthcare system. They are also more optimistic about the inclusion of AAL system into the architecture design of new homes.

HEU vs NoH.

1)

Table 68: HEU vs NoH. AAL has to be integral part of electronic healthcare system.

AAL has to be integral part of electronic healthcare system	HEU	NoH	Total
Distant future (50 and more years)	1	0	1
Future (10-50 years)	8	9	17
Nearest future (5-10 years)	15	3	18
Today	13	1	14
Total	37	13	50

Interpretation: group HEU is significantly more optimistic

Table 69: HEU vs NoH. AAL has to be integral part of electronic healthcare system. Chi-square and LR

	Value	df	p
X^2	10.167	3	0.017
Likelihood ratio	10.372	3	0.016

Interpretation: p-ratio for chi-square and LR is less than 0.02

2)

Table 70: HEU vs NoH. All homes have to be built with AAL option

All homes have to be built with AAL option	HEU	NoH	Total
Distant future (50 and more years)	1	3	4
Future (10-50 years)	9	3	12
Nearest future (5-10 years)	12	1	13
Never	4	3	7
Today	11	3	14
Total	37	13	50

Interpretation: group HEU is more optimistic, than NoH

Table 71: HEU vs NoH. All homes have to be built with AAL option. Chi-square and LR

	Value	df	p
X^2	8.449	4	0.076
Likelihood ratio	8.151	4	0.086

Interpretation: p-ratio is less than 0.1

Analysis: there are two statements with similar results as for pair comparison HEU vs NoHP.

VI.1.6. Clinical Experience.

51 respondents have direct clinical contact with patients, while 9 have rare, indirect or no contact. 5 out of 9 have or had indirect medical contact, 1 respondent – personal administrative. 1 respondent claims no contact with patients. 1 – personal medico-

technical. There are two groups of 51 and 9 respondents.

Table 72: Clinical experience groups

Members of the group	Size of the group	Abbreviated name	Average age	Main counterpart
Direct clinical contact with patients	N=51	CLEXP	50.1	NoCLEXP
Rare, indirect or no contact.	N=9	NoCLEXP	48.9	CLEXP

Interpretation: both groups have relatively close average age, with slightly lover number for NoCLEXP

There are 3 statements, where p-value is lower than 0.1:

1) Section 8, I) “AAL system for patients with MCI is better to build from ready Commercial-Off-The-Shelf (COTS) elements and devices”.

2) Section 10, C) “The laptop is the most convenient computing device on the patient's home side in AAL system for patients with MCI”.

3) Section 10, D) “Computer tablet is the most convenient computing device on the patient’s home side in AAL system for patients with MCI”.

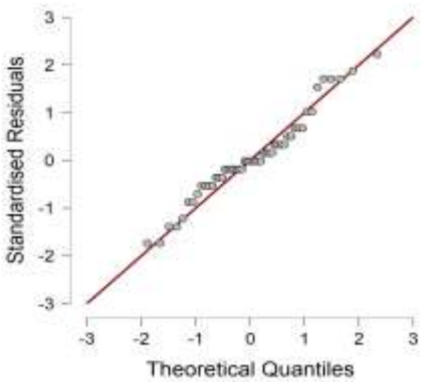

Figure 42: Q-Q plot. Age distribution in the CLEXP group.

Interpretation: group CLEXP has close grouping of values around the line

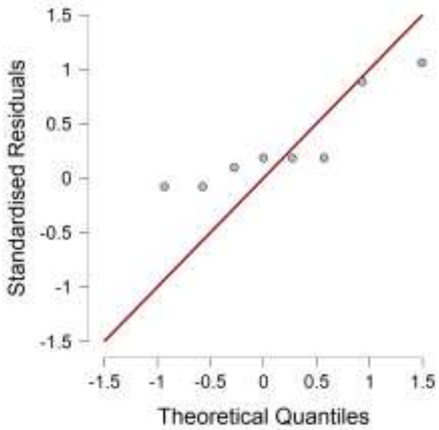

Figure 41: Q-Q plot. Age distribution in the NoCLEXP group.

Interpretation: group NoCLEXP has some deviation of average age values from the line, showing generally younger age of respondents in the group

Table 73: CLEXP vs NoCLEXP comparison

MWW p-value	KW p-value	Mean 1	Median 1	Mode 1	Mean 2	Median 2	Mode 2

1)	0.076	0.075	6.9	7	5	8.3	9	10
2)	0.085	0.083	5.9	6	5	7.4	8	10
2)	0.003	0.003	6.8	7	8	8.9	10	10

Analysis:

a. The difference between the two groups is related to statements with the technical load. There is no difference on all questions with emphasized healthcare components.
b. Groups with clinical experience is consistently more skeptical in all statements, including the possibility to make a COTS-based system, laptop for MCI patients and, especially, tablet for the MCI patients.
c. There is much less variety than in the more detailed experience groups in the previous parts analysis.
d. The result can be partially explained by the small size of the group with rare or no clinical experience. However, the consistency of answers in the current statement supports the idea of more genuine difference.
e. There are no significant difference for one answer per line matrix questions.

VI.1.7. IT Proficiency.

5 respondents defined themselves as professional IT users, 2 – semiprofessional, 13 – advanced users. 40 defined themselves as normal or occasional users.

1) Respondents with professional and semi-professional skills (PROF), N=7

2) Respondents with advanced skills (ADV), N=13

3) Combined group of respondents with professional and advanced skills (PROFADV), N=20

4) Respondents with normal skills and occasional use of IT (NORMOC), N=20

Table 74: IT proficiency groups.

Members of the group	Size of the group	Abbreviated name	Average age	Main counterpart
Professional and semi-professional IT users	N=7	PROF	49.6	NORMOC ADV
Advanced IT users	N=13	ADV	47.5	NORMOC PROF
Professional and semi-professional with advanced users	N=20	PROFADV	48.3	NORMOC
Normal and occasional IT users	N=40	NORMOC	50.7	PROF ADV PROFADV

Interpretation: there is no significant difference in the average age, with slightly lower value for advanced users.

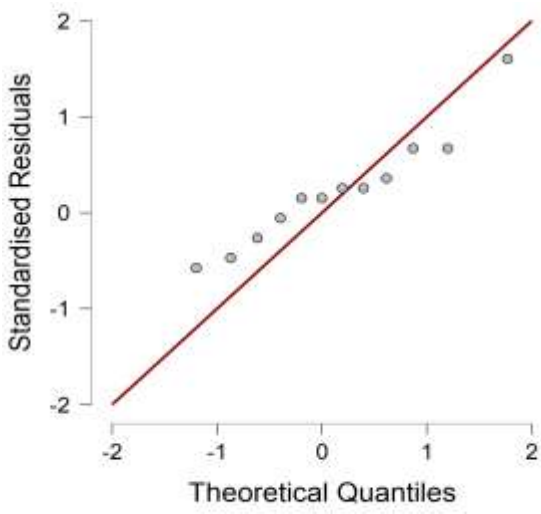

Figure 43: Age distribution for the ADV group

Interpretation: the group ADV demonstrates slightly lower age values, than expected in

Q-Q test line

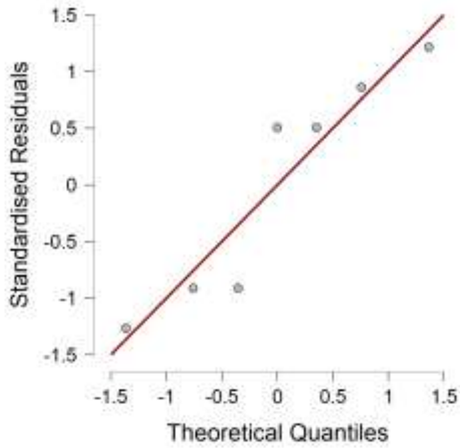

Figure 44: Age distribution for the PROF group

Interpretation: the group PROF demonstrates slightly lower age values, with gap

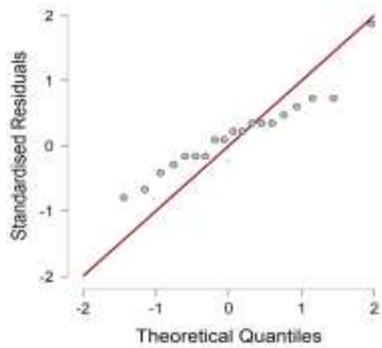

Figure 45: Age distribution for the PROFADV group

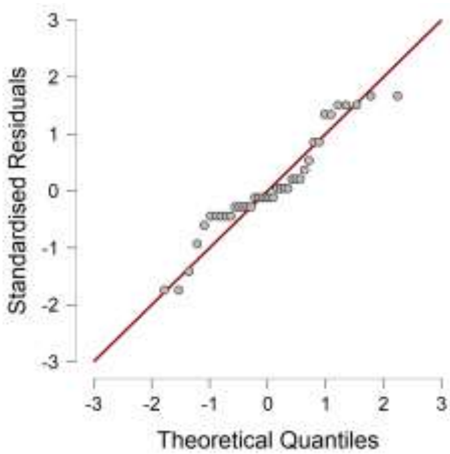

Figure 46: Age distribution for the NORMOC group

Interpretation: the group PROFADV demonstrates age deviation from the line

Interpretation: the group NORMOC demonstrates age values around the line

VI.1.7/1. Relevant Statements.

1) Section 7, E) “AAL system has to recognize sleep disturbance”.

2) Section 8, B) “AAL system for patients with MCI has to include an organizer with an automatic reminder”.

3) Section 8, C) “AAL system for MCI patients has to include electronic tablet dispenser with an automatic reminder”.

4) Section 8, K) “Devices in the AAL system for MCI patients have to be only or mostly wired because it is hard to remember about charging all the batteries”.

5) Section 9, C) “The video camera and microphones are too invasive to be used 24 hours a day/7 days a week as AAL sensors for patients with MCI”.

6) Section 9, D) “Video cameras and microphones can be used in AAL only for emergency”.

7) Section 9, J) “Pressure sensors have to be part of smart furniture and have to be mounted on beds, couches, chairs for the position registration of patients with MCI”.

8) Section 9, K) “Entrance door and windows have to be with sensors, to report about the open or closed status in AAL system for patients with MCI”.

9) Section 11, A) “AAL system has to measure ADL automatically”

10) Section 11, B) “AAL system can measure ADL and IADL automatically”

VI.1.7/2. Groups Comparison.

Table 75: IT proficiency. Groups comparison by statements

	PROF	ADV	PROFADV	ADV

Statement	vs NORMOC	vs NORMOC	vs NORMOC	vs PROF
1)	0.123	0.206	0.075	0.511
2)	0.064	0.270	0.075	0.191
3)	0.078	0.877	0.427	0.046
4)	0.988	0.018	0.069	0.084
5)	0.042	0.328	0.069	0.185
6)	0.045	0.803	0.226	0.084
7)	0.641	0.010	0.027	0.124
8)	0.338	0.709	0.831	0.092
9)	0.288	0.046	0.037	0.934
10)	0.404	0.113	0.099	0.776

Remark: significant findings are discussed below.

Table 76: IT proficiency. Groups comparison by statements with p-value less than 0.1

	Group pairs	MWW p-value	KW p-value	Relevant Mean	Relevant Median	Relevant Mode
1)	PROFADV vs NORMOC	0.075	0.074	8.5	9	10

2)	PROF vs NORMOC	0.064	0.062	7.7	7	7
2)	PROFADV vs NORMOC	0.075	0.074	8.5	9	10
3)	PROF vs NORMOC	0.078	0.076	7.3	7	7
3)	ADV vs PROF	0.046	0.041	9	9	10
4)	ADV vs NORMOC	0.018	0.017	4.9	5	5
4)	PROFADV vs NORMOC	0.069	0.068	5.8	6	7
4)	ADV vs PROF	0.084	0.077	4.9	5	5
5)	PROF vs NORMOC	0.042	0.040	8.4	9	10
5)	PROFADV vs NORMOC	0.069	0.068	7.5	8	8
6)	PROF vs NORMOC	0.045	0.043	8.3	9	10
6)	ADV vs PROF	0.084	0.077	6	7	7
7)	ADV vs NORMOC	0.010	0.009	8.5	9	9
7)	PROFADV vs NORMOC	0.027	0.026	6.9	7	10
8)	ADV vs PROF	0.092	0.085	9	9	10
9)	ADV vs NORMOC	0.046	0.045	8.8	9	9
9)	PROFADV vs NORMOC	0.037	0.037	8.6	9	9
10)	PROFADV vs NORMOC	0.099	0.097	8.4	8.5	8

Analysis:

a. There is a number of technical issues raised in statements, which clearly indicate the nature of group selection

b. Groups of more proficient users are usually more technology positive, as seen in statements 1), 2), 3), 7), 8), 9), 10).

c. Proficient users are more concerned with the invasive nature of video cameras and microphones, a seen in statements 5) and 6).

d. There is an interesting difference between professional and advanced users. Sometimes it manifests as separate concern about the statement, as seen in statements 2) and 5). In the number of cases the difference is significant, as in statements 3), 4), 6), 8). In some statements the position is opposite – statements 3) and 6).

e. There are no significance in the answers on the technical matrix questions.

VI.1.7/3. Matrix Questions. AAL role in Healthcare.

Included all statements with p-value 0.1 and below for chi-square and Likelihood ratio. All combinations with PROF group are excluded for the reason of small sample size.

PROFADV vs NORMOC.

1)

Table 77: PROFADV vs NORMOC. AAL has to be integral part of electronic healthcare system.

AAL has to be integral part of electronic healthcare system	NORMOC	PROFADV	Total
Distant future (50 and more years)	2	1	3
Future (10-50 years)	17	2	19
Nearest future (5-10 years)	12	10	22

AAL has to be integral part of electronic healthcare system	NORMOC	PROFADV	Total
Distant future (50 and more years)	2	1	3
Future (10-50 years)	17	2	19
Today	9	7	16
Total	40	20	60

Interpretation: PROFADV group is more optimistic about integration in the nearest future.

Table 78: PROFADV vs NORMOC. AAL has to be integral part of electronic healthcare system. Chi-square and LR.

	Value	**df**	**p**
X^2	6.683	3	0.083
Likelihood ratio	7.529	3	0.057

Interpretation: p-value for chi-square and LR is less than 0.1

2)

Table 79: PROFADV vs NORMOC. AAL is administratively easy to organize

AAL is administratively easy to organize	NORMOC	PROFADV	Total
Distant future (50 and more years)	4	0	4
Future (10-50 years)	14	1	15
Nearest future (5-10 years)	15	14	29
Never	3	1	4
Today	4	4	8
Total	40	20	60

Interpretation: group PROFADV is more optimistic.

Table 80: PROFADV vs NORMOC. AAL is administratively easy to organize. Chi-square and LR

	Value	df	p
X^2	10.839	4	0.028
Likelihood ratio	13.277	4	0.010

***Interpretation*:** p-value for LR and chi-square show significance

Analysis: respondents in the PROFADV group expect AAL system to become part of integral electronic healthcare system soon. They also optimistic about administrative possibility to implement it.

ADV vs NORMOC.

Table 81: ADV vs NORMOC. AAL is administratively easy to organize.

AAL is administratively easy to organize	ADV	NORMOC	Total
Distant future (50 and more years)	0	4	4
Future (10-50 years)	0	14	14
Nearest future (5-10 years)	10	15	25
Never	1	3	4
Today	2	4	6
Total	13	40	53

Interpretation: group ADV is consistently more optimistic.

Table 82: ADV vs NORMOC. AAL is administratively easy to organize. Chi-square and LR

	Value	df	p
X^2	9.334	4	0.053
Likelihood ratio	13.264	4	0.010

Interpretation: p-value is less than 0.1 for chi-square and equal 0.01 for LR

Analysis: respondents in the ADV group are optimistic about administrative possibilities to implement the general AAL system.

VI.1.8. Level of Medical Education.

40 medical doctors and 2 dental medicine doctors form a group of 42 specialists. 11 nurses, 4 paramedics and 3 clinical psychologists form a group of 18 respondents. While

clinical experience is not a direct equivalent to the level of formal medical education, formal education may not fully reflect medical knowledge.

Table 83: Level of medical education. Groups.

Members of the group	Size of the group	Abbreviated name	Average age	Main counterpart group
40 MD and 2 DMD	N=42	UNIM	51.4	Non-UNIM
Nurses, paramedics and clinical psychologists	N=18	Non-UNIM	47.4	UNIM

Interpretation: average age in Non-UNIM is slightly lower, than in UNIM

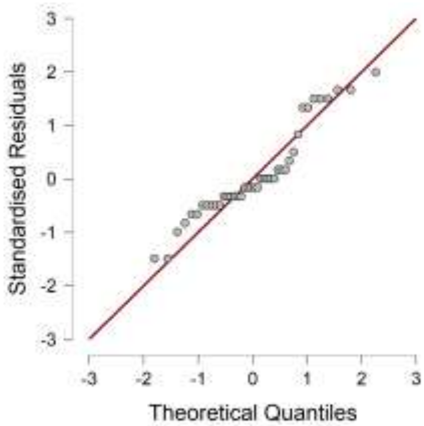

Figure 47: Age distribution in the UNIM group

Interpretation: values in UNIM are grouped around the line

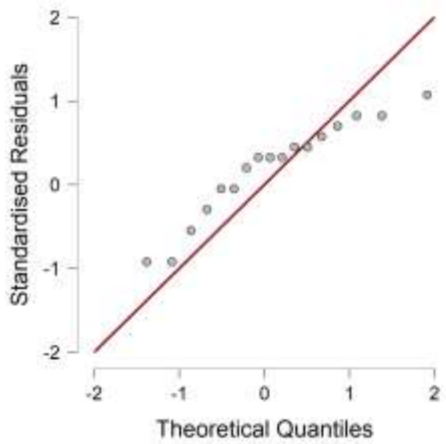

Figure 48: Age distribution in the Non-UNIM group

Interpretation: values in Non-UNIM are grouped along the line with some prominence for younger ages

VI.1.8/1. Relevant Statements.

Statements with p-value for MWW test 0.1 and below are:

1) Section 4, K) “AAL system is helpful in chronic somatic conditions”.

2) Section 7, E) “AAL system has to recognize sleep disturbance”.

3) Section 8, B) “AAL system for patients with MCI has to include an organizer with an automatic reminder”.

4) Section 9, E) “Video camera and microphone can be used in AAL for patients with MCI. for communication only”.

5) Section 10, B) “The server for the healthcare stakeholder side and personal computer on the patient’s home side is the best configuration in AAL system for patients with MCI”.

6) Section 13, B) “Some of the patients with MCI are skeptical about home AAL”.

VI.1.8/2. Comparison, MWW and KW Tests.

Table 84: Comparison, MWW and KW tests for UNIM vs Non-UNIM

	MWW p-value	KW p-value	Mean 1	Median 1	Mode 1	Mean 2	Median 2	Mode 2
1)	0.031	0.030	7.1	7.5	8	8.2	8.5	10
2)	0.026	0.025	7.2	7	7	10.7	9.5	10
3)	0.070	0.068	9.2	10	10	8.3	9	10
4)	0.094	0.093	5.4	6	1	7	7.5	8
5)	0.015	0.015	7.1	8	6	5.6	5	5
6)	0.033	0.032	6.7	6.5	5	5.4	5	5

Analysis:

a. There is slight difference in the medical approach. UNIM respondents are more skeptical in statements 1), 2) and 6), while more positive in statement 3).

b. There are two technically important statements, 4) and 5). UNIM group demonstrates more versatility.

c. There are no other significant differences for these groups.

VI.1.8/3. Matrix Questions.

There are is one statement with p-value significance.

Table 85: UNIM vs Non-UNIM. Every home-visiting medical practitioner has to know

AAL.

Every home-visiting medical practitioner has to know AAL	Non-UNIM	UNIM	Total
Future (10-50 years)	4	1	5
Nearest future (5-10 years)	2	18	20
Never	0	1	1
Today	12	22	34
Total	18	42	60

Interpretation: group UNIM is more optimistic

Table 86: UNIM vs Non-UNIM. Every home-visiting medical practitioner has to know AAL. Chi-square and LR

	Value	df	p
X^2	10.644	3	0.014
Likelihood ratio	11.147	3	0.011

Interpretation: p-values for chi-square and LR are slightly above 0.01

Analysis: respondents in the UNIM group are more prone to think there is a growing necessity for the home-visiting healthcare professionals to know about AAL system today or in the nearest future.

VI.2. Results Interpretation and Discussion.

VI.2.1. Results Interpretation.

Group analysis demonstrates marked uniformity regardless of groups. This indicates common underlying features of the whole set of responses. Taking into account differences in medical professions, clinical experience and countries of practice, we see domination of common professional sense in most of the answers. Nevertheless, most of the groups are genuine, which is reflected in the difference of answers between groups on few specific questions.

VI.2.2. The Necessity of AAL in Healthcare System.

Majority of the respondents, 68%, agree with statements about the importance of AAL as a solution to the ageing crisis. Most of the respondents, 88%, see the AAL system as the way of support for healthcare professionals and not a stand-alone autonomous system. 93% agree, and 80% strongly agree that AAL system can help to diagnose deterioration of the patient. 99% agree and 78% strongly agree that AAL system is helpful in the case of medical emergencies.

VI.2.3 The Place of the AAL in the Healthcare System.

AAL system is not a noticeable part of the healthcare system in any country. However, an opinion of respondents is quite positive. 66% believe AAL system will replace part of the non-hospital healthcare system today or in 10 years time. Additional 23% expect it in 10-50 years.

59% are sure, the AAL system will replace most of the non-hospital healthcare today or in 10-50 years. 46% think AAL system will fully replace non-hospital medical help in future.

64% expect AAL to be an integral part of the combined electronic healthcare system today or in 10 years time. Additional 32% -- in 10-50 years. 51% of the respondents believe that houses have to be built with AAL implementation options today or in 10 years time. 23% -- in 10-50 years time.

90% of respondents think that AAL system has to be taught in medical schools today or in the nearest future, 5-10 years time. 63% believe it should be done today.

There is no significant difference in opinions between groups.

VI.2.4. The Ability of the AAL to Provide Basic Healthcare Functions.

Basic healthcare functions, e.g. registration of vital signs and reporting are understood by most of the respondents as main functions. Respondents support opinions that AAL system is helpful in the case of cardiac accident (99%), pulmonary and airways emergency (97%), neurological accident (82%), acute infection (73%), psychiatric emergency (63%), fall o trauma (93%), chronic somatic condition (58%), chronic neuropsychiatric condition (65%). There is no significant difference between groups.

Somatic emergencies are regarded as more important for automatic registration and reporting by the means of the AAL system. There is little doubt for most of the respondents about the technical ability or necessity to be a supplementary combination of tools in the healthcare system. Chronic conditions or pathologies with less clear vital signs signatures (psychiatric emergencies, chronic somatic and neuropsychiatric conditions). There is no difference for groups of specialists in psychiatry and close professions.

Reaction of the medical doctors group on the statement “AAL system is helpful in chronic somatic conditions” is more skeptical, than group of specialists with college and non-medical university degrees. The difference is statistically significant.

100% of respondents agree that the AAL system has to send reports about somatic emergencies.

VI.2.5. The Ability of the AAL to Provide an Extensive Range of Functions.

As mentioned above, the main role of AAL system is comprehended as registration and report of vital signs and significant changes in the health conditions. Extensive range of functions adds to the list of basic healthcare tasks capacity to automatically help with diagnostics; register ADL and IADL; control of the in-home environment; registration of the electricity and water usage; medical and general security control; medication intake control; memory level registration and memory training; household chores support; abuse prevention and possible number of other functions, which can be added to the system.

Most of the respondents did not show any signs the AAL system is unable to include smart devices or execute a wide range of duties. Part of the functions are supposed to be in a specialized AAL system for MCI patients.

From the other side, some functions are recognized as unnecessary, excessive for the AAL system.

82% of respondents believe in the necessity of Automatic Diagnostic Software to be included into the AAL system. 82% see registration of ADL as important (for MCI patients), and 80% -- registration of IADL. 68% agree, the AAL system has to register day and night activity. In-home environment control, e.g. air quality, temperature (73%) and gas leak registration (95%) is recognized as important for MCI patients by most of the respondents. Yet 58% recognize these systems as not very important (58%) and not very informative (55%) in general AAL system.

Water and electricity usage smart control is recognized as important in specific AAL system for MCI patients. Water – 83%, smart electricity meter – 78%. An additional function is: prevention of the water overflow in the first case and registration of unusual day and night patterns of electricity use.

Systems and devices for medical security control include sensors` enabled windows and entrance doors (93% support), suicide risk registration ability (72%).

Medication intake control is recognized as important in the general AAL system (53%). Tablet dispenser with reminder and medication compliance reporting is marked as necessary for AAL for MCI patients by 97%.

Memory registration soft is mentioned as important for MCI patients by 75% of respondents. 82% ready to include memory training software. Memory training software is mentioned as important in general AAL only by 37%. When proposed for aged patients, the percentage grows to 67. Automatic reminder is marked as important for MCI patients by 85% of respondents.

The supportive soft for patients and medical professionals is recognized as quite important (43% and 35% respectively). The percentage grows to 63% for patients with memory problems. The importance of the organizers for patients in AAL: systems is not supported, while they are widely proposed.

Abuse control is regarded as important, and the majority of interviewees (75%) recognize video camera as the best device for it.

group comparative analysis shows some difference for specialists with psychiatric and neurological experience in additional functions for MCI patients. It will be discussed below.

VI.2.6. The Main Design Components of AAL as Seen by Healthcare Specialists.

This part of the questionnaire was most problematic for respondents. Technically loaded, even after adaptation for common IT users with average college or university education, it required concentration on the work with relatively uncommon information. Explanations, placed before every unit did not help to turn the way of answering from already known information towards the newly learned. It was registered by the “trap table” about smart devices, where rows and columns exchanged places. Still, most of the answers on other sections of table questions where obtained without limitations.

VI.2.6/1. Computing Devices.

63% of respondents described themselves as “normal IT users”. While definition is not clear cut and allows some ambiguity, this clearly signifies superficial knowledge about hardware, software or networking. Average user of IT technologies has less knowledge about the nature of server operations or role of microcomputers in the smart home or local network applications. Still it is expected that “normal IT user” has average practical experience with such devices as PC, laptop, tablet or smartphone. Size of the screen, usability, interface, common advantages and disadvantages. At the same time 39% named themselves as advanced or professional users, and, theoretically, it has to affect results. However, group comparative analysis did not show statistically significant difference.

62% named the server a most important computing device in the AAL system. At the same time 52% think the server must be in the AAL system. 62% believe PC possess high computer power, which places it second after server (82%). Server and PC lead in information security (65% and 52%). PC is placed first for technical versatility – 67%.

Understandably, smartphones took the lead as the computing device with highest usability (75%), most affordable price (77%), best technical service convenience (68%). Smartphone is also recognized as the computing device most convenient for the patient – 87%. 82% of respondents see the smartphone as the best device for bearable sensors. Only 13% think smartphone is not necessary in the AAL. 70% want to see this device in the AAL, and 80% suppose it to be part of the best AAL combination of computing devices.

Tablet overtakes the smartphone as the device with the best interface – 67%. Tablet has second place in the category of "usability" – 70%. At least 75% of interviewees see the tablet convenient for the patient, which is also the second place after the smartphone. The 55% want to see this computing device in the AAL system – second place after smartphone. Service convenience – second place after smartphone, 57%. The 63% also see tablet as the second most affordable computing, while for microcomputer – only 32%.

Laptop sometimes takes third or fourth place for technical service convenience (50%) or usability (50%). But only 25% think laptop has to be part of the AAL system.43% believe laptop is not necessary in the AAL. In the same category PC has 45%.

Single board microcomputer is widely proposed in the AAL system, as a device for wearable sensors and node of the in-home network. An explanation was given before the computing devices section. However, microcomputer obtained 38% as the best device for wearables, while tablet – 37%. The 33% of the respondents marked it as important for AAL, and 28% – as unnecessary. In the best combination of the computing devices for AAL system single-board microcomputer occupies fifth place with 42%.

Computing devices are mostly preferred for reasons of usability, affordability and widespread exploitation. While discussing COTS-based devices, it should be taken into account: standard devices are preferred before specially made computing devices, as single-board microcomputers. Software applications can turn standard computing devices into the part of the specific AAL system. At the same time responses have to be balanced by the IT knowledge and experience and limited implementation of AAL system.

As was mentioned before, group differences are not reflected in answers about computing devices.

VI.2.6/2. Sensors.

The main feature of the sensors topic is orientation on the vital signs devices. Wearable sensors for cardiac monitoring, blood pressure, body temperature and respiratory signs registration are recognized by respondents as most important – 82%. Positioning sensors collected only 60% in the “best combination” question, while wearables – 80%.

Another tendency is recognition of the prominent role of video cameras in the AAL system – for security (68%) and for abuse prevention (75%). At the same time the invasive nature of video registration is acknowledged. 48% of the respondents think that video sensors can be switched on only at the time of the emergency. Still, wearable sensors are perceived as more invasive (47%) than video cameras (33%). The 72% of the interviewees marked video camera as second best for communication.

Microphone received 82% for the communicative purposes. Microphones are recognized as second best for the security and abuse prevention.

About 72% of the respondents believe that video camera is best sensor in the AAL system for the MCI patients. The 68% support the importance of the microphones in the system. Preference of the video camera as one of the most important sensors, even if it can be switched on 24 hours 7 days a week, raises question about privacy of the patient. It will be discussed below.

The least important sensors, as seen by the respondents are temperature and air quality sensors (58%). At the same time 73% agree that temperature and air quality sensors are important for MCI patients. Probably, the difference is connected to the nature of the condition. Gas leak sensors are marked as important by 95% of the interviewees.

There is no statistically significant difference between groups, except for discussion about smart electricity meters between psychiatrists, close associates and other specialists.

VI.2.6/3. Smart Devices.

This table was intentionally changed for the concentration and attention control. For the reason of “over-zealousness” it worked more in the opposite direction. The change between rows and columns led to the incomplete filling of the table. Results are still consistent enough to be analyses, and there is no significant discrepancy with questions in the sections about AAL for MCI patients.

Answers show an already mentioned tendency for focusing on the vital signs equipment. Smart blood pressure machine is marked as most important by 82% of the respondents. Smart ECG by 72%, as well as smart pulse oximeter and smart body thermometer. Smart vital signs devices in the question about the best combination received: smart thermometer – 27%; smart pulse oximeter – 33%; smart ECG – 30%; smart blood pressure machine – 37%. All other devices in this question category received less. The highest percentage is for smart furniture – 20%, and smart tablet dispenser – 17%. Smart climate control system and robotic carer received both 15%.

Separate questions were asked about devices specially designed for the AAL system by the dedicated company and possibility to use Commercial-Off-The-Shelf (COTS) devices in the AAL. Preferences show uncertainty in answers. 40% believe robotic carer cannot be COTS, while 22% think it could. Smart furniture needing special design for the system was answered by 32%, and 22% marked the possibility of COTS devices. Smart refrigerator requires special design – 30%, and 27% see it as a possible COTS device.

Smart body thermometer as COTS-device is seen by 45%, and only 10% think it needs special design. Smart blood pressure machine – 38% for COTS and 8% -- special design. Climate control system – COTS 37%, specific design – 17%. Smart tablet dispenser – COTS 32%, special design – 22%. Smart pulse oximeter – COTS 30%, special design – 22%. Smart electricity meter – COTS 30%, special design – 8%.

There is no difference between groups in responses about the general AAL system. More specific results of the comparative group analysis of the AAL system for MCI patients will be discussed below.

VI.2.6/4. Software.

Questions about software included only diagnostic programs, supportive and communication software. For the clarity they were divided into two categories: software for the healthcare workers and software for patients and relatives. Patients had the subcategory of MCI diagnosis.

There is clear preference for automatic or semi-automatic diagnostic programs for healthcare workers: 82%. For patients the main application is automatic reminder. Communication software is recognized as equally important for the healthcare specialists and patients: 57%.

Medical importance is marked for the diagnostic software – 87%, and communication software – 45%. For aged patients 78% marked automatic reminder, 67% – memory training soft. For MCI patients' importance of automatic reminder see 85% and memory training software – 80%. Activity and day organizer is marked by 43% for general AAL and by 64% for MCI-oriented AAL.

There is no significant difference between groups.

VI.2.6/5. Networks.

This part was perceived by many respondents as specifically technical. Medical importance is mentioned only in some questions. The main idea was to obtain not only professional, but also common sense view reflection.

The best connection inside of the home is wireless one (60%). There are more variations for the external connection, but the majority of the respondents marked mobile network as preferable one (47%), and internet as next in importance (38%).

Information security is a serious issue in the AAL system. The 50% of the respondents pointed on the special cable external connection as most secure. Special wireless connection was second with 40%. The Internet and mobile network received 10% and 17% respectively. Cable and wire connection – 22%. Information security of the most used networks is perceived as low.

Health and safety issues were recognized with cables and wires – 77%. Mechanical obstacles can be a serious problem for aged patients with problems of vision and mobility. Wireless in-home networks are considered preferable for this reason as well.

The Internet (40%) is supposed to be an affordable option for connection. 38% marked mobile network connection, and 32% see cables and wires cheap enough.

Specific question about in-home networks in the AAL system for MCI patients is discussed below.

VI.2.7. The Capability of AAL to Provide Assistance for Patients with MCI.

Almost 90% of the respondents agree with the statement “AAL system is the best solution for MCI patients”. As high as 98% think the AAL system is a good addition to the healthcare solutions for the patients with MCI. The 78% disagree with statement about inconvenience of the AAL system for MCI patients. At least 65% do not think the AAL system is too complicated for MCI patients. At the same time 75% of the respondents do not think the AAL system is suitable for the patients with dementia and not for patients with MCI. Almost 92% think AAL system for MCI patients give good support to the relatives.

Group comparative analysis shows statistically significant differences in some questions between groups of psychiatrists and close specialists from one side and other healthcare specializations from the other. Psychiatrists see even less problems with AAL for MCI patients: they disagree more with the statement “AAL system is inconvenient for MCI patients”. At the same time a group of psychiatrists and close specialists more agree with the statement “Patients with paranoid thoughts are not advised to live in a home with the AAL system”, and the difference is statistically significant.

There is one more statistically significant difference – between groups of those with everyday experience of work with MCI patients and group of specialists without this experience. Specialists with experience agree more with the statement “AAL system is good support for relatives of patients with MCI”. Difference grows with addition of those who have routine home visits and, especially, with addition of respondents who have experience with MCI patients outside of duties.

Same groups demonstrate another statistically significant disagreement: while answering the question “Majority of the relatives have a negative attitude towards the home AAL”. Specialists with experience of work with institutionalized patients tend to agree with the current statement more, than specialists with experience of work with home-based MCI patients or out of work experience. Position reflects the background of the respondents.

VI.2.7/1. Main Design Features of the AAL System for Patients with MCI.

AAL system for the MCI patient includes all the features of the general purpose AAL system with addition or enhancement of some specific functions. Somatic condition control, home environment control, lifestyle support and communication basically are the same. The difference is in the more detailed behavioral monitoring, supportive reminders, memory level registration and memory training.

MCI condition, regardless of its etiology, may require specific changes in every level or device of the AAL system.

VI.2.7/2. Computing Devices.

One of the main questions about specific requirements for computing devices in the AAL for MCI patients is general usability: convenient screen, comprehensive interface, user-oriented design of the patient's side input device, practical battery and wires solution. For the system computing device has to be part of the whole system: information tool with functions of data collecting, receiving, sending, and transformation; which possess ability to work with or control other devices; equipment which gives practically fit communication channels with healthcare and technical service providers. Computing device is home for middleware and software applications. Everything has to be suitable for the average MCI patient.

Questions are asked about every computing device on the patient side except for a single-board microcomputer. As much as 48% see the server form the patient side a suitable device. The 68% support scheme with server on the healthcare service side and PC on the patient's side. The 62% think laptop is suitable for MCI patient. At least 75% prefer tablet on the patient's side, and 80% – smartphone. There is no difference from the answers about general AAL system.

groups show uniform position on questions about computing devices for MCI patients.

VI.2.7/3. Sensors.

Vital signs sensors supposed to be most important in the AAL system for MCI patients by majority of the respondents. Almost 87% think wearable sensors must be a part of the AAL. The 48% disagree that wearable sensor can be inconvenient for the patients with

MCI.

For medical reporting, communication, abuse control and security video cameras are supposed to be suitable by 72% – they believe it is the best sensor. Microphones are supported by 68%. Still, 65% of the respondents agree that video camera and microphones are too invasive to be switched on 24/7, and 63% think it can be turned on in the case of an emergency. Only 58% agree with the statement that video camera have to be used for communication only. For the reason of simplicity there were no questions about types of cameras and microphones.

Infrared motion registration is seen important by 77% of the respondents. The 72% think gesture recognition is necessary in the AAL system for MCI patients. Around 72% accept the necessity of pressure sensors, mounted on the furniture for positioning.

Safety and security sensors are supported by a strong majority of the interviewees. Entrance door and windows sensors have to be mounted in accordance with the opinion of 93%. Gas leak chemical sensors envisage in the AAL system for MCI patients 95% of the respondents. Smart water meters are marked by 83%, and climate control sensors – 73%.

Smart electricity meters, reporting about the day and night abnormalities of electricity usage are seen in the AAL system for MCI patients by 78% of the respondents.

Groups of psychiatrists and close specialists demonstrate statistically significant skepticism in this question. Comparison of different groups allows to register more skeptical reaction of neurologists, gerontologists, and specifically clinical psychologists and general practitioner.

VI.2.7/4. Smart Devices.

Most of the smart devices are discussed in the sections of general AAL system. Specific devices in the AAL for MCI patients have a functionality of reminder and reporting function in the case of compliance problems. Almost 97% think the AAL for MCI patients has to include electronic tablet dispenser with automatic reminder. The 97% think the dispenser has to report about irregularities in medicine intake. While such dispenser will not solve all problems with low compliance or medication intake – there are other than tablet forms of medications – this device certainly seen as an utmost necessity for the system

Around 93% agree that information “from electronic thermometer, blood pressure machine, pulse oximeter, glucometer and other vital signs measuring devices” has to be collected automatically. All 100% accept the necessity to have a reminder for a blood pressure machine or blood glucose measuring device.

The 85% of the respondents think devices for the MCI patients` AAL have to be designed by a special engineering company. At the same time 75% admit the possibility of these devices to be COTS-based. Spearman Rho shows correlation between two groups of answers.

Group analysis demonstrate relative similarity except of one question: “Pressure sensors have to be part of smart furniture and have to be mounted on beds, couches, chairs for the position registration of patients with MCI,” group of advanced IT users agree with the statement significantly more than normal users.

VI.2.7/5. Software.

Applications for the MCI patients in the AAL system are diagnostic, supporting, controlling or with training abilities. General AAL applications are suitable for the MCI systems as well. Emergency somatic control and reporting systems are supported by 100% of the respondents. And 93% of the interviewees believe that the AAL system for MCI patients has to send immediate report about psychiatric emergency. It clearly contrasts with similar question asked about the general AAL system. The Spearman Rho value shows statistically significant with p-value = 0.00112. It can be explained by the understanding of higher significance for psychiatric emergencies in the case of specially oriented AAL if compared with general AAL.

The 87% agree with statement about necessity to control cognitive deterioration. Almost 95% think the system has to possess the ability for reporting about strange and unusual behaviour. At least 82% support the system for registration of sleep disturbances as a potential sign for mental problems and 79% – register day and night activity to look for possible abnormalities in patterns. The 89% think that unusual night activity points on to possible mental deterioration. The 72% agree with ability of the system to register unusual emotions and 70% see feasibility of the automatic assessment of suicide risk.

Around 82% accept the necessity for the AAL system to measure ADL automatically, and 80% – IADL.

The 75% want to include software for regular memory checks and 82% -- memory training software. Almost 97% see the place for organizer and reminder.

Group comparative analysis demonstrates statistically significant difference for question about the ability of the system to measure level of cognitive deterioration. group of psychiatrists and associated specialists shows more skepticism.

VI.2.7/6. Networks.

The main problem in networking of AAL system for MCI patients, presented to the healthcare respondents, was in-home necessity to prefer wireless connection or wired connection. Wireless connection removes health and safety problem with mechanical obstacles by wires and cables. Also, it is a matter of convenience for the patient as a user of wireless computing and smart devices. On the other hand, wireless devices require follow-up in order to timely replace batteries, charge accumulators and guarantee normal functioning.

As much as 87% agree with the statement “Devices in the AAL system for patients with MCI have to be only or mostly wireless”. At the same time 67% support the partially opposite statement “Devices in the AAL system for MCI patients have to be only or mostly wired because it is hard to remember about charging all the batteries”. Spearman Rho shows correlation between answers on both questions, or, more correct, shows no signs of non-correlation, with p-value 0.19418.

Group comparative analysis demonstrates statistically significant difference for a group of advanced IT users in question “Devices in the AAL system for MCI patients have to be only or mostly wired because it is hard to remember about charging all the batteries”. Advanced users mostly disagree with the statement, while normal IT users and those who claim to be professional or semiprofessional IT users generally agree.

VI.2.8. Feasibility of AAL for Patients with MCI in Present Healthcare System.

The questionnaire was constructed around long term technical ideas, applied in healthcare. There is no widespread practical implementation of AAL system. Moreover, there are no well-established practical area of AAL system for MCI patients. Most of the questions and answers consider the potential possibility of construction and implementation of such systems. Medical knowledge and practice, IT experience and general comprehension are inevitably taken an adequate background for the responses. From a number of opinions, it is possible to construct every main aspect of the future AAL system for MCI patients.

VI.2.8/1. Medical.

There is a real necessity to apply the AAL system and create its specification for the MCI patients. Majority of the respondents (66%) think AAL system will replace part of non-hospital healthcare in 5-10 years, and 23% – in 10-50 years. 63% see the necessity to teach about AAL system in medical schools today, and 90% – today or in 5-10 years time. 57% of interviewees think the AAL system has to be known today to every home-visiting medical practitioner. For time from today to 5-10 years the percentage grows to 90. 88% believe any medical practitioner will have to learn about AAL system.

AAL system for MCI patients see as a good addition to the contemporary healthcare system 98% of respondents. There is no disagreement about general medical functions of registering and reporting about somatic or psychiatric emergencies. The main points of differences are specific permanent functions of automatic measurement for cognitive and memory levels, chronic psycho-neurological conditions, behavioral abnormalities, assessment of ADL and IADL, emotional status. Predictive function is desirable for general somatic diagnostic, but a number of specialists in psychiatry are more skeptical about diagnostic abilities of AAL for MCI and close conditions. Number of proposed functions, as smart electricity meters reporting about day and night activity, cognitive level measurements are open for professional debate. Most skeptical are specialists in clinical psychology, neurology and geriatrics. However, the common outlook of responses is positive, regardless of the topic. Variety does not change the position of interviewees from optimistic to skeptical. Psychiatrists and associated specialists are more optimistic about suitability of AAL for MCI patients, even with limitations for paranoid patients.

VI.2.8/2. Technical.

Technologies of the smart home, telemedicine and internet of things are recognized as practical for the creation of the AAL system. There are really few respondents, who see technical inability to create a fully functional AAL system with specifications for MCI patients. The argumentation tends to differ on time of possible practical implementation. 25% see possibility today, 45% in 5-10 years, 23% – 10-50 years. Only 4 respondents, 7%, think the AAL system is for the far future or never will be employed.

AAL is perceived as part of electronic healthcare by the vast majority of respondents. 27% see it possible today, 37% – in 5-10 years and 32% – in 10-50 years time. The 23% think homes have to be built with AAL option today, 28% – in 5-10 years, 23% – in 10-50 years time.

Special configuration of AAL system for MCI patients includes a server on the provider side, tablet or smartphone on the patient's side, internet or mobile network for outside connection. preferable wireless in-home network. Smart devices and sensors must include wearable vital signs registration and reporting devices, wide usage of remainder options. Gesture recognition is debated, but mostly seen as necessary. Less debated are systems for positioning registration. Advanced IT users group respondents are active proponents of furniture-placed positioning pressure sensors.

Specific important role is envisaged for video cameras: registration, monitoring, abuse prevention.

Software range starts from memory registration and training software and goes toward behavioral registration, control and diagnostic software. Separate function is delegated to applications for functional measurement of ADL and IADL.

Significant is the importance of environment, home appliances and security control. There is little space for discussion, according to obtained numbers.

VI.2.8/3. Financial.

This area is mostly outside of the competence of many respondents. Some practical experience in professional area and outside, and common knowledge about appliances used by average users gave a possibility for projection to answer these questions. We cannot build objective picture from responses and have to treat them as cloud of subjective opinions, influenced by a number of commonly held assumptions and guesses.

Only 13% think the AAL system is financially affordable today. Nearly 33% see it possible in 5-10 years time, and 37% – in 10-50 years time. Almost 82% regard AAL system for MCI patients as expensive. There is a place for comparative analysis of traditional healthcare finances and AAL-enabled healthcare system, but this goes beyond current research. Technical and administrative stakeholders ought to provide information and their opinions about the issue.

VI.2.8/4. Administrative.

Responses demonstrate unequivocal widespread distrust of administrative structures. While medical and technical issues are seen as solvable, administration is considered the main obstacle for the AAL system implementation. 60% agree with the statement “AAL for patients with MCI is difficult to organize.” 72% disagree and 47% strongly disagree with the statement “AAL for patients with MCI is easy to organize and finance.”

Still there is some hesitant optimism. Only 13% do not see complication for implementing AAL system today. At least 48% believe it can be done in 5-10 years and 25% – in 10-50 years.

VI.2.8/5. Ethical.

Medical deontology prescribes a number of rules and requirements the healthcare professional must follow while treating patients. Moral questions are wider than professional ethics. Nevertheless, the questionnaire suggests answers in professional settings.

There were a number of questions about invasiveness of the AAL system or its segments or devices. Privacy of patients was placed against the medical utilitarian value. One of the questions was: “AAL system is not more invasive than traditional healthcare”. The 60% agreed with the statement. These answers do not give clear picture if invasiveness is an inescapable outcome of the more effective monitoring system or negative externality, which has to be avoided.

Three questions about priority of healthcare or privacy of the patient with MCI are grouped together. The first two questions are opposing each other, and the third one gives an option of equal importance to health monitoring and privacy. The 68% agreed with the statement “Patient's health is more important than privacy issues in AAL”. 22% agreed and 78% disagreed with the next statement: “Privacy is more important than the patient's health in AAL.” The 58% agreed and 42% disagreed with the third statement: “Patient's health and privacy are equally important in AAL.” We see clear preference for a patient's health importance before privacy. Interestingly, in group comparative analysis those who work in hospitals more often marked priority of patients' privacy before health, and the difference with those who have experience of work in hospital and outside is statistically significant for all three questions. While in hospital the problem of healthcare is less acute, privacy can be questioned. At the same time at home patient has some distance to reach the healthcare system, while privacy is of the less concern.

The same pattern of preferences for heath before privacy is repeated for all respondents groups in question: “Emotionally sensitive patients are not advised to live in a home with the AAL system.” The 65% of respondents disagree with this statement and only 35% agree. There is some sensitivity shown in answers on the question: “Privacy issues in AAL can harm the mental health of patients with MCI.” The 40% disagree with the statement and 60% agree.

Another important issue is application of video cameras in the AAL system for MCI patients. Almost 72% support the assertion that video camera is the best sensor for AAL system, even though 65% agree with statement: “The video camera and microphones are too invasive to be used 24 hours a day/7 days a week as AAL sensors for patients with MCI.” The 58% agree with claim “Video camera and microphone can be used in AAL for patients with MCI. for communication only” and 63% – with an opinion: “Video cameras and microphones can be used in AAL only for emergency”.

Answers show a clear tendency for prioritization of health issues before privacy.

VI.2.8/6. Socio-Psychological.

Acceptance of the AAL system is an important matter. There was not enough place in the questionnaire for the extensive debate on this topic. Patients and their relatives have to be asked separately and questionnaire with priority of related questions. However, medical practitioners work closely with patients and their relatives, and a number of them have been in these roles themselves.

The 72% of respondents believe that MCI patients are favorably disposed towards the AAL system implementation. The 60% agree that some of the patients can be skeptical about the system – which does not imply negative inclination. The 2% disagree with the statement about disinclination towards the AAL system.

Group comparative analysis shows more skepticism about acceptance of the AAL system by MCI patients from the group of respondents with little or no experience of work with MCI patients. group of respondents with experience demonstrates statistically significant difference.

More respondents think relatives of the patients are positively predisposed toward the AAL system for MCI patients. The 77% agree with the statement. At the same time 87% disagree with the opinion “Majority of the relatives have a negative attitude towards the home AAL.”

There is a statistically significant difference in group comparative analysis. Healthcare workers with routine experience of work with MCI patients. These respondents disagree with the last statement more than other groups, formed on the base of experience with MCI patients. When the group is “enriched” by those who have experience with MCI patients outside of duties, the difference grows.

Majority of the respondents think the AAL system will be well accepted by MCI patients and their relatives. The percentage growth with personal experience of interaction with patients and their families.

VI.3. Summary and Analysis.

Most of the respondents see AAL system for MCI possible. The aggregate gain is significantly bigger than any possible complications. Number of advantages exceeds difficulties by a great margin.

The main functions of the system are:

1 Registration, reporting and pre-diagnostic analysis of acute somatic conditions.

2 Registration, reporting and pre-diagnostic analysis of acute neuro-psychiatric conditions.

3 Monitoring and analysis of deterioration signs for chronic somatic conditions.

4 Monitoring and analysis of deterioration signs for chronic neuro-psychiatric conditions.

5 Monitoring and reporting about medication and health regime compliance.

6 Monitoring, reporting and auto-correction for in-home environments.

7 Support of wellbeing and security.

8 Abuse prevention.

9 Communication with healthcare professionals, relatives and friends.

Technically AAL system for MCI patients have to include

1 Server on the healthcare provider side and, preferably, smartphone and/or tablet on the patient's side;

2 Wearable sensors for registering vital signs: pulse, ECG, blood oxygenation, thermometer, connected to the smartphone, tablet or another suitable computing and transmitting device;

3 Smart devices for vital signs registration, with enabled reminder function and connected to the network: smart blood pressure machine, smart glucometer for those who suffer from the diabetes mellitus;

4 Smart tablet dispenser with functions of reminder and reporting in the case of low compliance;

5 Infrared positioning sensors, furniture-mounted pressure positioning sensors.

Gesture registration sensors are desirable.

6 Environment and security controlling systems.

7 Video cameras (type is not specified) and microphones, which can be switched on for emergency and communication.

8 Smart water and smart electricity meters: for monitoring and possible behaviour patterns registration.

9 Networks outside of home can be based on internet and mobile network. In-home networks preferably wireless.

10 Automatic pre-diagnostic systems for main acute somatic conditions and neuro-psychiatric disorders; systems for ADL and IADL evaluation. cognitive abilities measurement;

11 Organizer system with reminders;

There are limited technical or medical problems for the implementation of AAL system for patients with MCI. Respondents believe that main obstacles are financial and administrative, but majority think they will be overcome in future.

Number of professional opinions were discovered with comparative group analysis. Most of the respondents put health problems before privacy, and this issue has to be thoroughly discussed in future. There are also quite a few disagreements about potential efficiency of some devices, certain functions and the configuration of the systems. Majority of the respondents expect healthcare professionals to be educated about AAL system today or in the nearest future. Predominant part also consider AAL system psychologically and socially acceptable by MCI patients and their relatives. Generally respondents see implementation of such systems beneficial for the healthcare system, patients and their families and society as a whole.

Respondents from the group Psy are positively disposed towards the AAL system for MCI patients. They have a more positive outlook with fewer limitations. However, there is significant skepticism about the technological abilities or necessities of the AAL system. Group Psy in comparison with the Non-PNG group demonstrates skepticism about the future implementation of AAL system. They show primary concerns with patients' health, which is seen as more important than privacy. Some answers reflect skepticism in the ability of the healthcare system to implement AAL for MCI patients. Altogether, Psy, PNG and PNG&AP groups show a mixture of skepticism and optimism about the implementation of the general AAL system and AAL for MCI patients. Skepticism is shown in the statements about specific technical abilities of the system to register a change in the condition or necessity to have it. An optimistic part is demonstrated about the potential technical and administrative implementation of the general AAL system and the suitability of AAL for MCI patients.

Most of the groups with experience with MCI patients support the statement 1) “AAL system is a good support for relatives of patients with MCI”. Group with institutional experience, IE, less sure that “A smartphone is the most convenient computing device on the patient's home side in AAL system for patients with MCI”. Majority of groups with relevant medical and institutional experience give less support to the statement 7) “Emotionally sensitive patients are not advised to live in a home with the AAL system”. The group with an institutional experience more agree with statements: “Majority of the relatives have a negative attitude towards the home AAL” and “AAL for MCI patients is expensive”. MIE (Medical and institutional experience) group demonstrates more optimism about administrative organization of general AAL system.

The hospital experience only (HEO) group usually holds a more skeptical position. The HEO group disagree with a statement about the inconvenience of AAL for MCI patients in a more pronounced manner. The group with hospital and external medical experience is more positively disposed towards AAL system and AAL system for MCI patients in most of the statements. All groups with hospital experience are more medically astute and positive towards AAL system and AAL system for MCI patients, than groups without hospital or clinical experience. Technically these groups are also more on the side of fully-fledged technical development in the AAL system. Respondents with hospital experience are more confident about the integration of the AAL system into the general electronic healthcare system. They are also more optimistic about the inclusion of AAL system into the architecture design of new homes.

In groups with IT experience there are number of technical issues raised in statements, which clearly indicate the nature of group selection. Groups of more proficient users are usually more technology positive. Proficient users are more concerned with the invasive nature of video cameras and microphones. Respondents in the PROFADV (professional and advanced IT users) group expect AAL system to become part of integral electronic healthcare system soon. They are also optimistic about administrative possibility to implement it. Respondents in the ADV (advanced IT users) group are optimistic about administrative possibilities to implement the general AAL system.

Chapter VII: Conclusion.

VII.1. Summary and Discussion

The questionnaire is consistent and reliable. Responses are obtained from different representatives of the medical professions, living and working in a wide range of countries. There is a diversity in IT exposure, clinical experience and specific medical involvement with MCI patients. Most of the respondents do not have theoretical or practical knowledge of AAL system. Nevertheless, the information, obtained from the initial results is rich and instructive.

The discussion is initially constructed around lines of investigation and null hypotheses. The necessity of a general AAL system is not obvious for any respondent, especially with limited knowledge of modern IT technologies and practical experience of medical electronic tools and software. The skepticism of respondents is consistent with findings from similar works. An additional degree of knowledge is added by the comparative group analysis. The most skeptical group has the biggest experience with psychiatric, dementia and MCI patients. At the same time, we see a generally positive vision of general AAL and specialized AAL system for MCI patients. Some specific aspects are taken by most experienced groups with the least confrontation, such as negating reasons for non-implementation because of potentially repulsive reactions from patients, even with emotional sensitivity and paranoid thoughts. These opinions are partially shared with other specialists who have more in-hospital and outpatient experience by visiting home-based patients.

If to list findings in accordance with the hierarchical hypotheses model, we register the predictable interest of healthcare stakeholders to the registration of the vital sign. The basic function of healthcare is fundamentally connected to vital functions. While the well-being and Quality of Life characteristics of AAL system are well understood by the medical workers, the importance of the first-line responsibilities is seen as primary. Many specialists have registered their opinions about the priority of healthcare before privacy. This is more obvious for those who work with emergency situations, especially in patients` homes. Respondents with predominantly hospital experience are more concerned with privacy issues, which is explainable by the effective medical provisions and limited privacy in hospitals and institutions, while the opposite is more relevant for those who have experience as an ambulance worker, home visiting specialist or medical consultant in the outpatient department.

Expectations of respondents about the future integration of AAL into general healthcare are also informative. There are practically no differences registered in groups or in the whole sample with a negative attitude. The majority believes in the necessity to educate healthcare workers and students as early as possible, to plan architectural options for AAL in newly built houses or to interconnect AAL with Electronic Health Records and other already available IT tools. There is still some unconvinced respondents, who do not see the implementation of AAL coming soon. There is widely shared disbelief that administrative barriers are easy to overcome. While technology is recognized as feasible, financial and managerial problems are seen as more serious. With all technological optimism, there are practically no opinions about the possibility of technologies to fully replace an existing system or to relieve human actors from their functions. AAL is seen as the supplement to the system, not the principal component or an alternative.

The technically loaded part of the questionnaire created some strain on the number of respondents and required some labor to go through the section. Even though the sections were maximally simplified, interconnected with clinical vision and had comprehensive explanations before, there are some limitations in the obtained answers. It is registered with help of a comparison of IT proficient and advanced groups and normal and occasional IT users, who comprised the majority of respondents. For the reason of the relatively decent size of the sample, there was no possibility to compare “groups inside groups”. It has to be left for future research continuation.

Computing units were relatively easy to discuss. The majority see the smartphone or tablet as the best tool for the patient. There are some signs of reservations about the ability of MCI patients to conveniently use a smartphone. There was limited space for more elaborated questions about the problem of smartphone multi-functionality, which make the device overloaded with AAL and other functions. Any damage, loss or limited battery life may disqualify it as a primary computing tool on the patient's side. A relatively small screen makes it less useful for elderly patients, who often have some problems with small size letters or symbols or experience musculoskeletal or neurological conditions, which limit the ability to use the interactive touchscreen. The same is partially applied to the tablet as well. However, the widespread use of smartphones and tablets prevails the limitations for most of the respondents. There was little discussion about server-based or cloud-based applications.

Statements about sensors also were with limited technological components and extensive clinical projection. There is much attention given to classical video cameras or microphones, which is intentionally connected to the discussion of privacy. Unfortunately, the all-embracing nature of the questionnaire put some restrictions on the possibility to develop the point of movement and ADL registration without obtrusive means. There are technical solutions with better privacy options than video cameras with the same level of informative data collection. At the same time, video cameras were mentioned for the additional reason to see the level of intrusion, acceptable by the respondents, if weighed against the health risks. There was also significant interest in the techniques to locate an inhabitant with help of smart furniture. Interestingly, while environmental and security functions of sensors are recognized by respondents, they are the least mentioned part of the sensors AAL architecture. Many participants do not see these functions as really necessary in the AAL system.

The networking was the most burdensome part of the questionnaire, according to informal feedback given by some respondents. All questions about types of networks, architecture or specific technical details were left outside of scope. The focus was made on two main issues: wired or wireless LAN in home and preferable type of connection with the outside part. The wireless connection comes naturally in most of the proposed AAL system, subject to architecture and coverage. However, in the case of MCI patients, when the memory functions can be compromised, a wired connection can be more secure or improve the power autonomy. The level of cognitive or memory dysfunction cannot be established for the general situation and have to be assessed on a case-by-case basis. There is still a place for consideration. The external connection is less clinically coupled. Here is the main reason for the statements in general. If it will be better to use a mobile network when the preferable computing device is a smartphone, or Internet options have the same or better level of convenience. The privacy issue is a reason for the inclusion of special wireless or wired external connection, with no questions about the price tag for the special system. A significant part of the respondents answered questions about special connection positively, as well as much marked preference for the special engineering provider while compared with the COTS option. Interestingly, the group with more IT experience is more pro-COTS.

The smart devices, associated with vital signs measurements received high support from all respondents` groups. Many interviewees marked smart tablet dispensers as a necessary device in the AAL for MCI patients, at least with functions of reminder for the patient and report to the system in the case of low compliance with medication intake. The number of exotic smart gadgets, such as smart refrigerators, smart electricity or water meters and robotic support units received much fewer marks. There is a clear mindset to rank systems in accordance with medical necessity, which differs from some technological works made for research reasons and which promote some features in the systems, more oriented on the socializing, communication, routine organizing. There is also a significant compendium of works made for fall prediction and fall prevention, but not favored by the healthcare specialists for practical reasons. Most of the falls are easily predicted by vital signs or specific health conditions stated, such as neurological or musculoskeletal disabilities. This is clearly the work of medical and care professionals to prevent predictable deterioration and to take measures well before the risk arises. The fall report is important as emergency data, but also do not require complex devices or arrangements to do it. There are proposals to register movements with help of Body Area Networks, wearable sensors or permanent accelerometer devices. They are informative but have limitations for biocompatibility, battery life, CPU power, signal encoding capacity and convenience for long-term usage. The smartphone can take over some functions, but also cannot be easily taken everywhere, like in the bath or cloakroom (toilet) without some compromise. Interestingly, smart climate and home environment systems received less attention from the respondents for the reason of indirect involvement in the health issues. At the same time, magnet sensors and reporting systems about open windows and doors are widely supported in the AAL system for MCI patients, while an explanation for a specific reason is given. It means that the functions of the AAL system are not easily understood by healthcare stakeholders as separate details and should be presented in a wider context.

The software tools are seen as the primary solution for healthcare and administrative matters. Organizers, reminders and communication software is recognized as important for the patient. But the significant emphasis is made on the automatic data processing for the healthcare stakeholders and medical practitioners. There is the support given for Decision Support Systems, including those with pre-diagnostic features. Most of the respondents think that movement reporting and analysis tools are useful, such as Activities of Daily Living registration, sleep and awakening pattern recording and analysis, memory and cognitive function measurement software. However, there is a professional skepticism about the last tools from the psychiatrists, who also do not see an easy way to predict and report the potentially suicidal behavior of the patient. Here we see the point of future discussion between medical specialists and the necessity to share the experience of healthcare stakeholders and technical stakeholders to look for possible solutions. Other similar points are privacy concerns, ways of communication between primary and secondary professional end-users and lower priority functions of AAL system.

There are limitations in the current work. The complexity of the questionnaire and COVID pandemic restricted number of the respondents. It was theoretically possible to make a questionnaire part of a whole program with shorter versions presented to the same respondents. There is visible obstacle to recruit respondents twice or more times, and one-time survey administration was chosen. Despite the extensive effort and multiple contacts with potential respondents, it was hard to ask every contacted and agreeing person to finalize the questionnaire. Some claimed difficulties and unfamiliarity with a topic. Others mentioned unusual workload connected to the ICU or pulmonary care, often outside of normal professional duties. As a result, the sample was limited in size and could not provide enough subgroups for specific issues of psychiatric and IT experience. It has to be accepted, that there was an open preference to specialists with neurological and psychiatric specialization, but efforts yielded not enough results.

Besides that, the technical load was recognized by some participants as significant. Despite the calibration and measured time of answers, some interviewees spent from 40 to 60 minutes to fill the questionnaire. At the same time, there was no difficulty for others to do it in 20-30 minutes, as was claimed. Clearly, there is an issue that required addressing in future.

To summarize results in accordance with null hypotheses, provided before:

H01. Answer: AAL is necessary in the healthcare.

H02. Answer: The place of AAL is important and will grow in future.

H03. Answer: AAL is able to provide basic healthcare functions.

H04. Answer: AAL is extendable and can provide extensive range of functions.

H05. Answer: Healthcare specialists can advice on rational design of AAL as a system or in detail.

H06. Answer: AAL system is capable to provide assistance for the MCI patients.

H07. Answer: There are number of significant features in special AAL system for MCI patients.

H08. Answer: AAL system for MCI patients is feasible in contemporary healthcare.

VII.2. Future Work.

An immediate outcome of the work is demonstrated in the second part of the analysis. Groups comparison shows significant differences of opinions on key questions depending on the depths of medical experience, specific knowledge of the MCI theme and contact with patients in the home and hospital environment. These results can be a basis for guidance for other specialists in the area, help to understand the level of necessary experience and knowledge in working with MCI patients. The familiarity with IT technologies also demonstrated a nuanced approach in some specific AAL questions.

Ideally, the healthcare specialist who deals with AAL for MCI patients will have an educational program with theoretical and practical parts, which will allow being well versed in all important and related topics. The research program can be also widened for the medical respondents. While the questionnaire can be repeatedly presented to a wider auditorium of professional interviews, there are different groups and potential new groups. Psychiatrists, neurologists, family medicine specialists, geriatricians and other associated specialists can be interviewed separately with comparative analysis afterwards.

The results of the current work are extensive, and their analysis allows expansion program of future research. There are full topics with the possibility of further investigation of answers. Basic rules for the general AAL system are universal for many more specialized systems. The program of development AAL in the healthcare system as seen by the healthcare stakeholders has immediate importance. The specific point of the AAL system for MCI patients requires more attention. Privacy and data protection have to be understood by healthcare stakeholders appropriately, and there is a space for further discussion with other stakeholders. System acceptance by patients and relatives are projected and need to be additionally evaluated by other means. Technology-related questions require the attention of technological stakeholders.

Shorter questionnaires focused on particular parts are additional instruments which are suggested for the program of research. Some fields definitely require more thorough thought through and cannot be included on a full scale into the extensive general questionnaire. Detalization has to include different medical conditions, a variety of available technical instruments and necessary additional education for potential respondents. General AAL system, as well as particular types of it, definitely require not only preparatory modelling and questionnaire-type investigation. Creation of working models, practical testing, desirable with healthy volunteers and then, after thorough check-up, patients and their relatives, is the main direction of the research.

The questionnaire is designed as a complex and multifaceted tool for opinion assessment and future systems concept evaluation. It has an option for Delphi style secondary questionnaires, produced as an outcome of the first expert group results. The secondary and tertiary questionnaires can be refocused on some topics of interest. Less relevant questions are left out, while more important have more details added and supplied by additional sub-questions. There are several potential lines of investigation and each one can have its own secondary and tertiary questionnaires, even brunched ones for deeper topic understanding. Delphi style questionnaire series can have an educational program for healthcare experts, with the theoretical and practical parts. Farther steps for modelling, prototyping and implementation will have similar repeated questionnaires or modified versions.

The logical steps for a continuous program of research include similar extensive questionnaires for the technical and administrative stakeholders. Special questionnaires have to be designed for the patients and their relatives. It is possible to create a framework for stakeholders interaction on every point of interest. Such an environment will give a wealth of information not only about opinion, acceptance or usefulness for part or the whole system. It will frame out specific strengths and weaknesses demonstrated in the answers of different stakeholders and help to consider them for future work. This will make the interaction between stakeholders more productive and predictable.

Questionnaires about AAL have to encompass all types of conditions of home-based patients. There is a full scope of problems, which can be organized as a database for potential solutions and questions about it. It opens a possibility to create a scheme for any AAL configuration with automatic questionnaire production and collection of results from different stakeholders. This process is clearly iterative with all later results built upon previous experience. The formalization of AAL concept creation will significantly shorten the time for the system development in any case of home-based treatment. An optimization will save academic, administrative and financial effort in the future and speed up an implementation of most advanced systems.

Technical aspects of future research include different configurations for AAL system. The scope is quite broad: from “minimal”-type AAL system with COTS-based appliances, smartphone and few sensors to the extensive systems with artificial intelligence, elements of machine learning integration into medical records and deep learning on the basis of converged data from many AAL sites. Every aspect requires thorough investigation already on the preconception stage. The established framework will help to implement upcoming

AAL system was proposed more than 20 years ago, but the field is still in the early stages of development. The current research is focused on the specific type of AAL system –

designed for the home-based patients with MCI. While the topic is relatively narrow and specific, it encompasses many fundamental problems as seen by the healthcare stakeholders,

Every implementation of new devices, appliances, programs, sensors or networking elements will require the questioning of specialists on every step before and after its application. Questionnaires can be standardized for the AAL development and routinely employed in each phase of experiments, going from theory to practice. But the real goal has to be an integral technology-reach IT-empowered healthcare. There is a necessity for the general Electronic Health Records, automatic analytical and semi-analytical tools, sensor and computer-rich ambient environment. A smart environment encompassing all spheres of life must include medical components and systems on every level, from individualized person-oriented systems for healthy individuals to global multiplex public health initiatives.

This is the task not only for small groups of enthusiasts. Government programs, societal and private initiatives have to interact in the atmosphere of the common good and collective progress. There is a necessity to involve legal stakeholders, especially in the later stages of implementation for AAL system and IT health. Ethical and behavioural researchers must collaborate with every team involved. Private financial initiatives and insurance companies have to find an understanding of the government on all levels and be inspired by the possibility of productive and profitable participation. There is a task to make technologically-based all-inclusive healthcare an important achievable goal for the current generation. The public and private initiatives have to become standards for the decades.

It is important to recognize smart healthcare as a hotbed for technological development. Internet of Things is industry and infrastructure-oriented. There is much excitement about the growth of non-human IP-addresses numbers. However, all efforts in this sphere are for the general improvement of living conditions and the creation of additional resources for the next developments. The so-called “normal health state” was widely different in previous times. Any improvement becomes the baseline for the next achievements. There is an idealized futuristic picture of perfect health for any member of society bordering myth about potential eternal life. The irony is that there is not much possibility to choose the direction of the development. It is either the improvement or stagnation and decline, measurable in healthcare statistics of life longevity, Quality of Life, lengths of productive working life and healthy retirement.

The Ambient Assisted Living system place can be projected as a point in the complex graph network of other technological and social initiatives. It cannot be separated from the common tendencies. The hardware improvement and industrial scale of production laid out the scene for powerful software solutions. Big Data collection, preservation and processing become a “staple food” for any activity area, including healthcare. Progress in any connected sphere will improve the situation in medicine and care. An opposite is also true – any advance, even partial, in the AAL system implementation will help to gain higher ground for other initiatives. While healthcare is supposed to be fundamentally valuable, there is the place for more practical and extensive use of technologies, if to compare it to data security, banking or fintech.

The mentioned ethical questions and search for solutions in conflicting social outcomes of technology implementation are not limited by practical issues only. Theoretical research is also gaining more information for thoughts. The conceptualization of a fully-fledged information-rich society are not futuristic or science fiction domain anymore. There is an essential need for academically strong think-tanks. The work out of robust theories is even more important with a wealth of modern data than before. The creation and testing of hypotheses are crucial for the successful paradigm shift in healthcare and society as a whole.

The demand for R&D in AAL has never been higher. If compared to previous times, there is more possibility for realization of healthcare provisions through the appropriately adapted technological tools than through the previously declared purely social and administrative instruments. The slowness of AAL implementation cannot be explained by the inability to solve practical issues with contemporary IT tools. We speak about the eagerness of different stakeholders to use more effective tools in order to overcome traditional obstacles. If in the commercial sphere the interest of private investors is clear, the initiatives, controlled by the government and public representatives require more discussions and more impressive results. It would not be an overstatement to say, that skepticism, demonstrated by healthcare stakeholders in relation to the implementation of

AAL system is based on day-by-day experience inside of the system. There is clearly more to be done for these issues to inspire and succeed.

Collaboration of all, however small, stakeholders is principal for the success. All in all, it can be encompassed with the quotes by Mahatma Gandhi: “The future depends on what you do today;” and by Abraham Lincoln: “The best way to predict your future is to create it.”

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QUESTIONNAIRE: Ambient Assisted Living for patients with Mild Cognitive Impairment.

60 responses

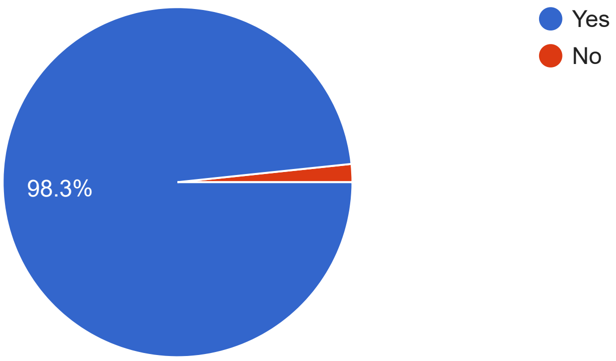
Publish analytics

This international questionnaire is designed for professionals with medical education and those who work in the medical field. The main goal is to compile a guide for engineers and technical specialists working on Ambient Assisted Living system for patients with mild cognitive impairment. Better interaction between medical and technical stakeholders for the benefits of patients is the basic aim of this research. All necessary explanations about technical details are given at the start of every section. There are instructions for every section and, if necessary, for questions in the section. The geographical scope is wide, mainly including such countries as the United Kingdom, USA, Canada, Israel, Republic of Belarus, Switzerland, Germany, Netherlands. The questions are devised to collect the opinion of professionals about the main technical, medical and other aspects of Ambient Assisted Living for patients with Mild Cognitive Impairment. There are several types of questions. Anonymous scaled answers will be combined, quantified and statistically measured. If you have any enquiries, please contact me through the email, shown below. Please, share your opinion about the future of the healthcare system. It will take 25-30 minutes to answer questions. Every next section opens after all marked question in the previous section are answered. Thank you for taking part in the research! N.B.: There is a free choice given to any participant to take part in the research, with no obligations to do it. If you, out of the free will, want to fill the questionnaire, please mark it below. If you do not want to take part, simply mark "no" and do not proceed farther. If you have any questions regarding the questionnaire or research, please feel free to contact. PhD project by Dr D Herzog, Faculty of Science and Technology, University Fernando Pessoa, Porto, Portugal herzogs@gmail.com

Please, use Chrome or Mozilla browser. Microsoft Edge is less than optimal. Successfully tested on Android smartphone.

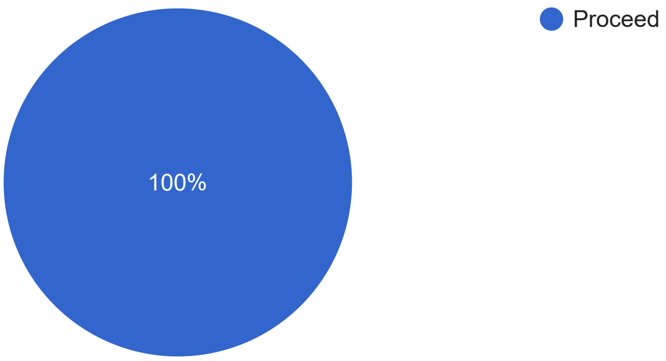
I am fully informed about the study. I am ready to willingly proceed and to fill the questionnaire

60 responses



If you agreed to fill the questionnaire, please mark "Proceed" to open the next section. Otherwise, questions will remain locked. In order to move to the next section of the questionnaire, it is necessary to answer all marked questions before it.

60 responses



QUESTIONNAIRE: Ambient Assisted Living for patients with Mild Cognitive Impairment.

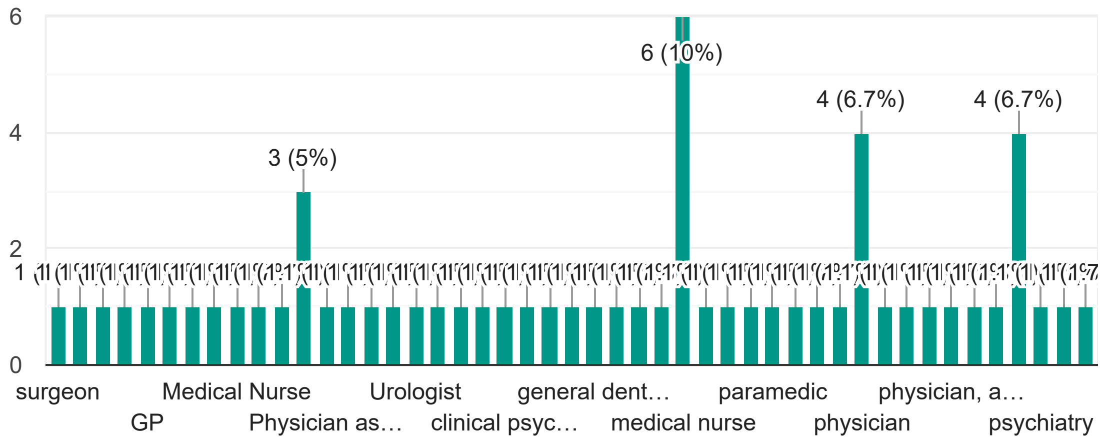
Please, share your opinion about the future of the healthcare system. It will take 30-45 minutes to answer questions. Thank you for taking part in the research!

PROFESSIONAL EXPERIENCE

Personal information will not be shared with other parties. All information will be anonymised.

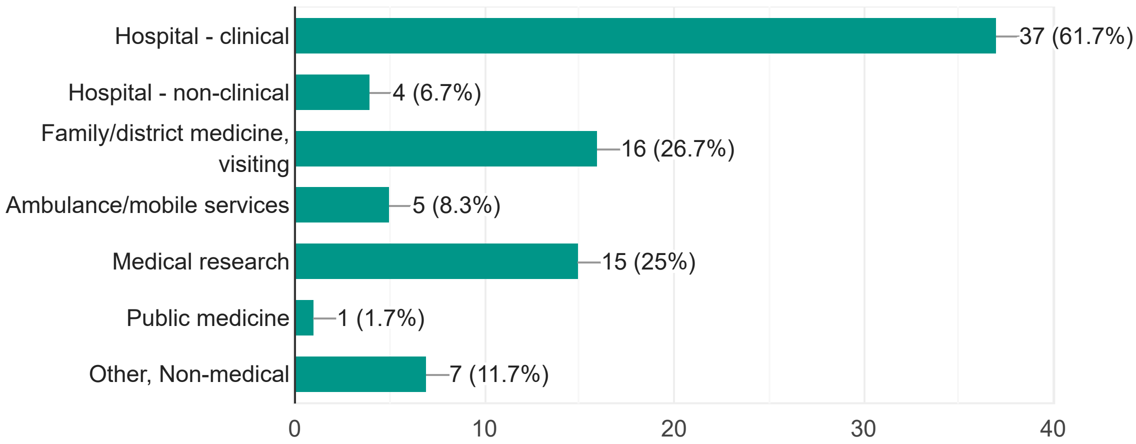
Medical Profession

60 responses



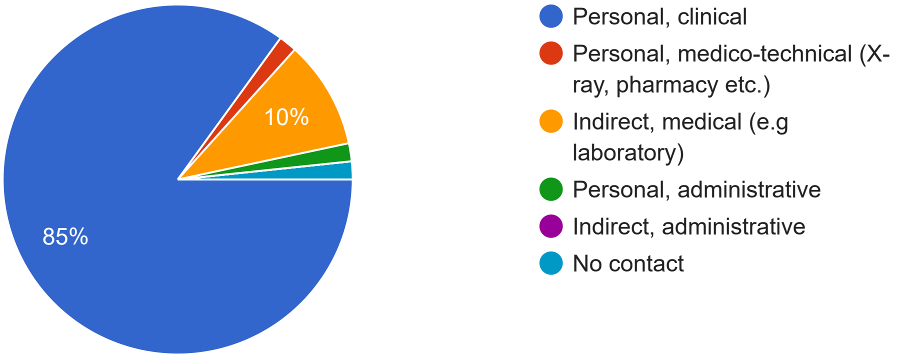
Area of medical experience. Please, mark the most appropriate answer or choose several answers:

60 responses



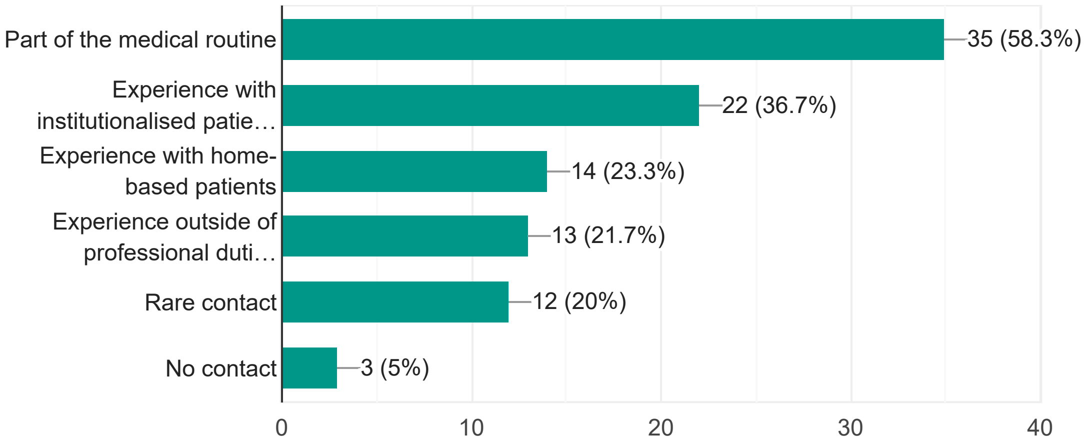
Most often modes of contact with patients

60 responses



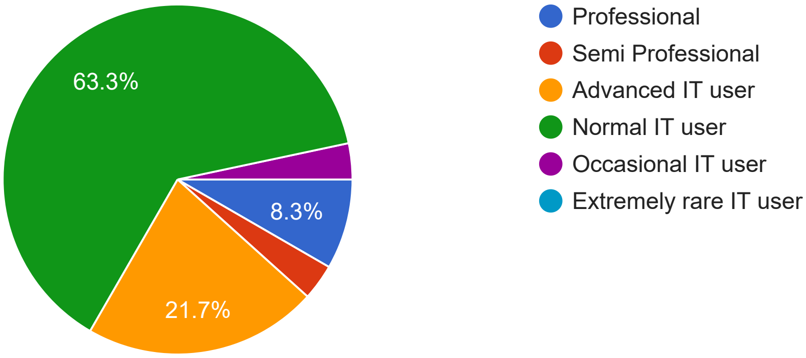
Personal experience with patients, diagnosed with Mild Cognitive Impairment (MCI) or dementia. Please, mark all relevant options

60 responses



IT, computer and smartphone skills

60 responses



Ambient Assisted Living technologies. General knowledge.

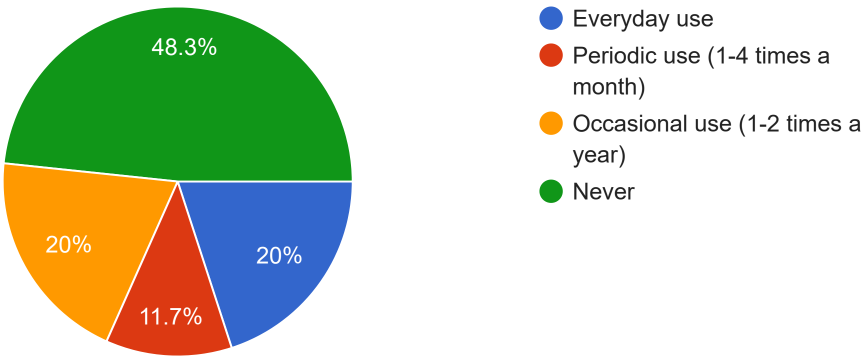
Instruction: Please, answer questions in this section without the help of external reference sources

TELEMEDICINE

Please, reflect your knowledge and opinion about telemedicine. Do not use external sources of information at this stage

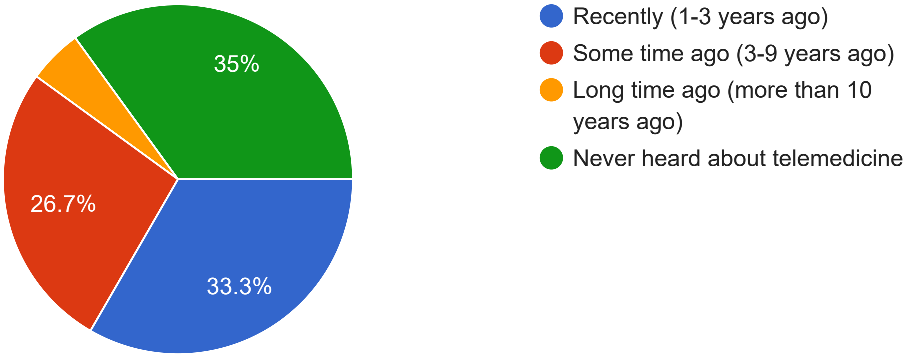
Your practical experience of telemedicine. Choose the most appropriate answer

60 responses



I have been taught about telemedicine or learned it myself:

60 responses

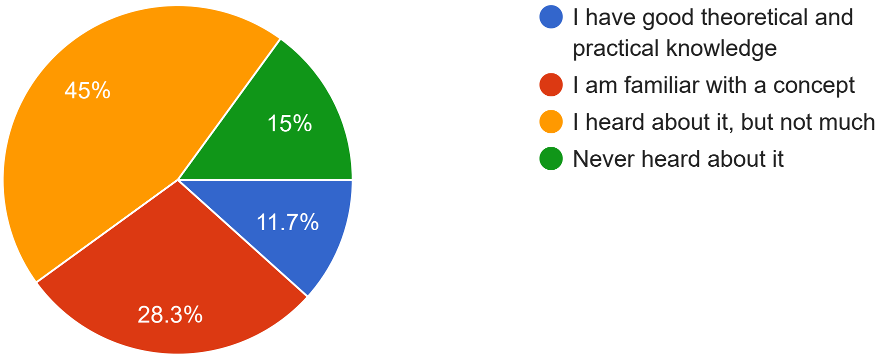


SMART HOME.

Smart home technology, theoretical and practical knowledge. Please, do not use external sources of information at this stage

Smart home technology. Personal knowledge

60 responses

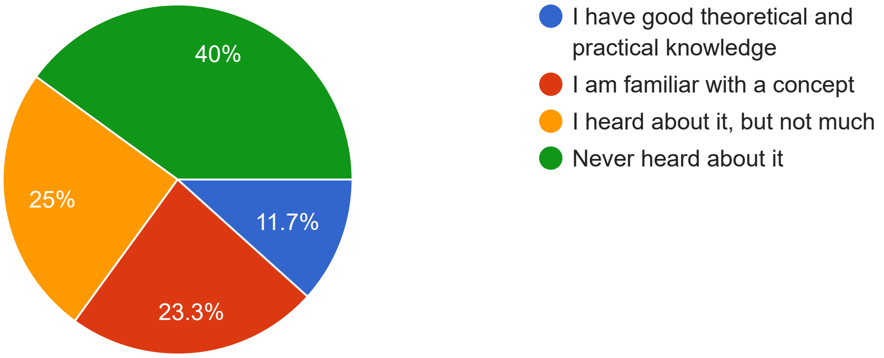


INTERNET OF THINGS

Internet of Things (IoT) technology. Please, do not use external sources of information at this stage

Internet of Things. Choose an appropriate answer

60 responses

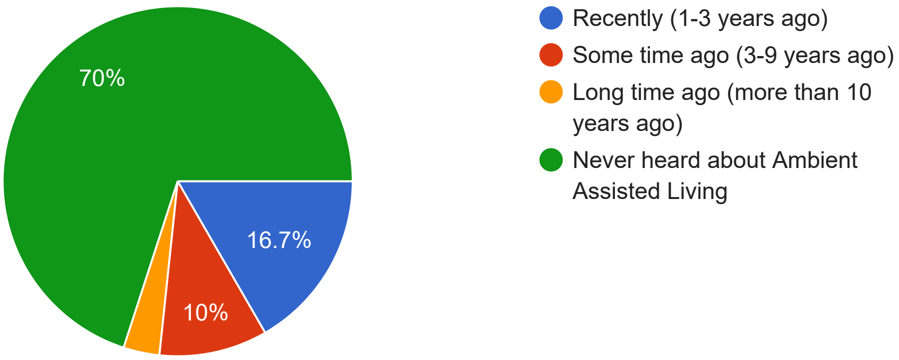


AMBIENT ASSISTED LIVING (AAL).

Please, do not use external sources of information at this stage

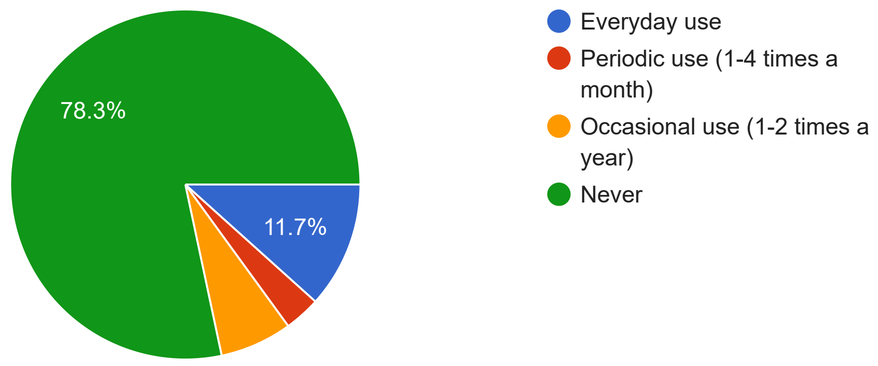
"I have been taught about Ambient Assisted Living:

60 responses



Practical knowledge of Ambient Assisted Living

60 responses



Ambient Assisted Living implementation.

Please, reflect your professional opinion about the Ambient Assisted Living (AAL) system. If necessary, consult the information below or use external sources in order to answer questions.

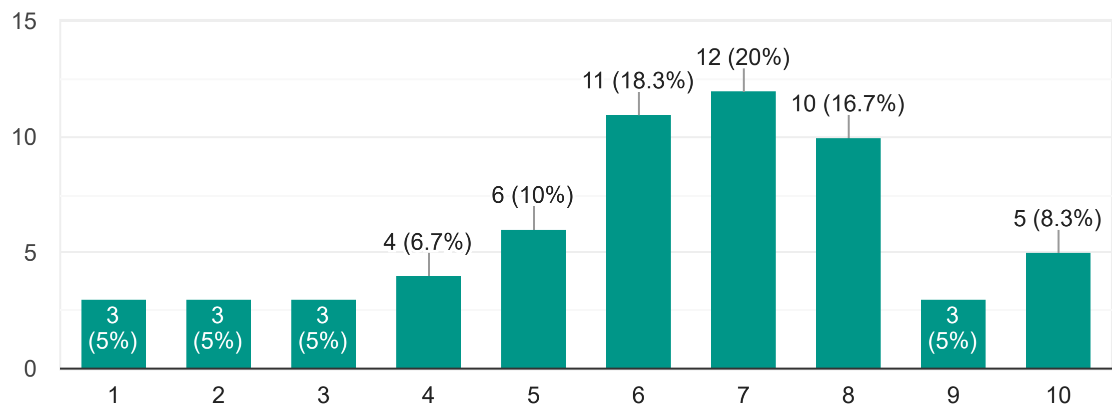
Ambient Assisted Living. Short description.

Ambient Assisted Living implementation.

Medical aspects of Ambient Assisted Living implementation.

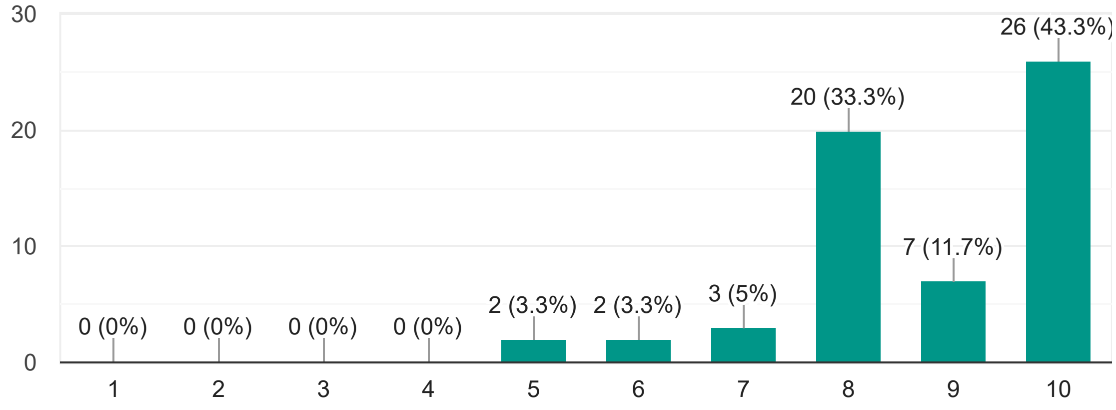
A) Ambient Assisted Living system is the only solution for the ageing crisis

60 responses



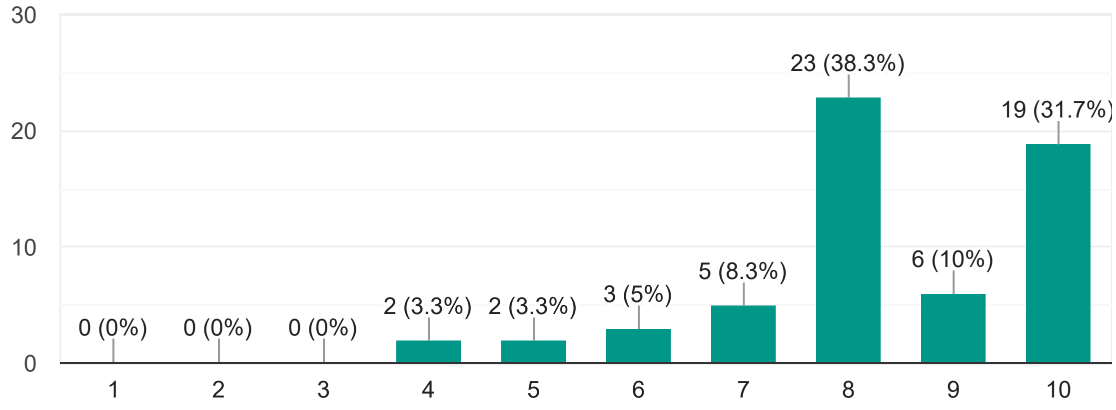
B) Ambient Assisted Living system can help the family doctor or visiting nurse to monitor the patient's condition between visits

60 responses



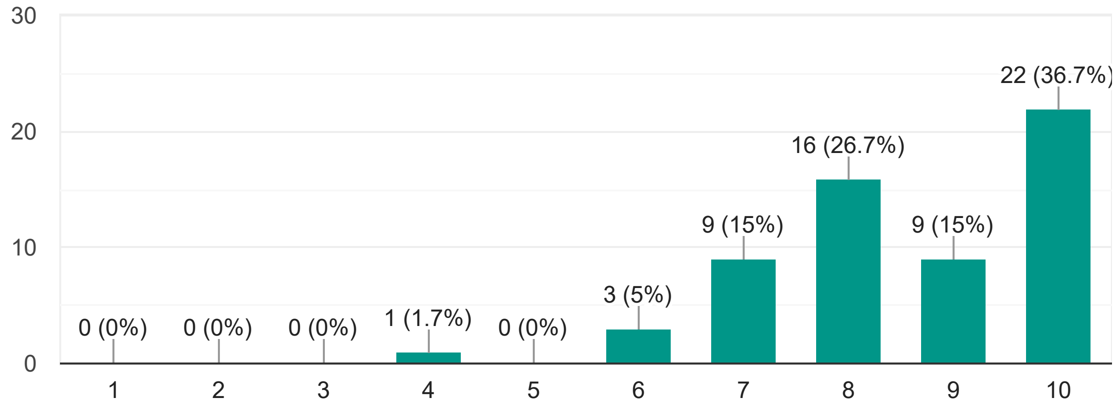
C) Ambient Assisted Living system can help to diagnose deterioration of the patient

60 responses



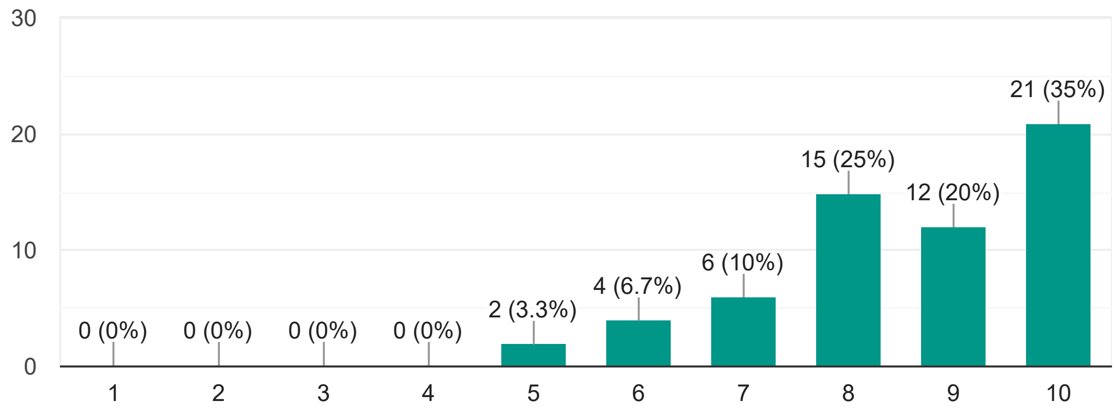
D) Ambient Assisted Living system can help to register medical emergency

60 responses



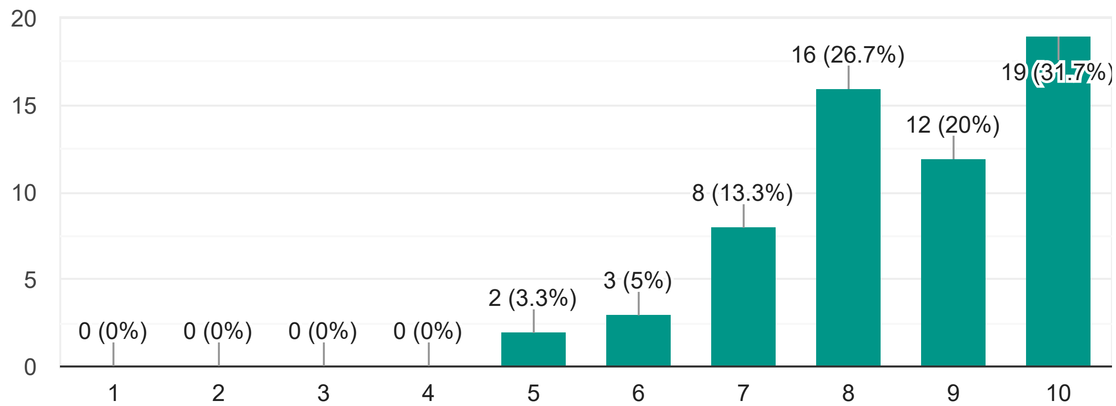
E) Ambient Assisted Living system can signal about heart emergency

60 responses



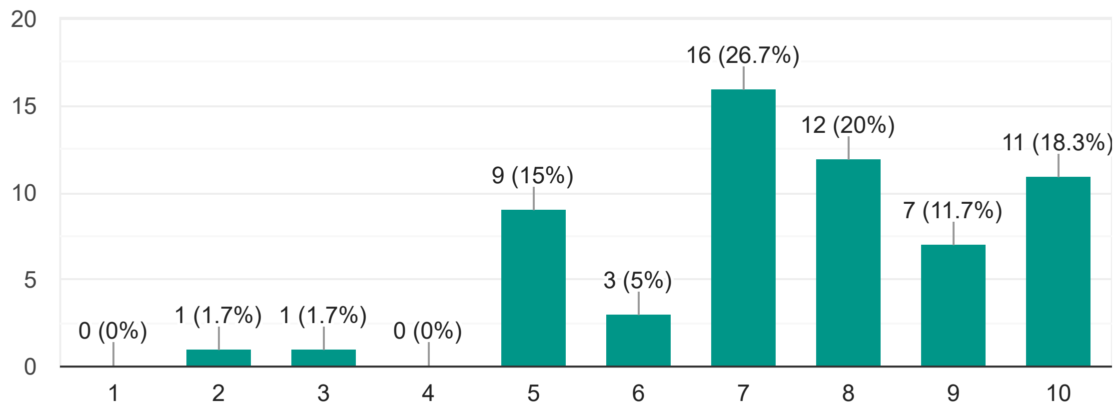
F) Ambient Assisted Living system can signal about pulmonary and airways emergency

60 responses



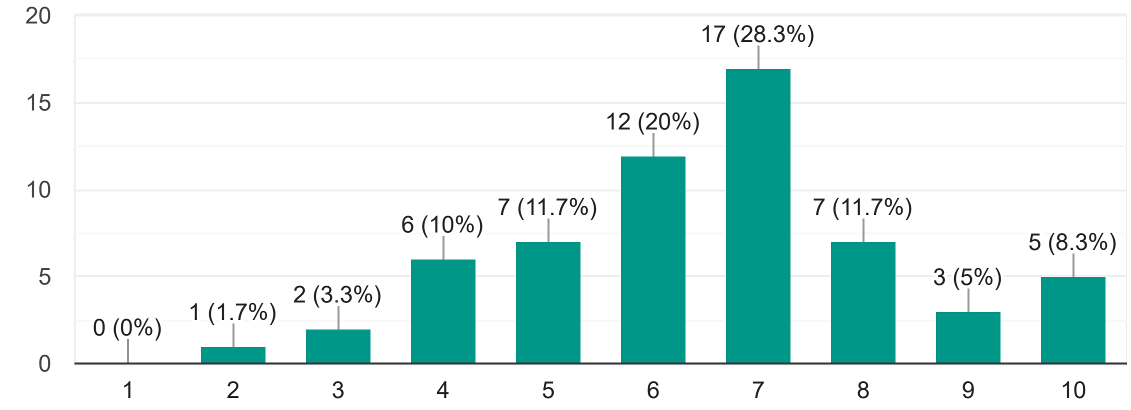
G) Ambient Assisted Living system can signal about the neurologic emergency

60 responses



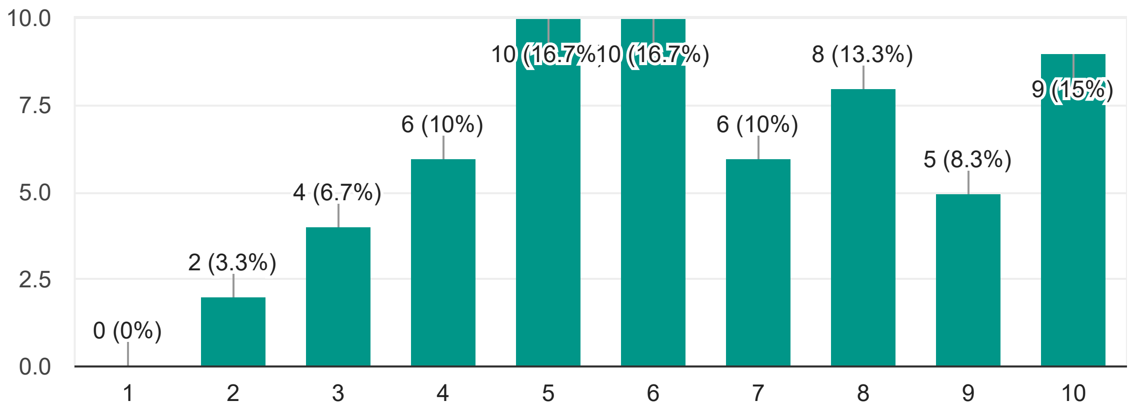
H) Ambient Assisted Living system can signal about acute infection

60 responses



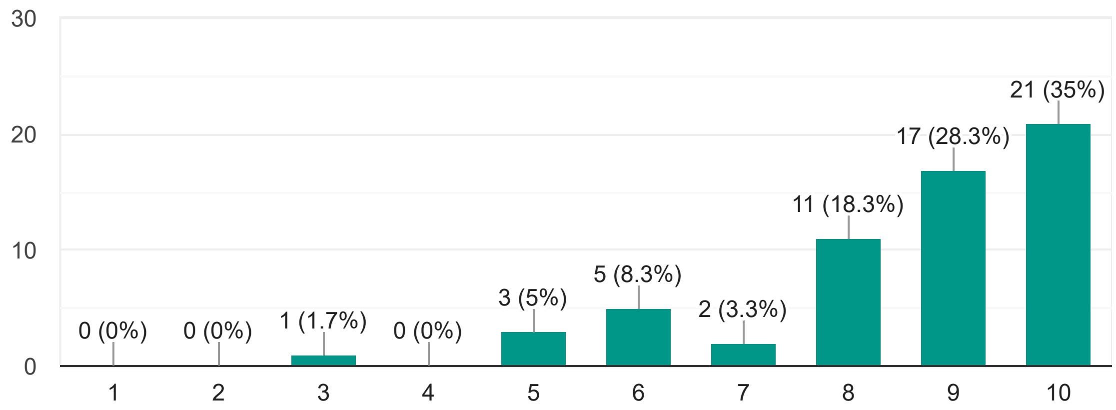
I) Ambient Assisted Living system can signal about psychiatric emergency

60 responses



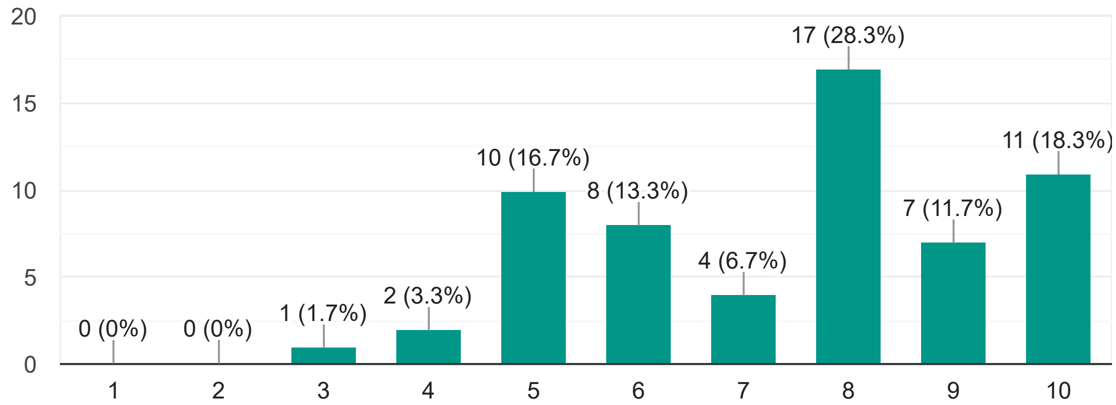
J) Ambient Assisted Living system can help to signal about fall or trauma at home

60 responses



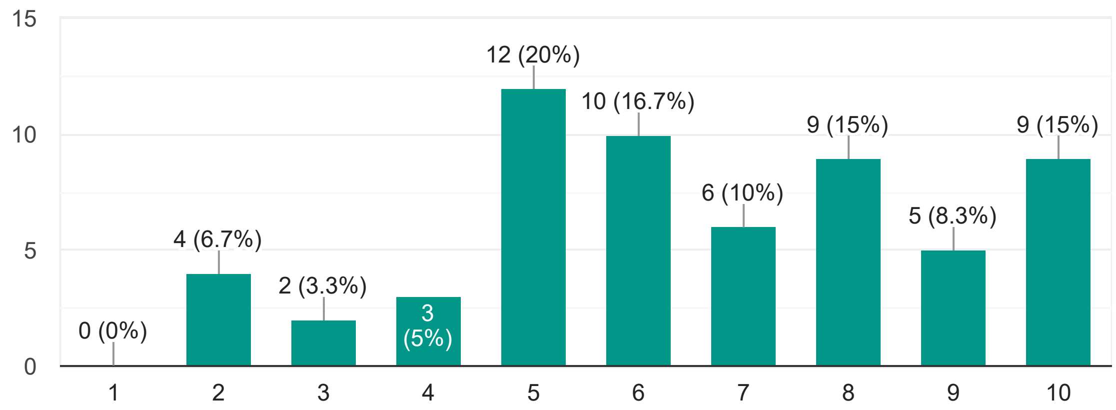
K) Ambient Assisted Living system is helpful in chronic somatic conditions

60 responses



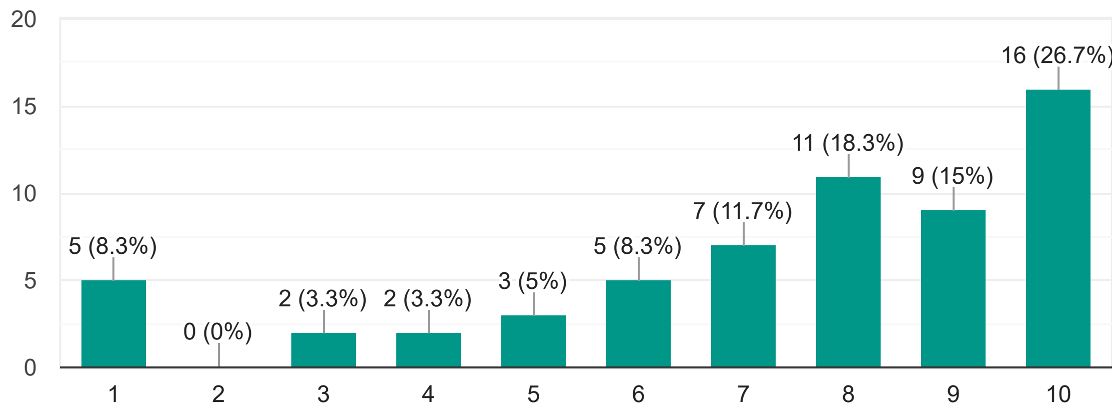
L) Ambient Assisted Living system is helpful in a chronic neuropsychiatric condition

60 responses



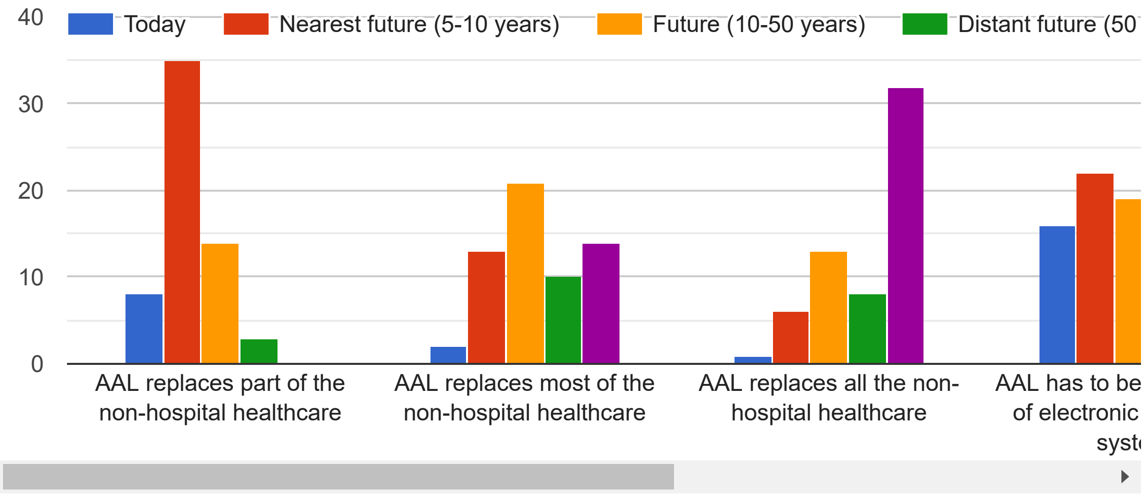
M) Ambient Assisted Living systems implementation will ease the load of the healthcare system

60 responses

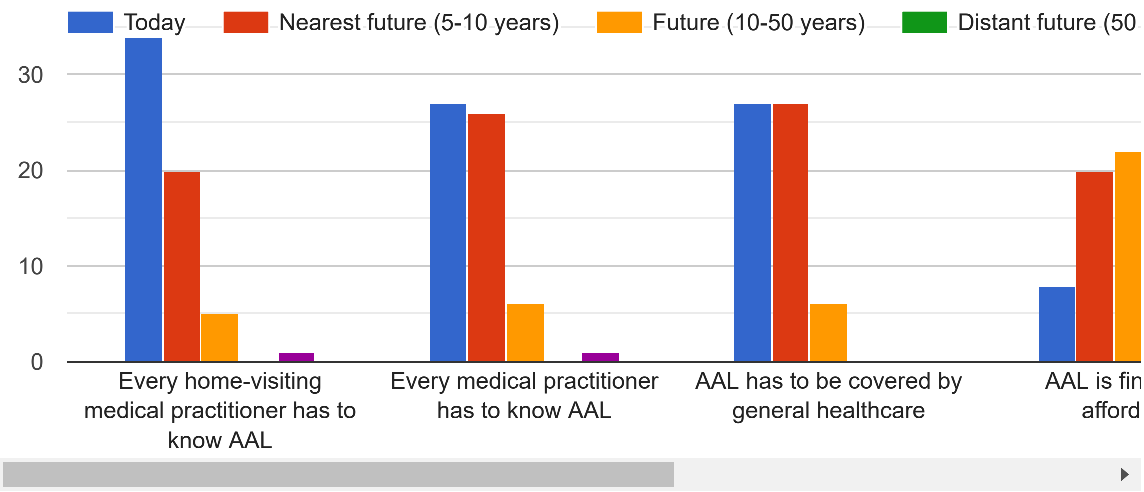


Ambient Assisted Living systems in healthcare

AAL role in healthcare. Please, choose one answer in the line.



Healthcare professionals and AAL system implementation. Please, choose one answer in the line.



Technical questions.

Ambient Assisted Living system. Computing units.

Please share your opinion about computing units for Ambient Assisted Living systems: servers, PC computers, laptops, smartphones, tablets, microcomputers. If necessary, consult the information below or use external sources in order to answer questions.

Servers.

Personal computers.

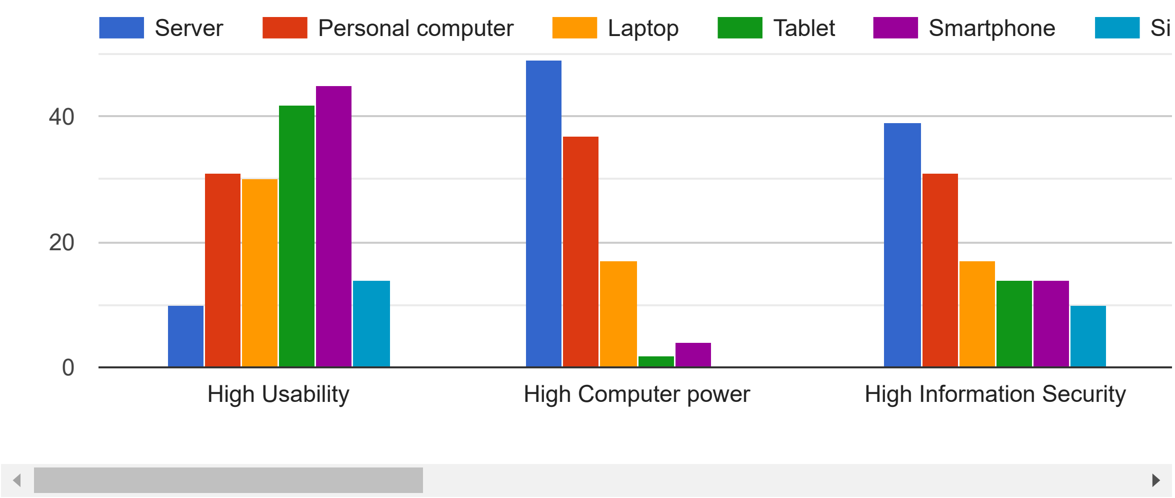
Laptops.

Tablet computers

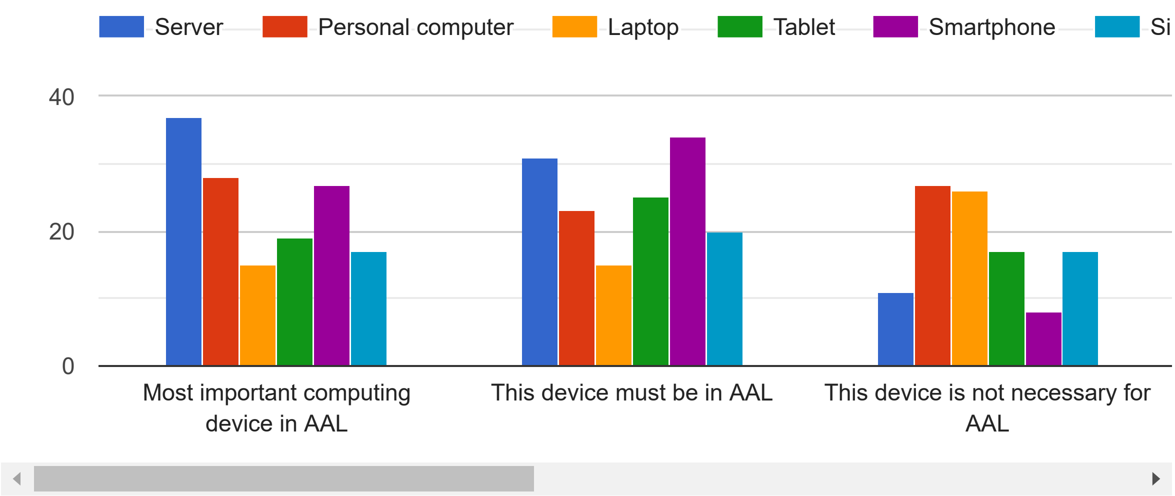
Smartphones.

Single-board microcomputers.

Please, mark every term, associated with a computing device. If several devices share the same answer, mark more than one box



Please, mark every term, associated with a computing device. If several devices share the same answer, mark more than one box



Please share your opinion about sensors for Ambient Assisted Living systems. If necessary, consult the information below or use external sources in order to answer questions.

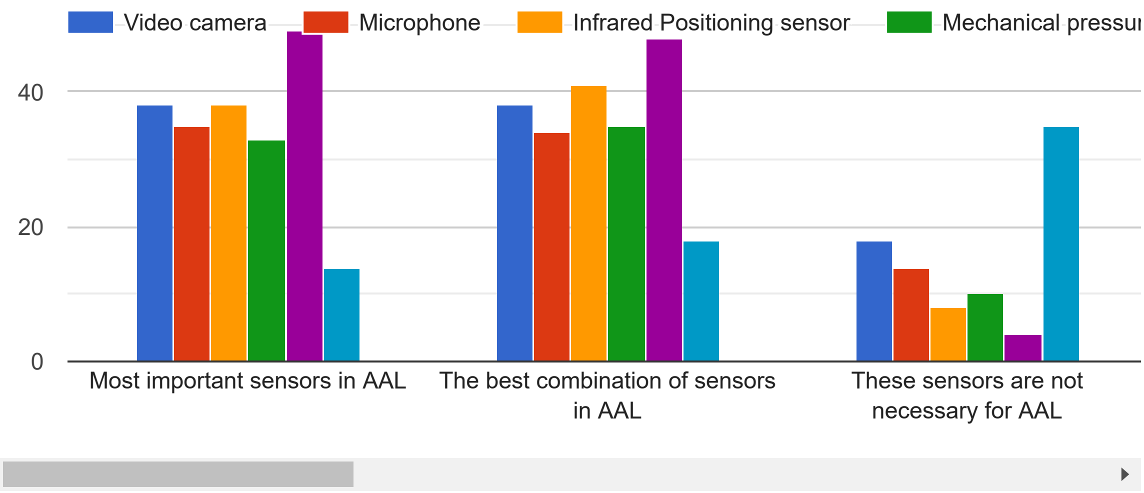
Sensors.

Infrared sensors.

Piezoelectric sensors.

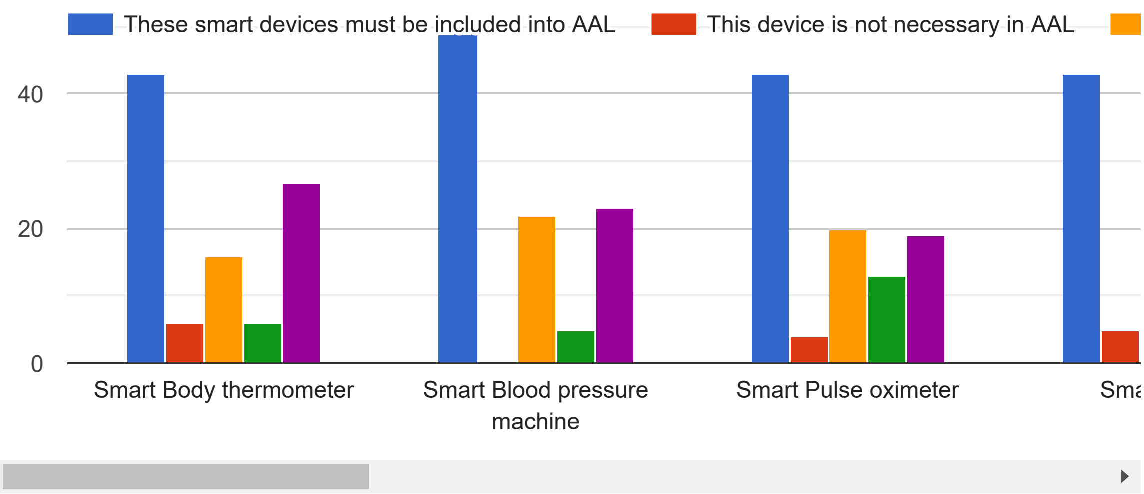
Wearable sensors.

Please, mark every term, associated with a sensor. If several sensors share the same answer, mark more than one box



Smart Devices in the Ambient Assisted Living.

ATTENTION, PLEASE! MAKE SURE EVERY VERTICAL COLUMN IS PROPERLY FILLED! Please, mark every term, associated with a device. If several devices share the same option, mark more than one box.

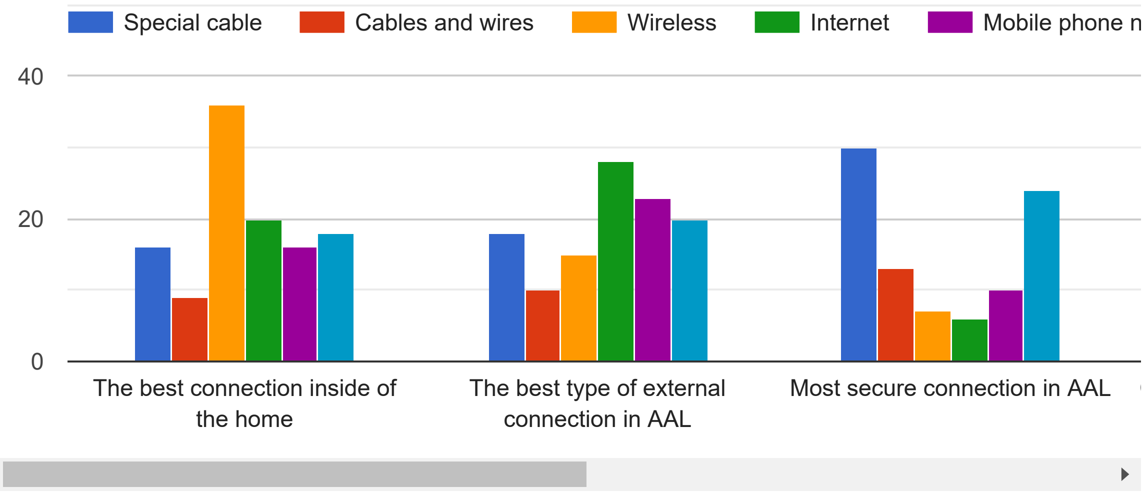


Networks in Ambient Assisted Living.

Local networks.

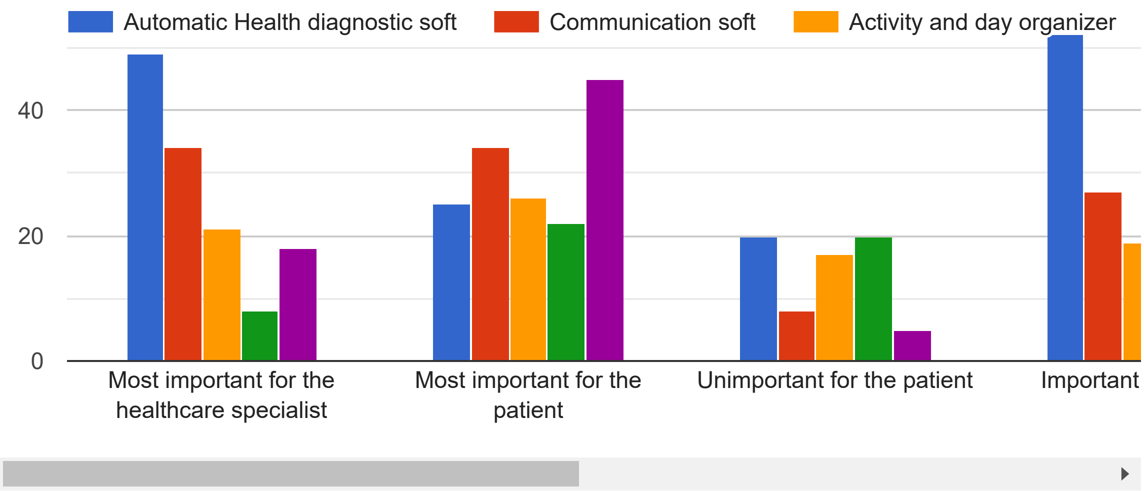
External networks.

Please, mark every term, associated with the network. If several networks share the same level, mark more than one



Medical software for Ambient Assisted Living systems.

Please, mark every term, associated with the software. If more than one software share the same level, mark more than one box

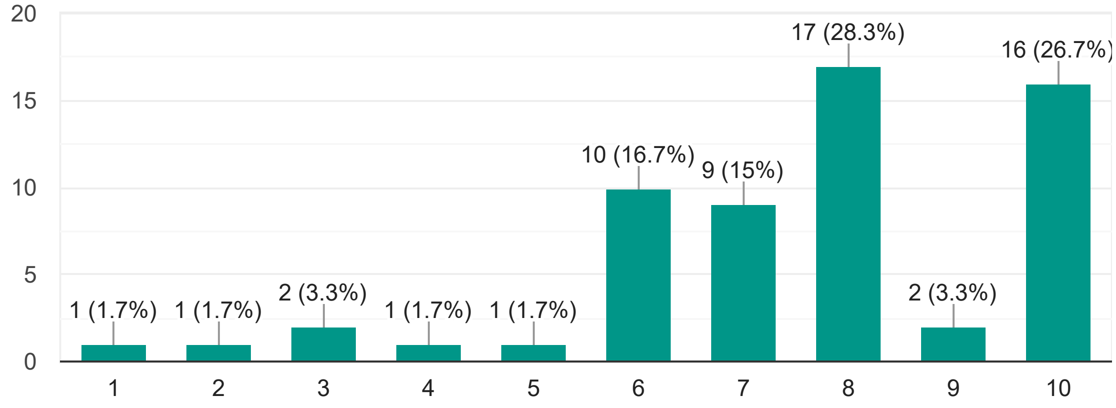


Ambient Assisted Living solutions for patients with Mild Cognitive Impairment.

Ambient Assisted Living system for patients with Mild Cognitive Impairment. General questions.

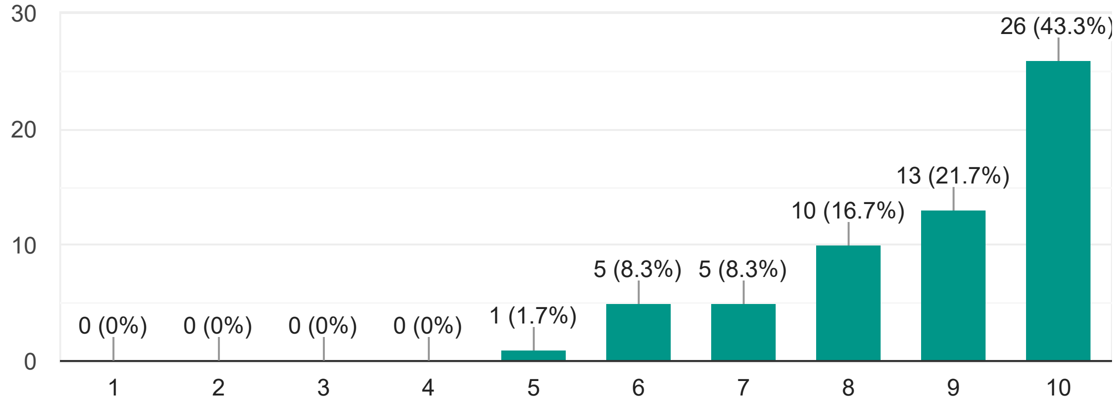
A) AAL system is the best solution for MCI patients

60 responses



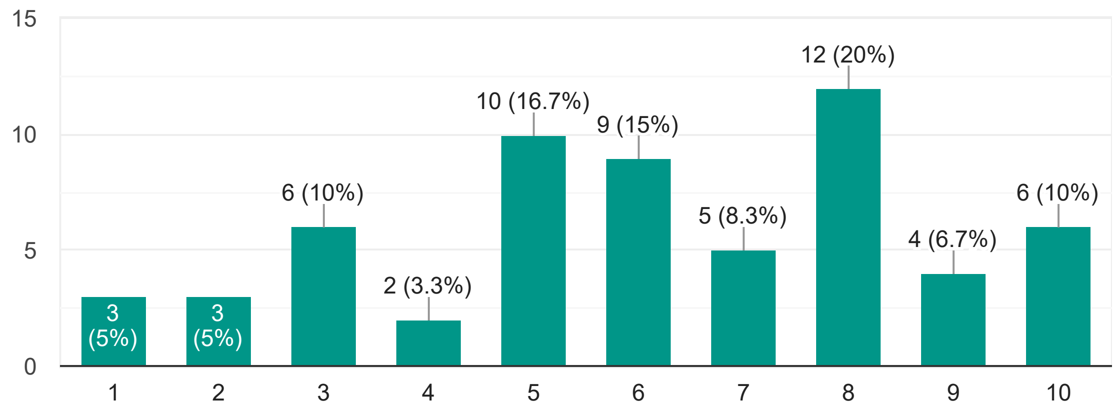
B) AAL system is a good addition to the existing healthcare solutions for patients with Mild Cognitive Impairment

60 responses



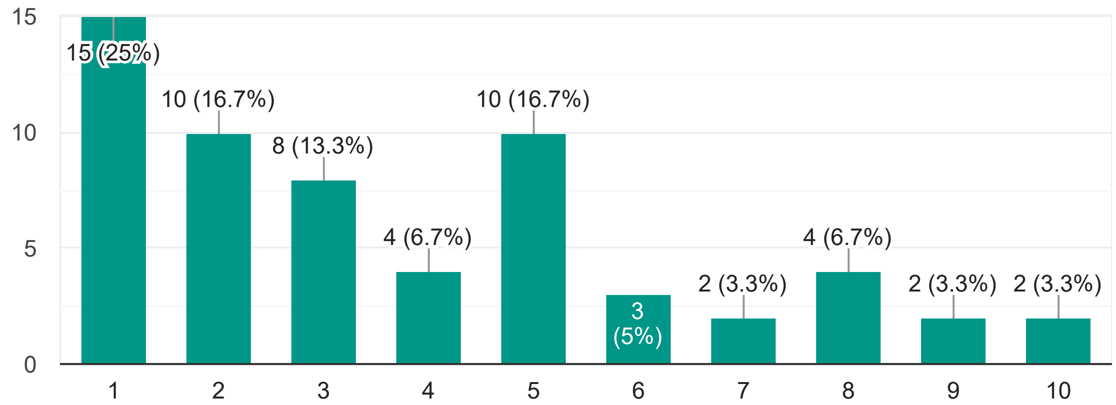
C) AAL system is helpful only for some patients with Mild Cognitive Impairment

60 responses



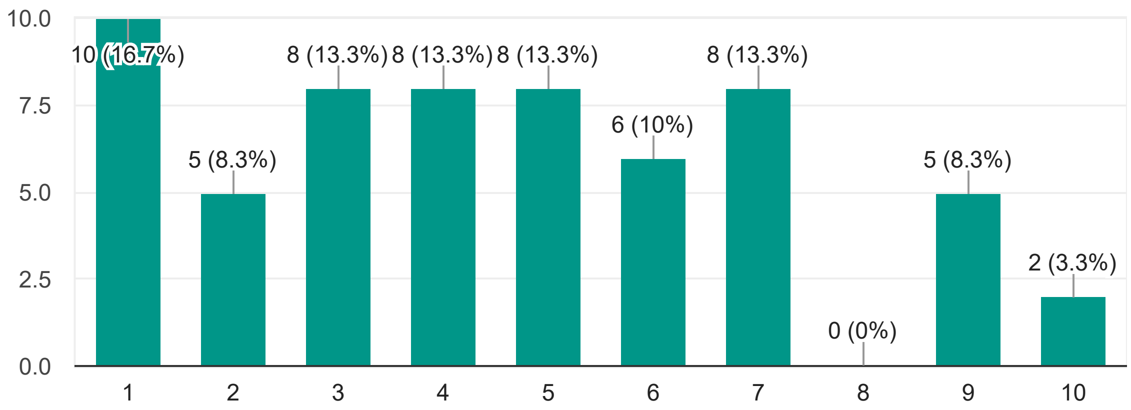
D) AAL system is inconvenient for MCI patients

60 responses



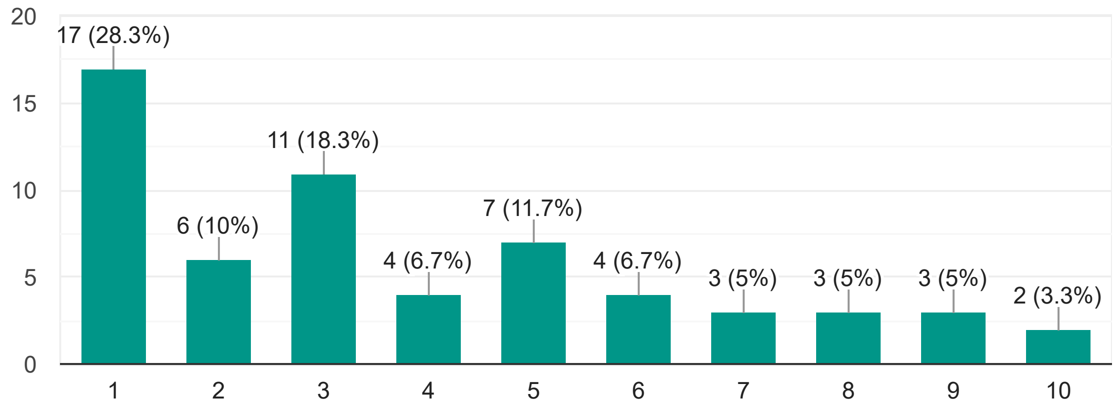
E) AAL system is too complicated to be used for patients with Mild Cognitive Impairment

60 responses



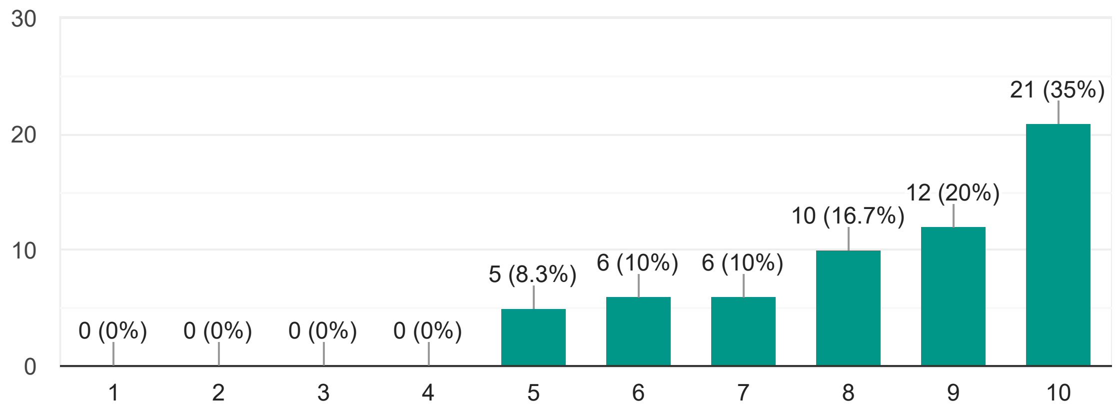
F) AAL system can help patients with dementia, not with MCI

60 responses



G) AAL system is a good support for relatives of patients with Mild Cognitive Impairment

60 responses

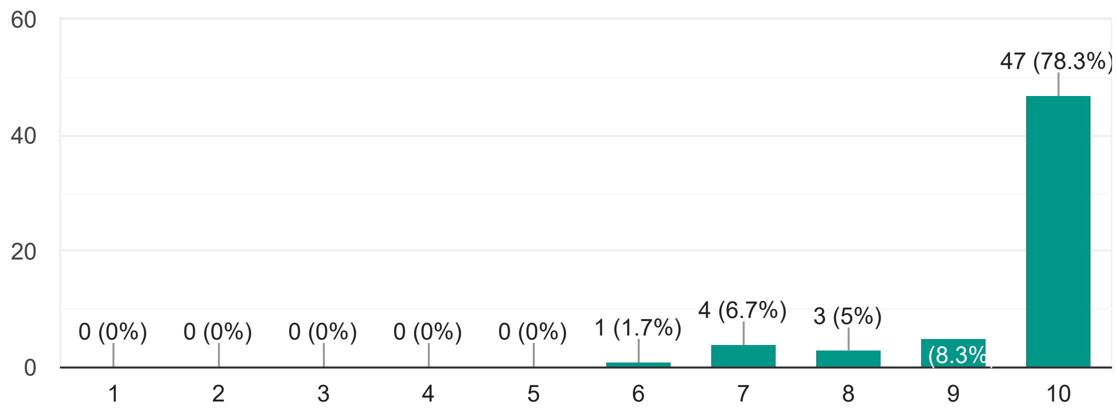


Diagnostic soft requirements in the Ambient Assisted Living system for patients with Mild Cognitive Impairment.

Please, mark the most appropriate answer in accordance with your experience and professional opinion:

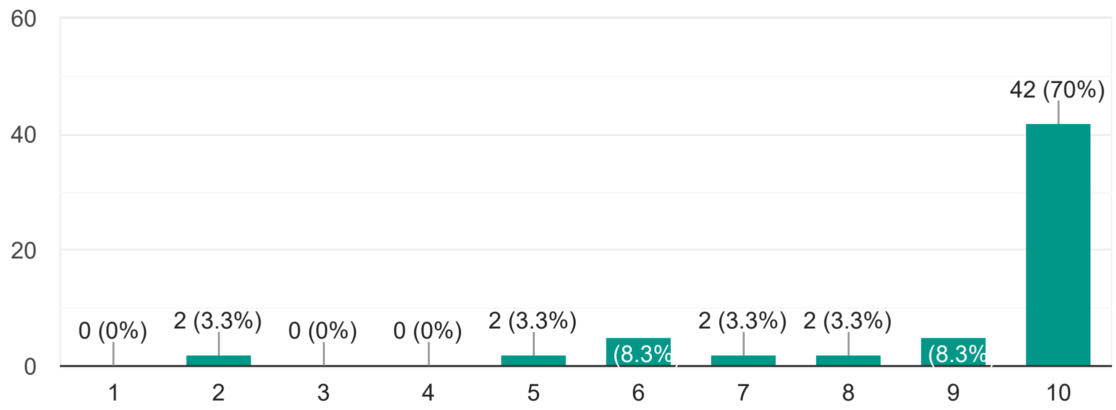
A) AAL system must send the immediate report in the case of a somatic emergency

60 responses



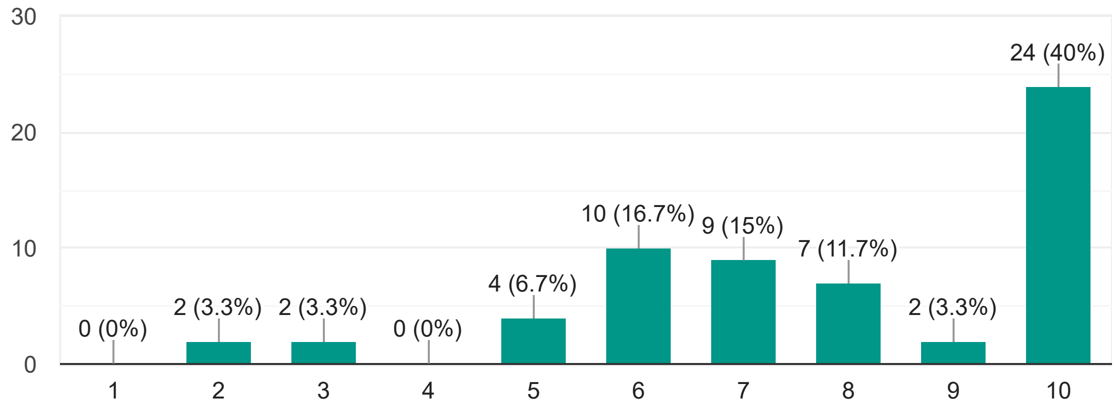
B) AAL system must send an immediate report about psychiatric emergency

60 responses



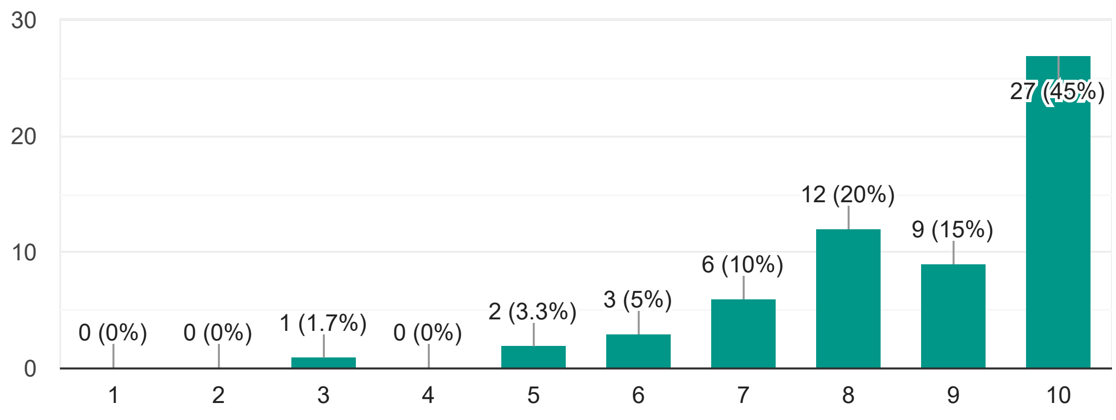
C) AAL system has to diagnose the level of cognitive deterioration

60 responses



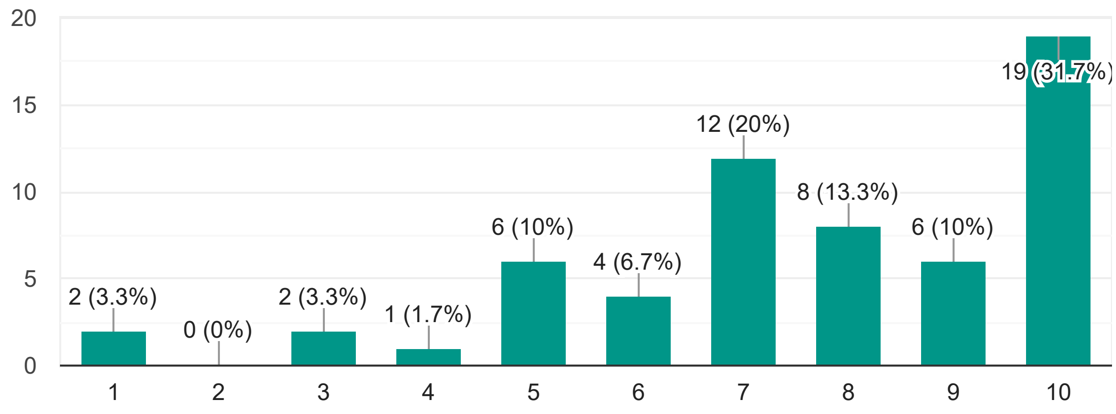
D) AAL system has to report about the strange and unusual behaviour

60 responses



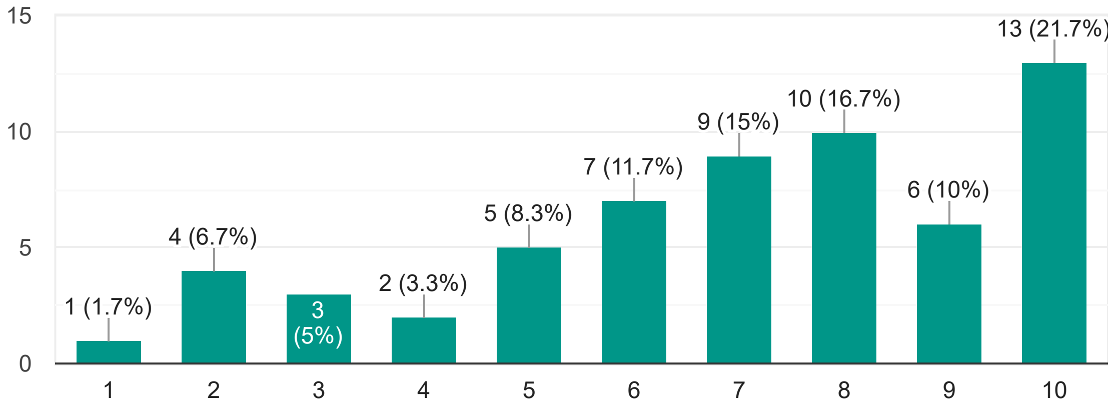
E) AAL system has to recognize sleep disturbance

60 responses



F) AAL system has to include specific software for a regular memory check

60 responses

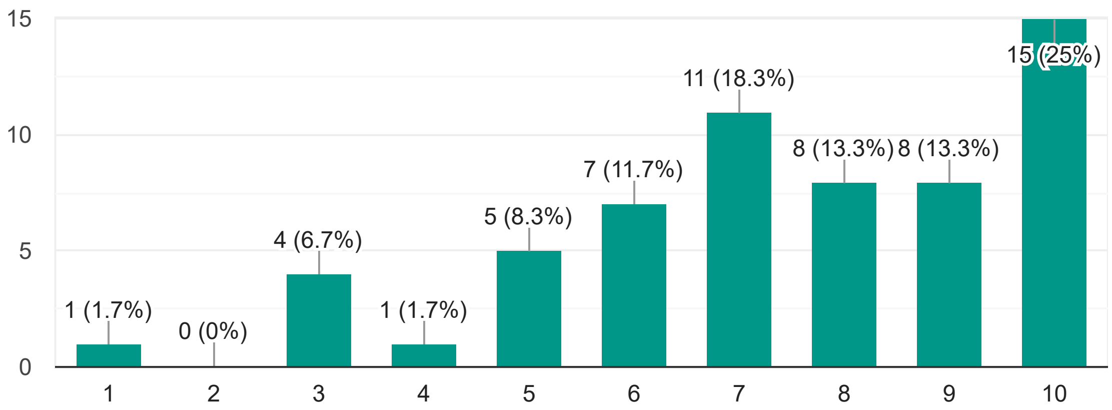


Smart devices and software in the Ambient Assisted Living System for patients with Mild Cognitive Impairment

Please, mark the most appropriate answer in accordance with your experience and professional opinion:

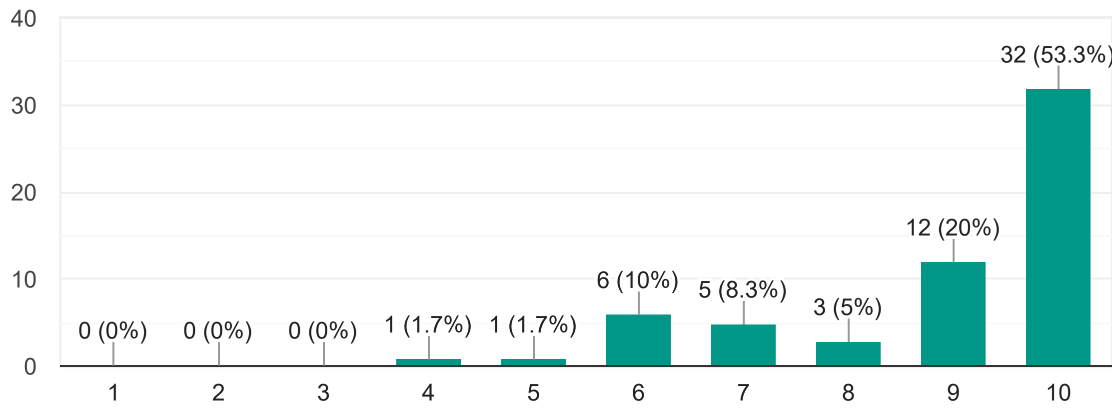
A) AAL system for MCI patients has to include memory training soft

60 responses



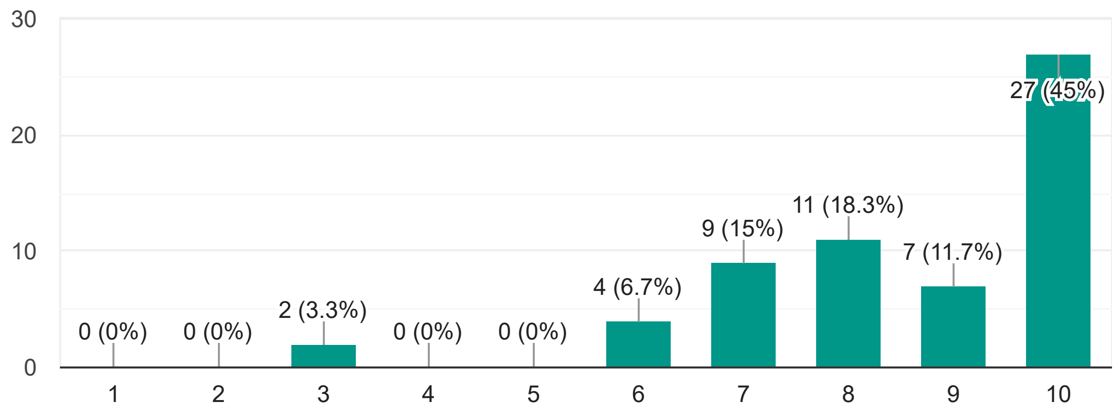
B) AAL system for patients with Mild Cognitive Impairment has to include an organizer with an automatic reminder

60 responses



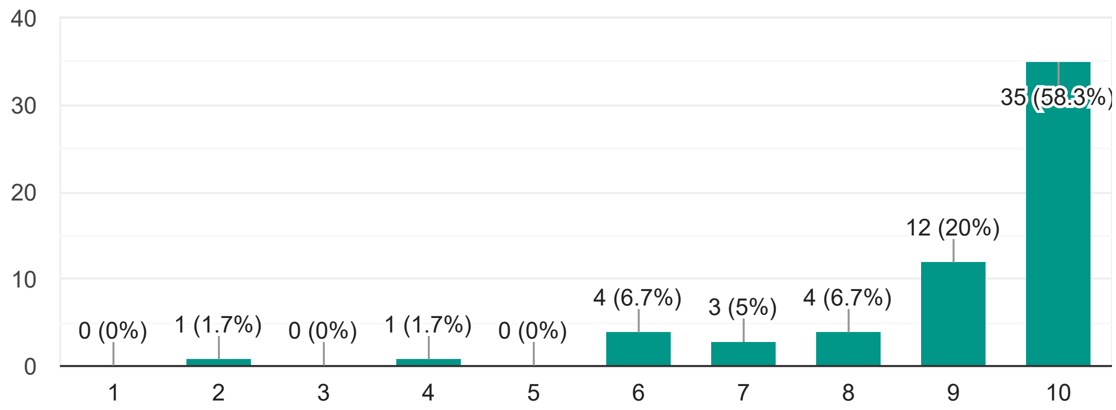
C) AAL system for MCI patients has to include electronic tablet dispenser with an automatic reminder

60 responses



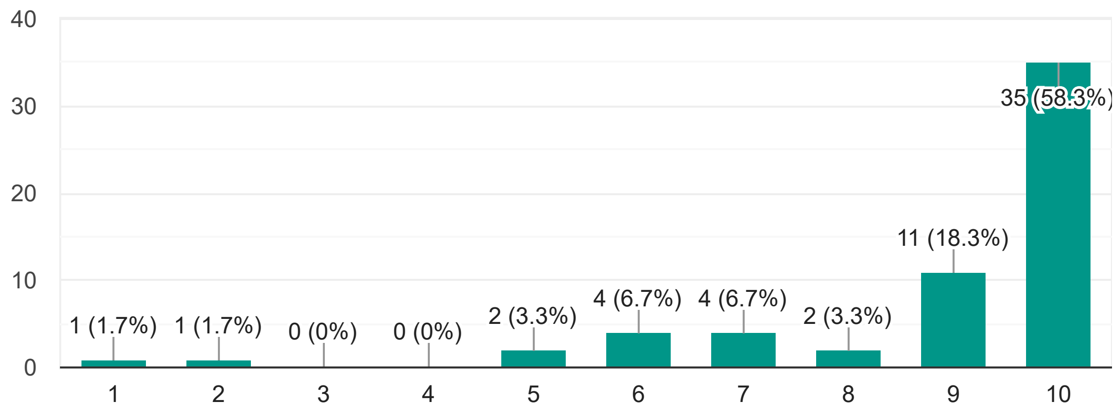
D) AAL system for patients with Mild Cognitive Impairment has to report about irregularities with medicines` intake

60 responses



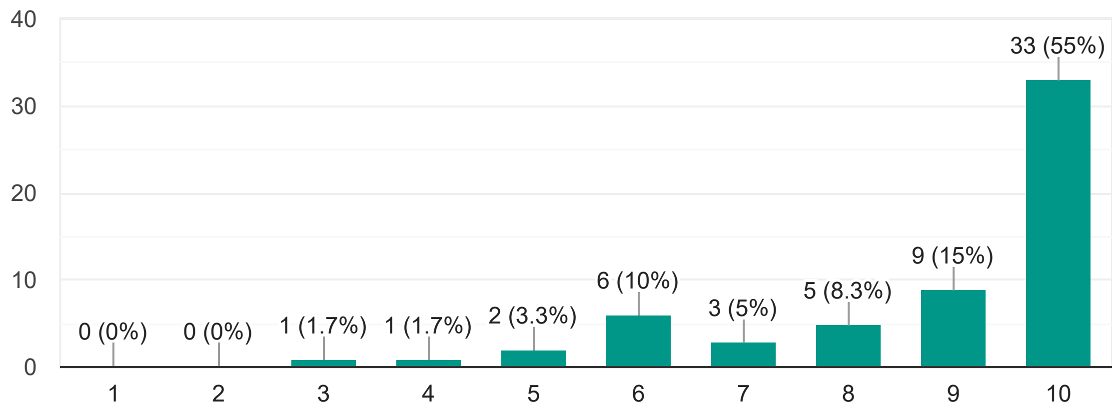
E) AAL system for patients with Mild Cognitive Impairment has to report about open water tap

60 responses



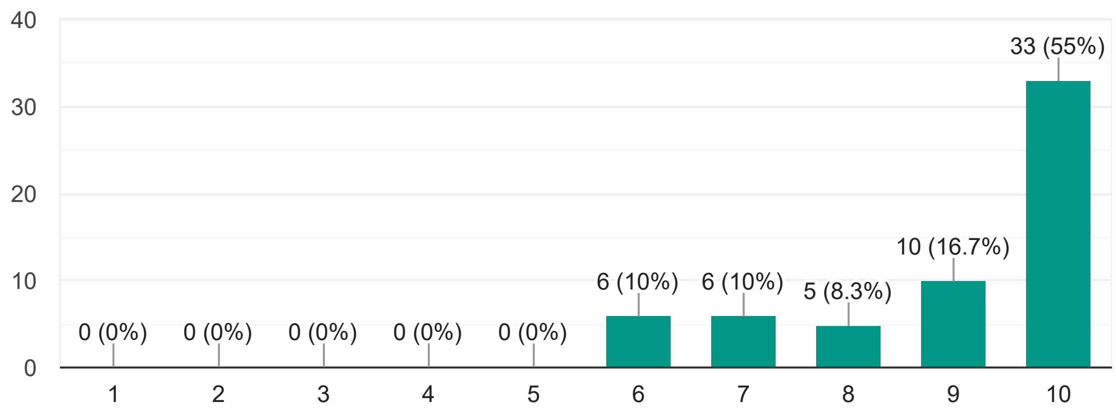
F) AAL system for patients with Mild Cognitive Impairment has to collect information automatically from an electronic thermometer, blood pressure machine, pulse oximeter, glucometer and other vital signs measuring devices

60 responses



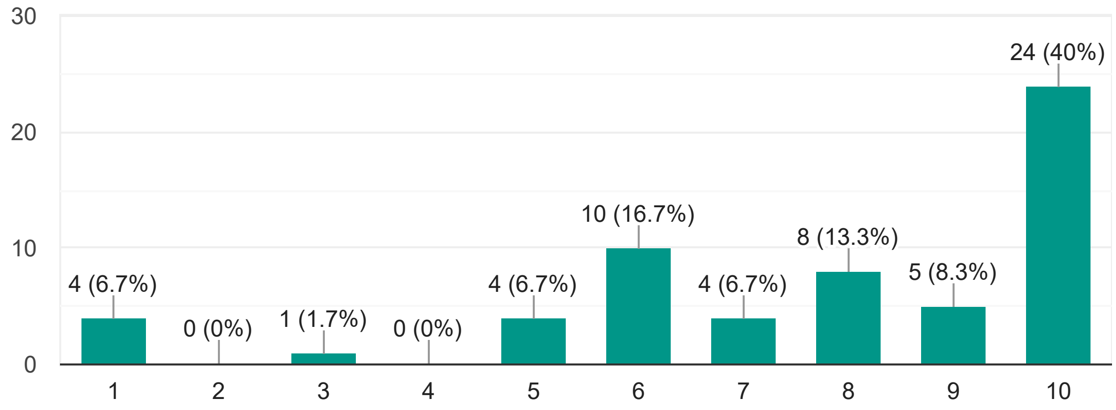
G) AAL system has to remind about the necessity to measure blood pressure or blood glucose

60 responses



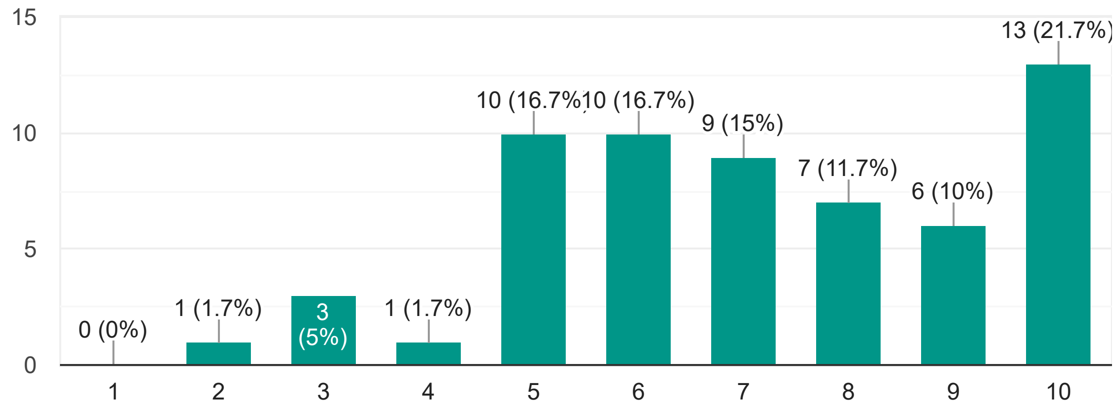
H) AAL system for patients with Mild Cognitive Impairment elements and devices have to be fully designed by specially designated engineering company

60 responses



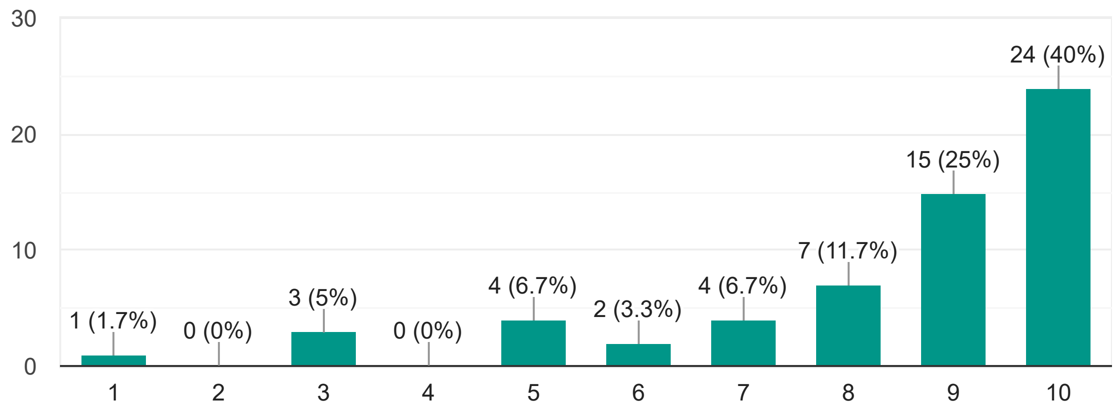
I) AAL system for patients with Mild Cognitive Impairment is better to build from ready Commercial-Off-The-Shelf (COTS) elements and devices

60 responses



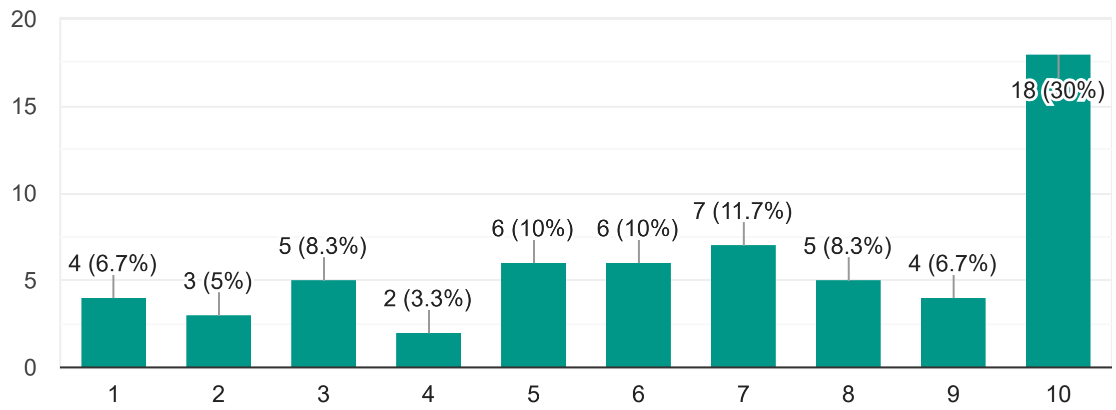
J) Devices in the AAL system for patients with Mild Cognitive Impairment have to be only or mostly wireless

60 responses



K) Devices in the AAL system for MCI patients have to be only or mostly wired because it is hard to remember about charging all the batteries

60 responses

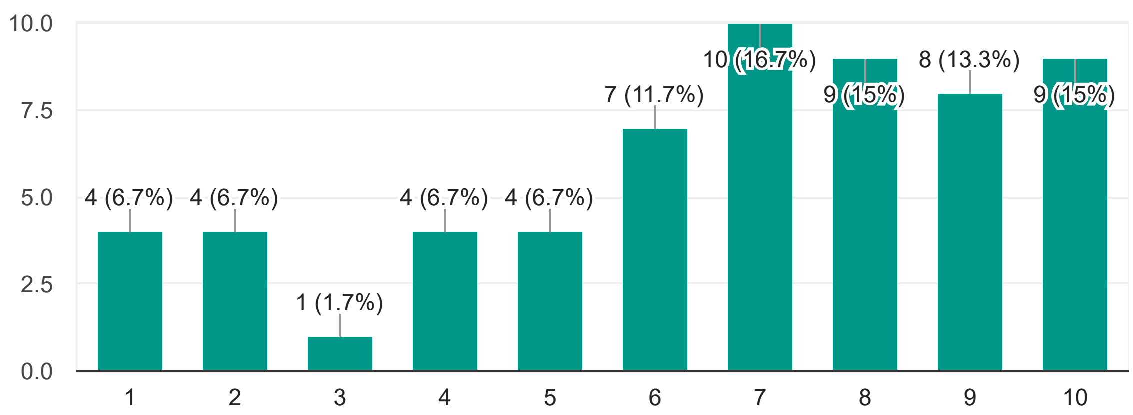


Sensors in the Ambient Assisted Living system for patients with Mild Cognitive Impairment.

Please, mark most appropriate answer in accordance with your experience and professional opinion:

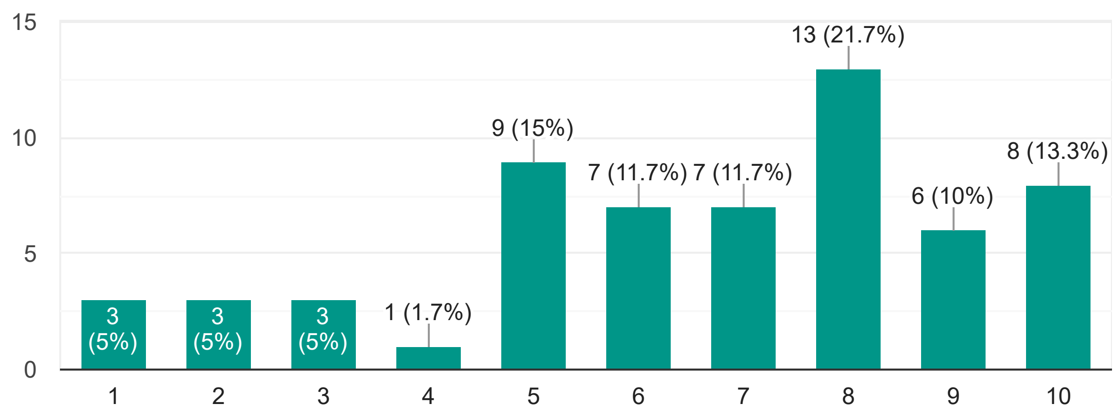
A) The video camera is the best sensor in the AAL system for patients with Mild Cognitive Impairment.

60 responses



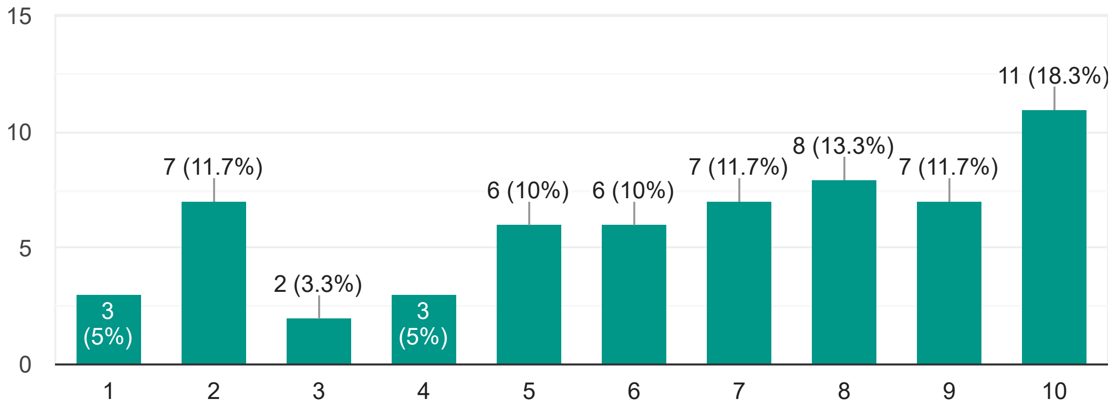
B) Microphones are very important in the AAL system for patients with Mild Cognitive Impairment.

60 responses



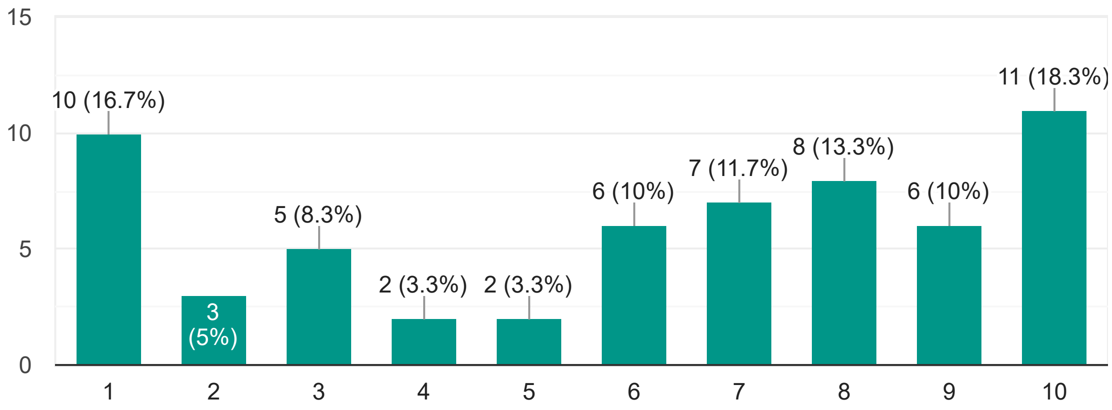
C) The video camera and microphones are too invasive to be used 24 hours a day/7 days a week as AAL sensors for patients with Mild Cognitive Impairment.

60 responses



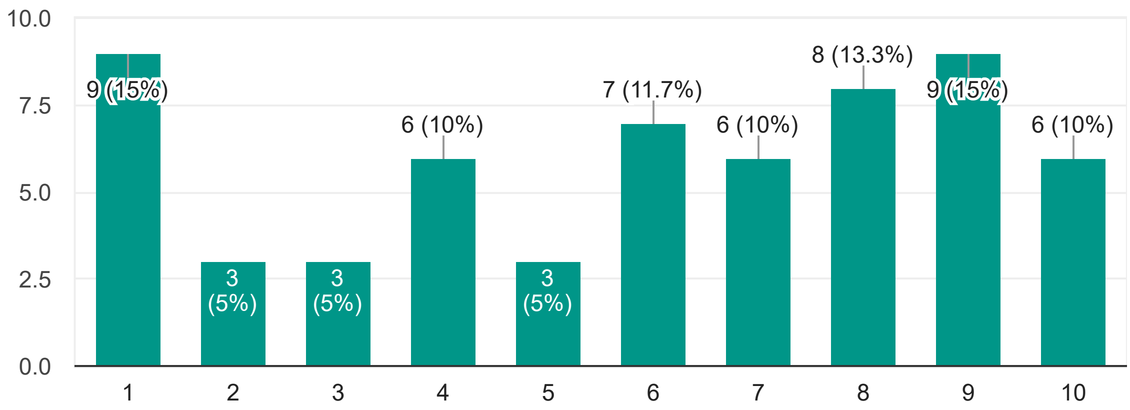
D) Video cameras and microphones can be used in AAL only for emergency

60 responses



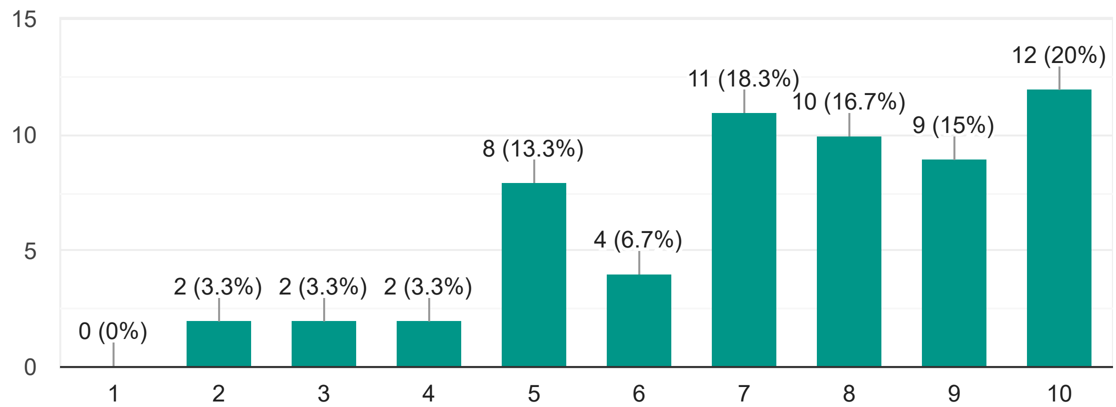
E) Video camera and microphone can be used in AAL for patients with Mild Cognitive Impairment. for communication only

60 responses



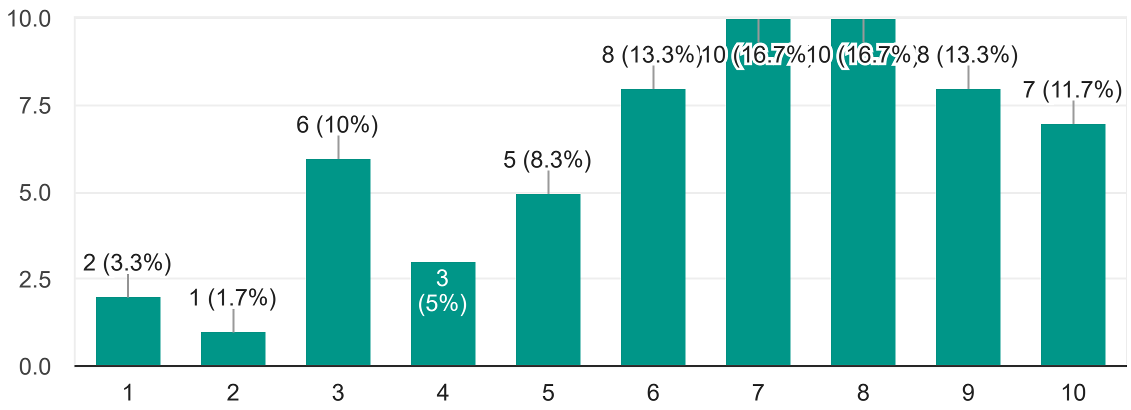
F) Motion registration by infrared sensors is very important in AAL for patients with Mild Cognitive Impairment

60 responses



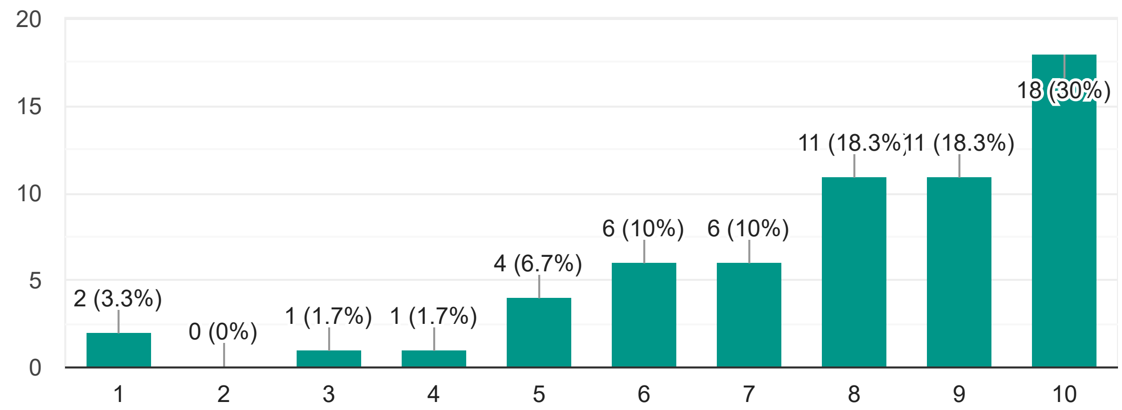
G) Gesture recognition by active infrared sensors is very important in AAL for patients with MCI

60 responses



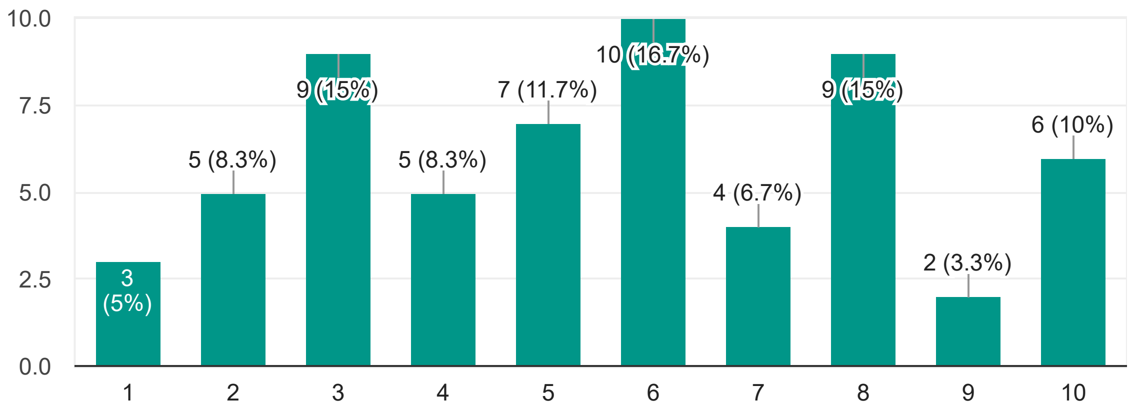
H) Wearable vital signs` sensors must be part of the AAL system for patients with MCI

60 responses



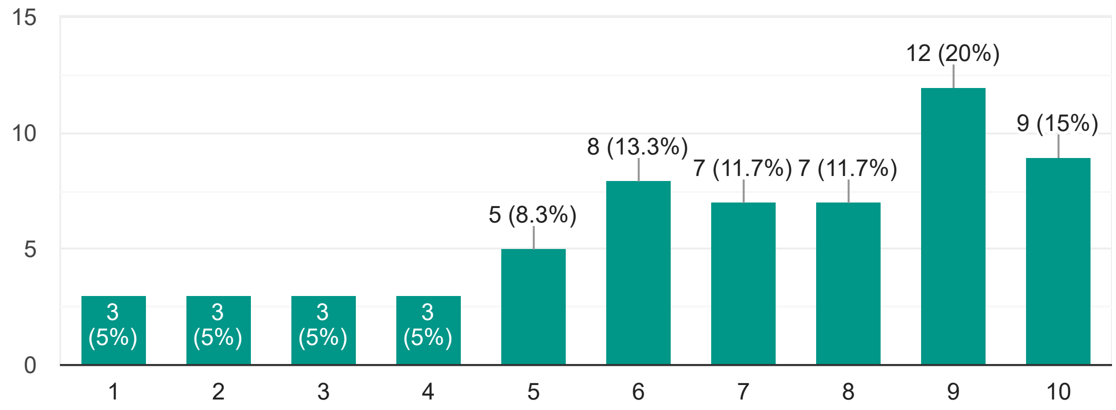
I) Wearable vital signs` sensors are inconvenient for patients with Mild Cognitive Impairment

60 responses



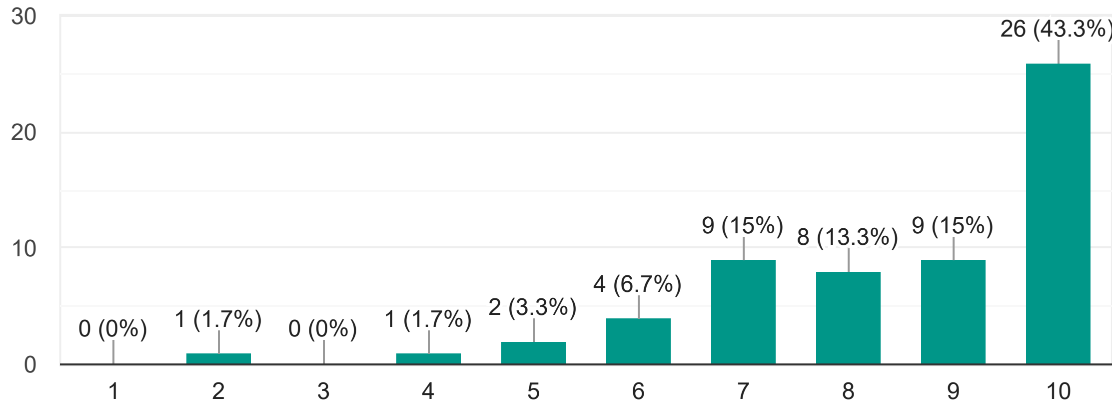
J) Pressure sensors have to be part of smart furniture and have to be mounted on beds, couches, chairs for the position registration of patients with MCI

60 responses



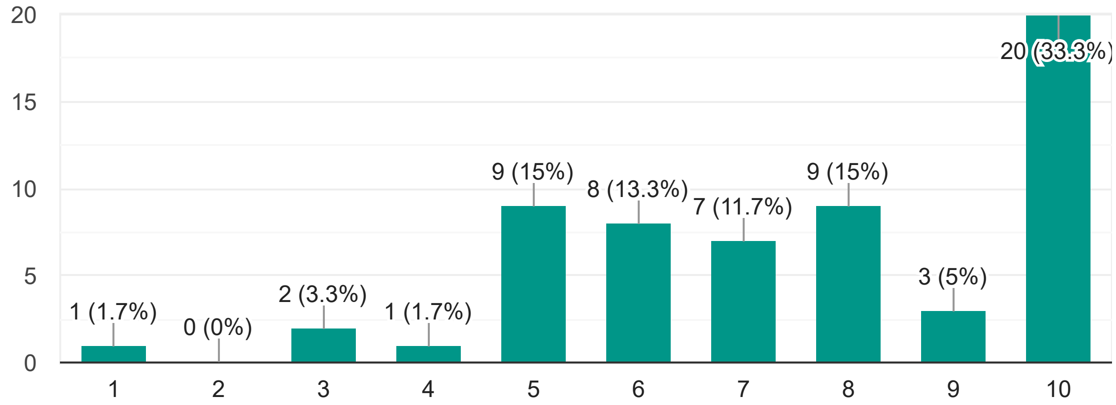
K) Entrance door and windows have to be with sensors, to report about the open or closed status in Ambient Assisted Living system for patients with Mild Cognitive Impairment.

60 responses



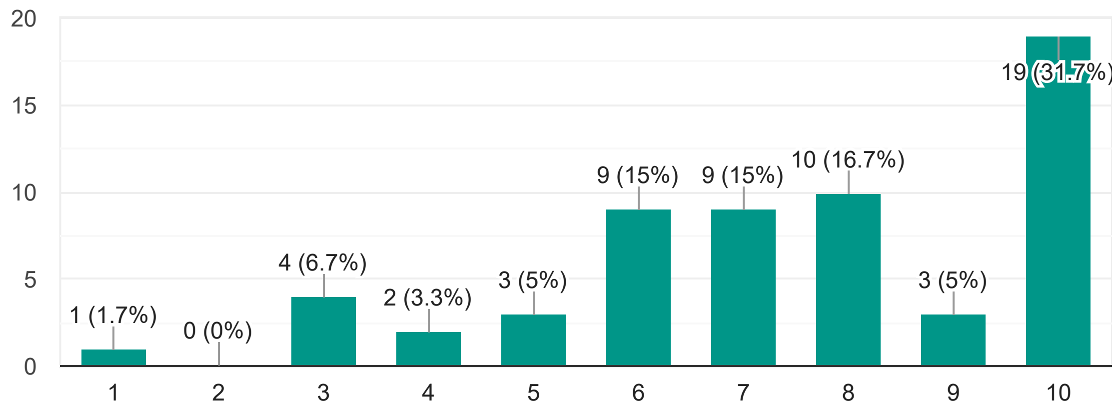
L) Smart electricity meters have to report about electricity usage pattern: day and night, unusual peak activities in AAL system for patients with Mild Cognitive Impairment.

60 responses



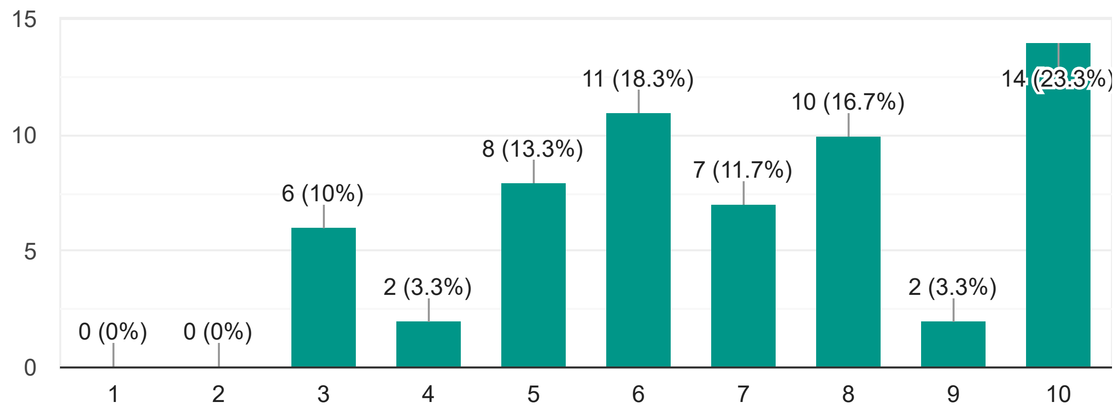
M) Smart water meters are necessary in the AAL system for patients with Mild Cognitive Impairment

60 responses



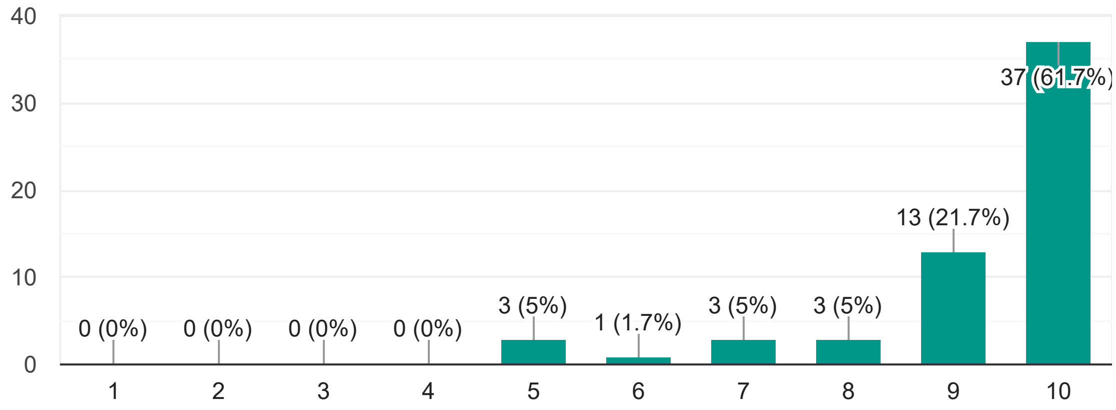
N) Temperature and climate regulation sensors are a very important part of AAL for MCI patients

60 responses



O) Gas leak chemical sensors have to control air quality in homes with gas stoves in Ambient Assisted Living system for patients with Mild Cognitive Impairment.

60 responses

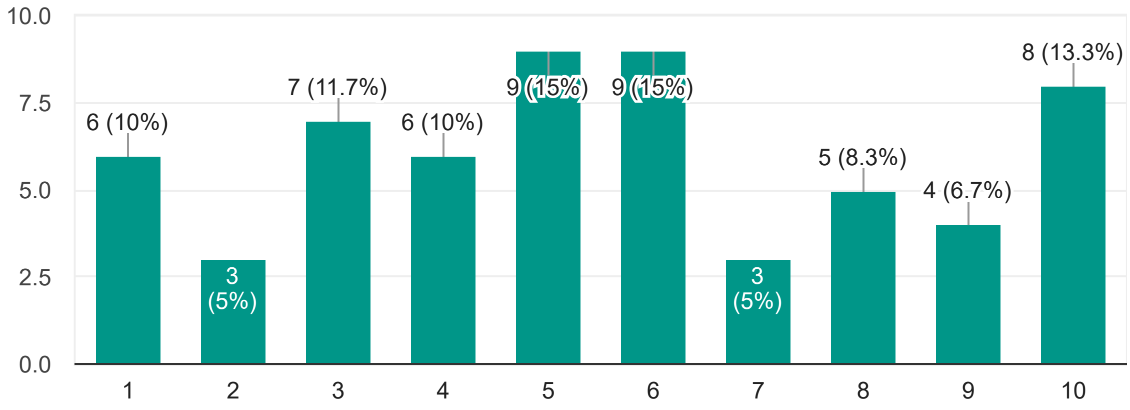


Computing devices in Ambient Assisted Living system for patients with Mild Cognitive Impairment.

Please, mark the most appropriate answer in accordance with your experience and professional opinion:

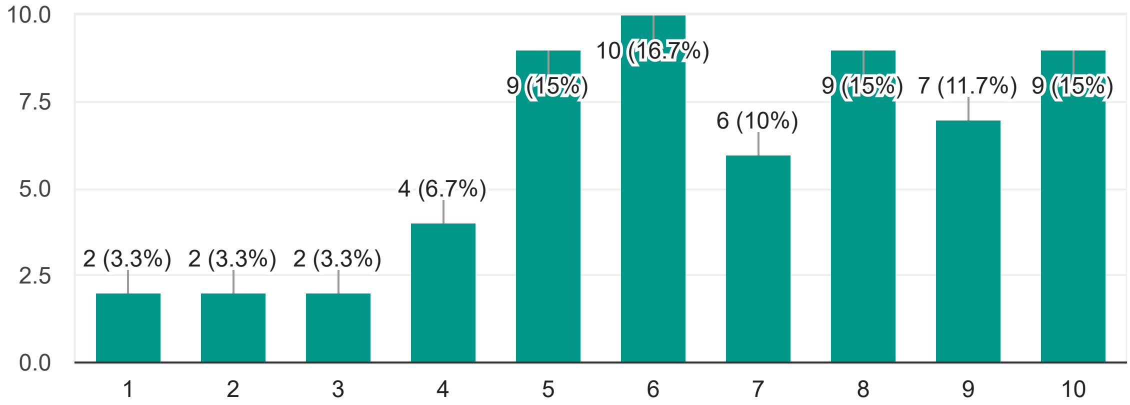
A) The server for the healthcare stakeholder side and server in the patient's home side is the best configuration in Ambient Assisted Living system for patients with Mild Cognitive Impairment.

60 responses



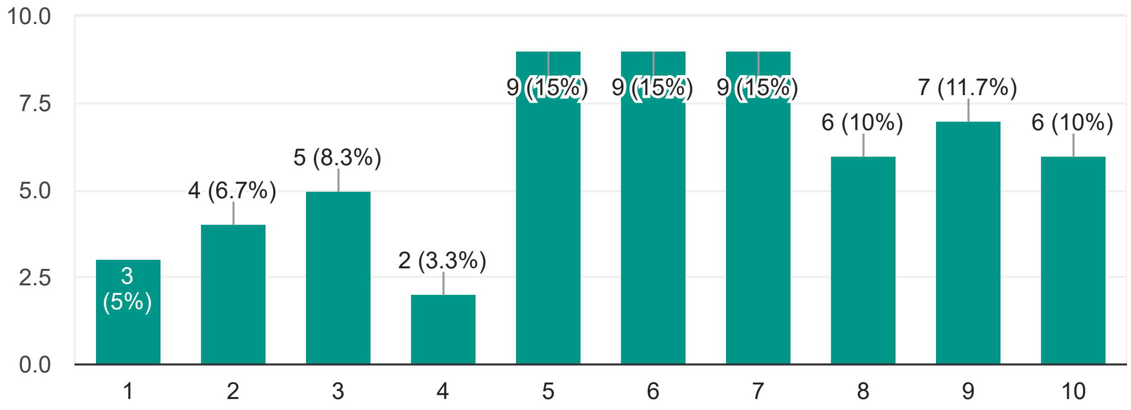
B) The server for the healthcare stakeholder side and personal computer on the patient's home side is the best configuration in Ambient Assisted Living system for patients with Mild Cognitive Impairment.

60 responses



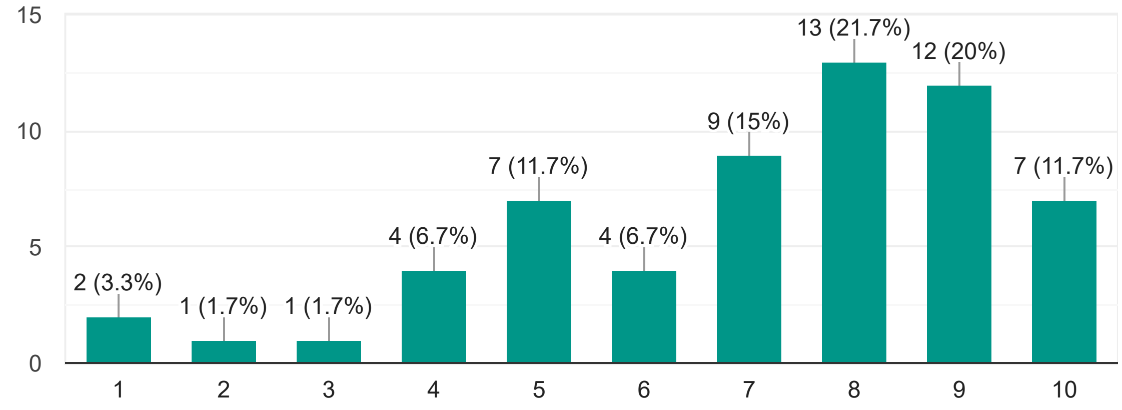
C) The laptop is the most convenient computing device on the patient's home side in Ambient Assisted Living system for patients with Mild Cognitive Impairment.

60 responses



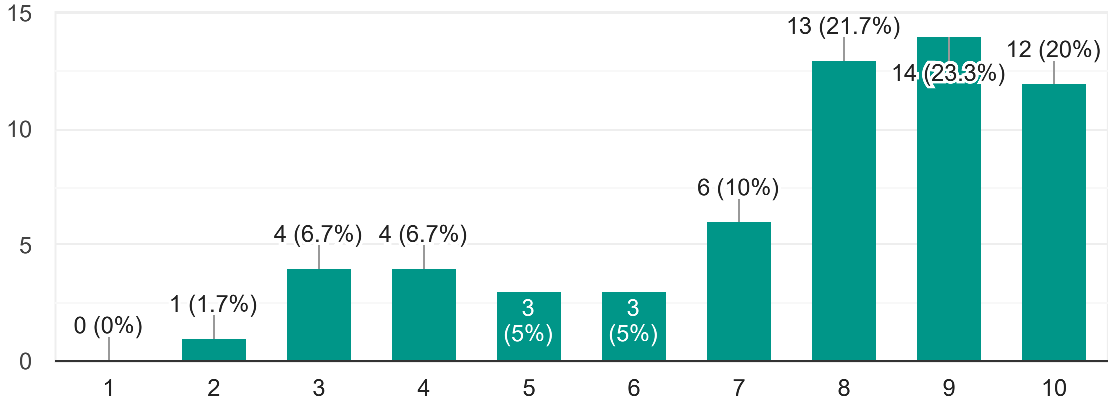
D) Computer tablet is the most convenient computing device on the patient's home side in Ambient Assisted Living system for patients with Mild Cognitive Impairment.

60 responses



E) A smartphone is the most convenient computing device on the patient's home side in Ambient Assisted Living system for patients with Mild Cognitive Impairment.

60 responses

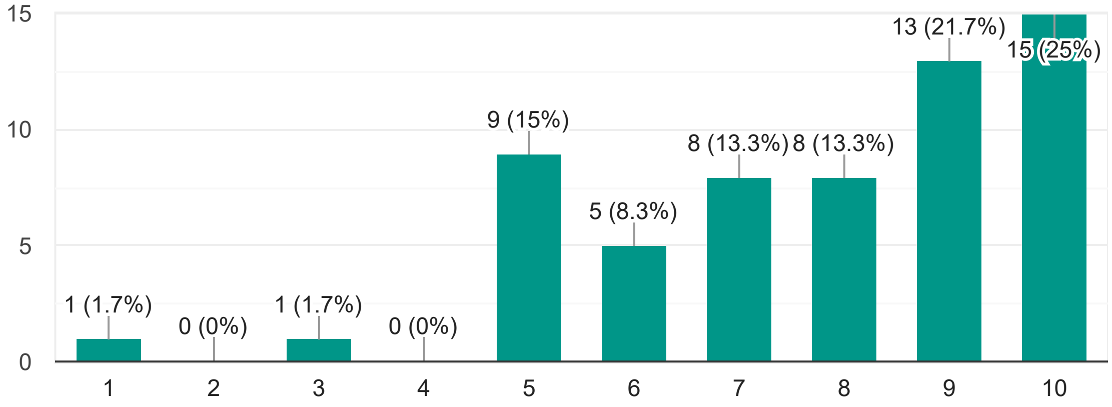


Activities of Daily Living and Instrumental Activities of Daily Living.

Please, mark most appropriate answer in accordance with your experience and professional opinion:

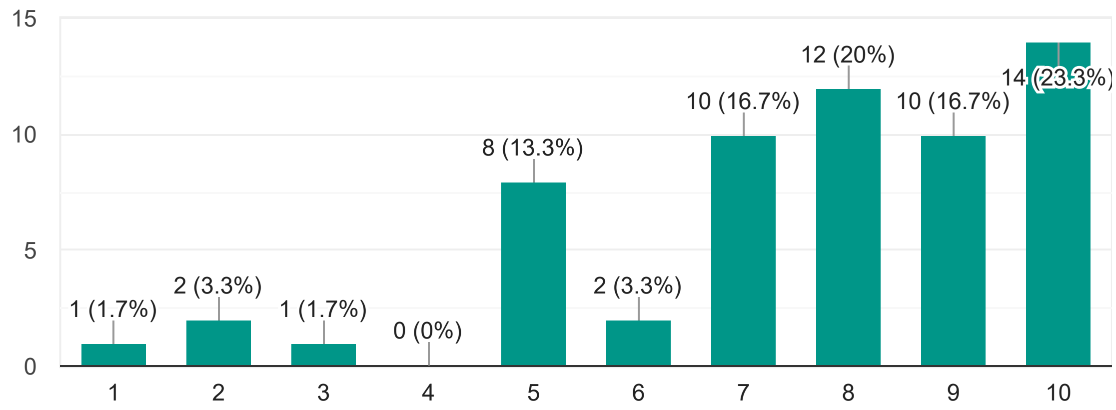
A) AAL system has to measure Activities of Daily Living (ADL) automatically

60 responses



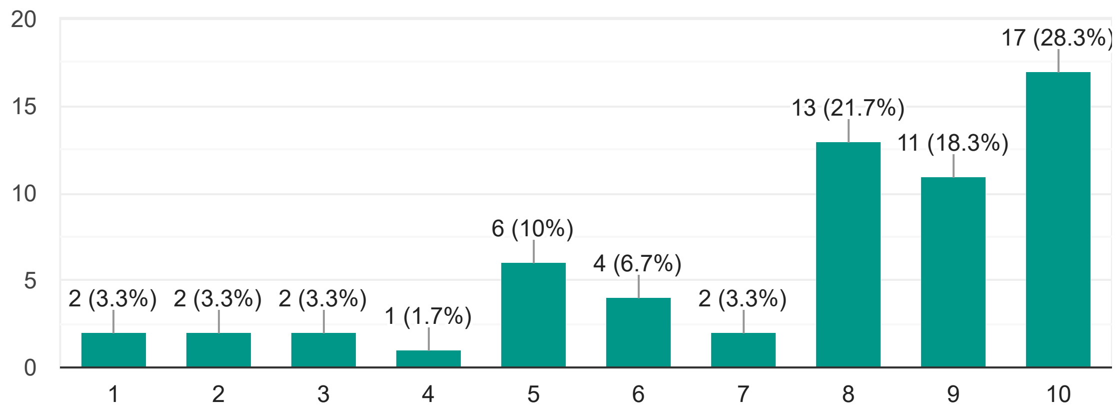
B) AAL system can measure Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL) automatically

60 responses



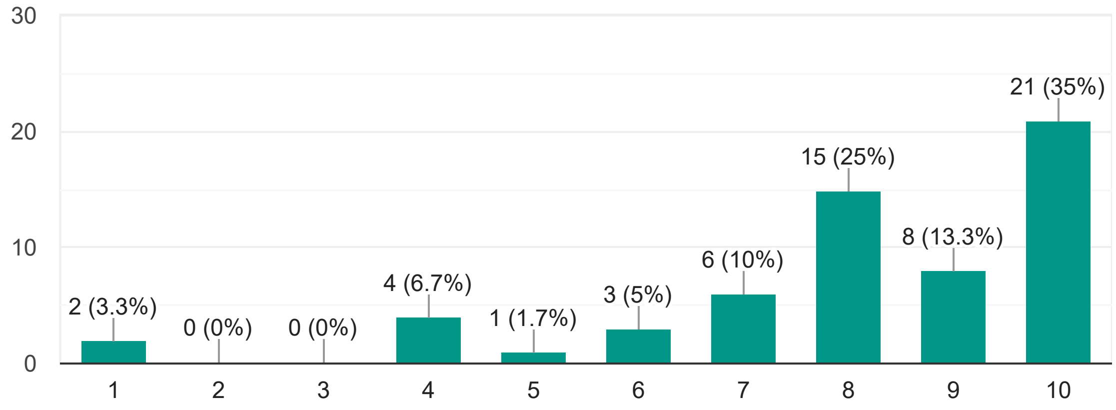
C) It is important to register automatically day and night routine activity and find out abnormalities

60 responses



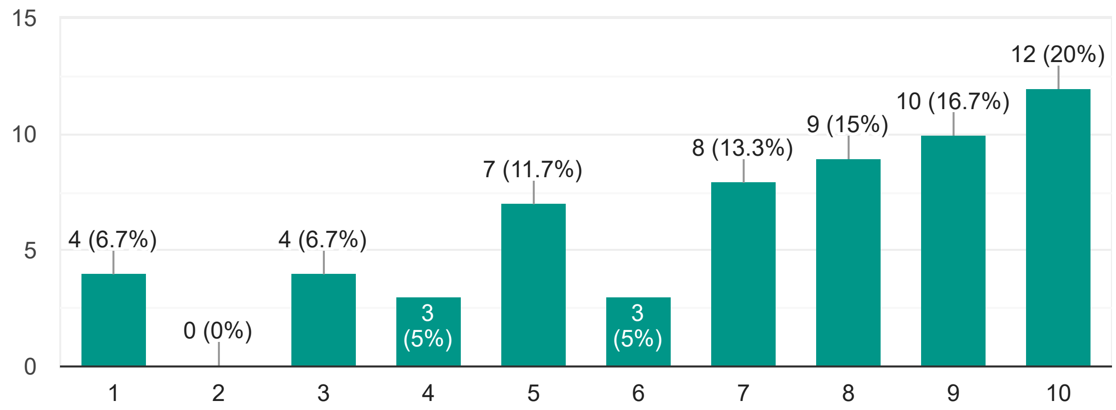
D) Registered unusual night activity can point on the mental deterioration

60 responses



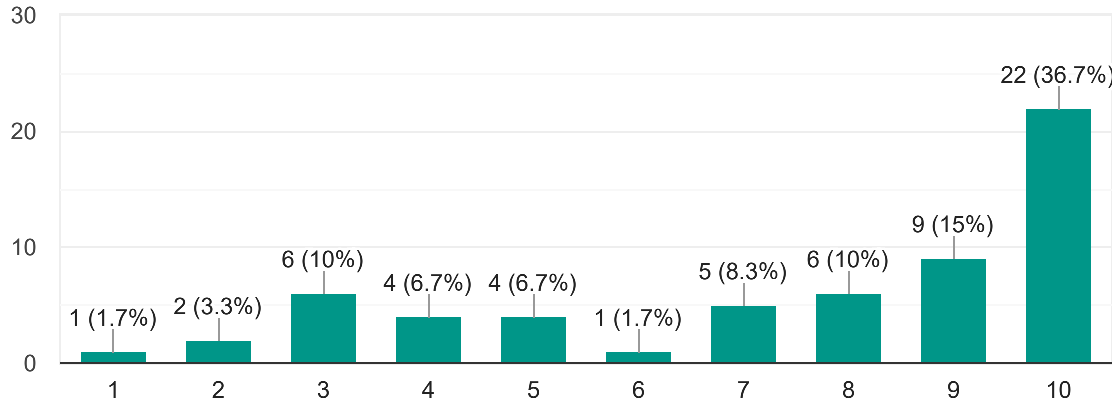
E) AAL has to register signs of unusual emotions

60 responses



F) Ambient Assisted Living can register signs suicide risk

60 responses

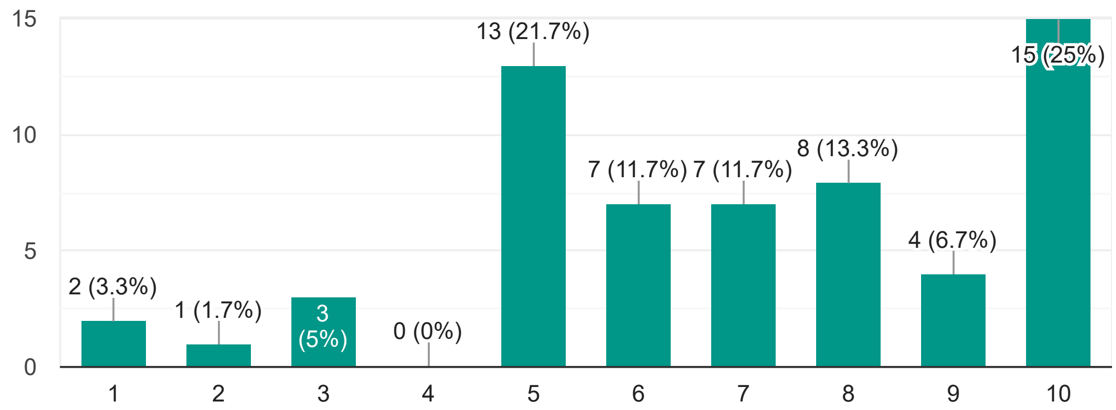


Privacy of the patient with Mild Cognitive Impairment in a home equipped with the Ambient Assisted Living system.

Please, mark the most appropriate answer in accordance with your experience and professional opinion:

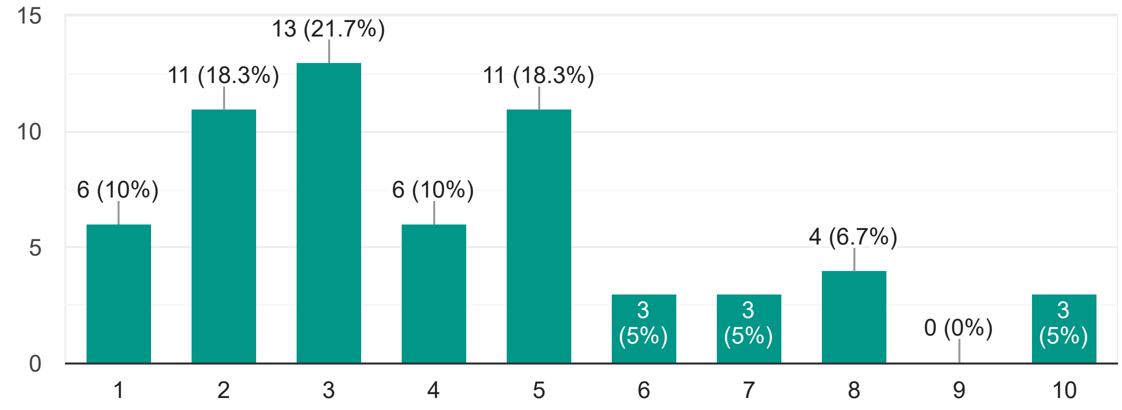
A) Patient`s health is more important than privacy issues in AAL

60 responses



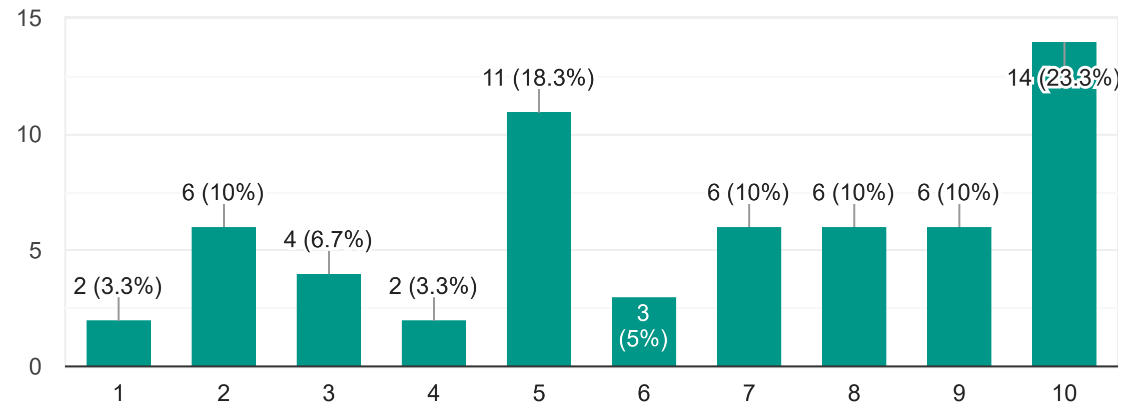
B) Privacy is more important than the patient`s health in AAL

60 responses



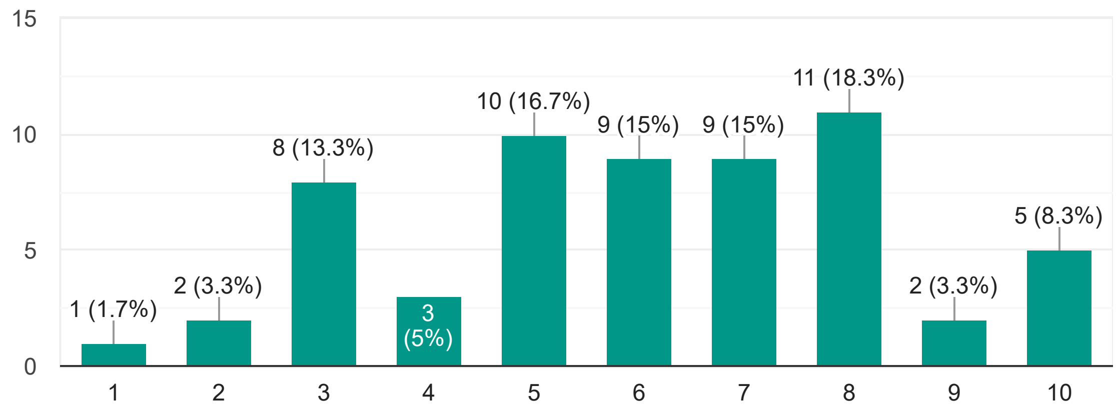
C) Patient`s health and privacy are equally important in AAL

60 responses



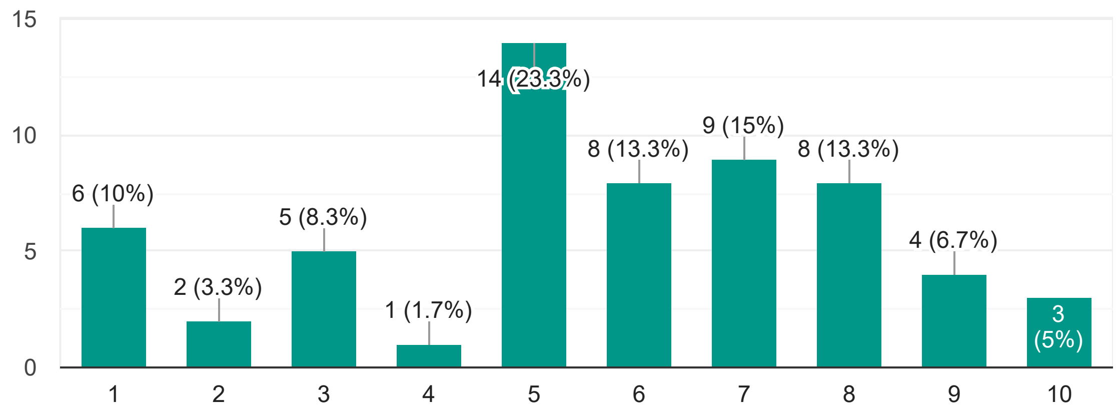
D) Privacy issues in AAL can harm the mental health of patient with Mild Cognitive Impairment

60 responses



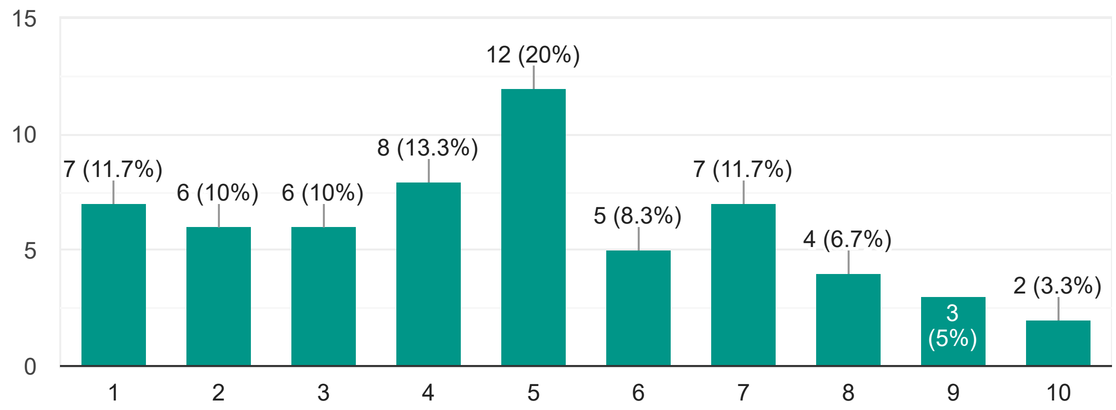
E) Patients with paranoid thoughts are not advised to live in a home with the AAL system

60 responses



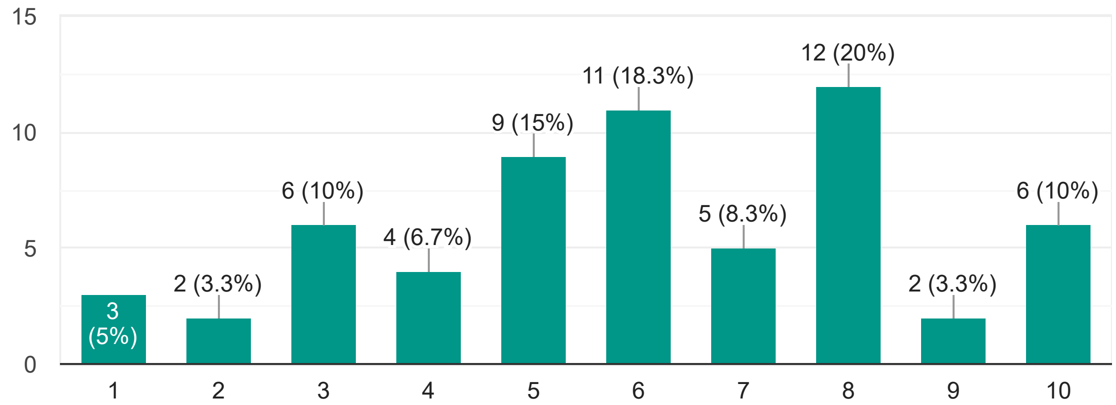
F) Emotionally sensitive patients are not advised to live in a home with the AAL system

60 responses



G) AAL system is not more invasive than traditional healthcare

60 responses

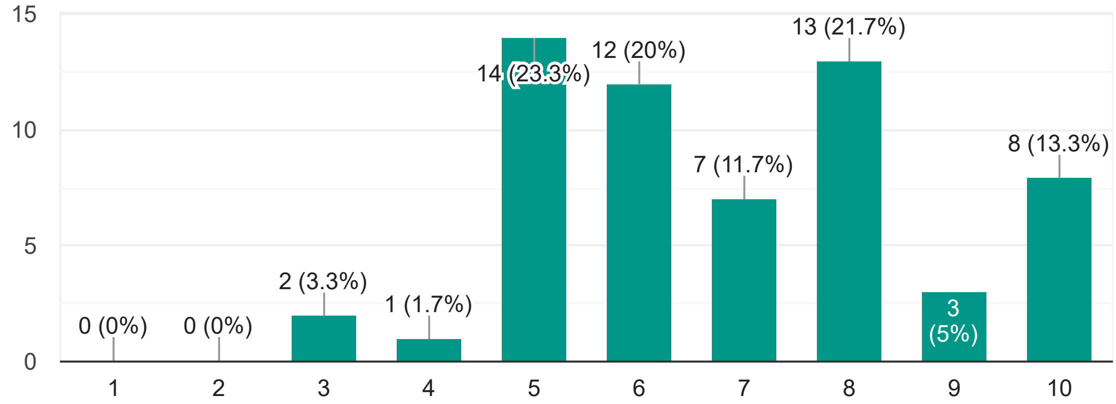


Acceptance of the Ambient Assisted Living system by patients with Mild Cognitive Impairment and their relatives.

Please, mark the most appropriate answer in accordance with your experience and professional opinion. What do you think about the acceptance of home Ambient Assisted Living system by patients and their relatives?

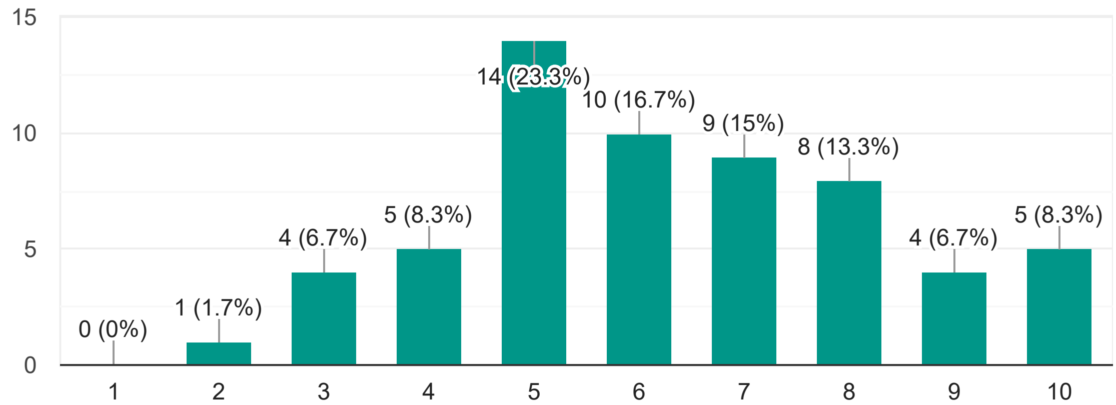
A) Most of the patients with Mild Cognitive Impairment are favourably disposed towards home AAL

60 responses



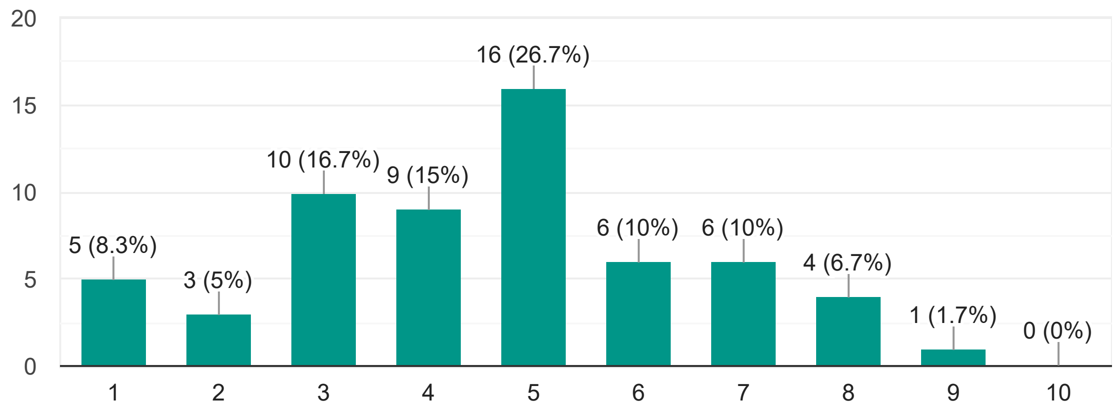
B) Some of the patients with MCIs are sceptical about home AAL

60 responses



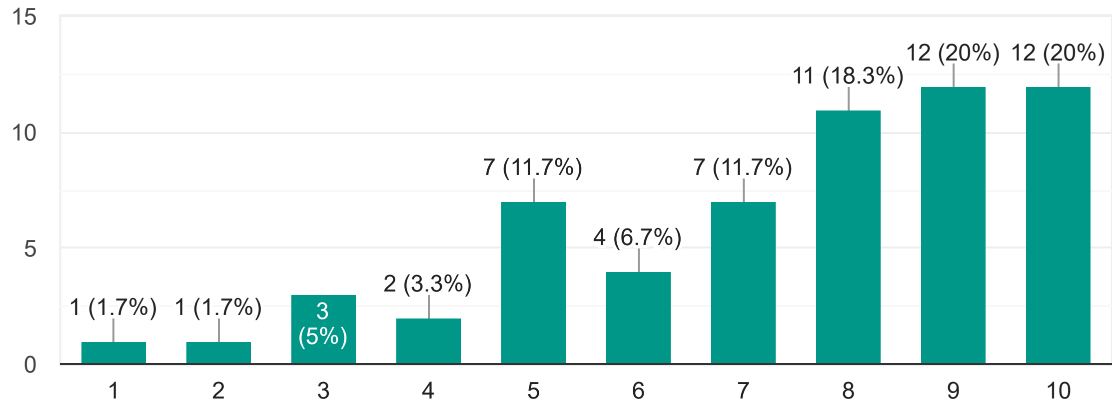
C) Majority of the patients with Mild Cognitive Impairment have a negative attitude towards home AAL

60 responses



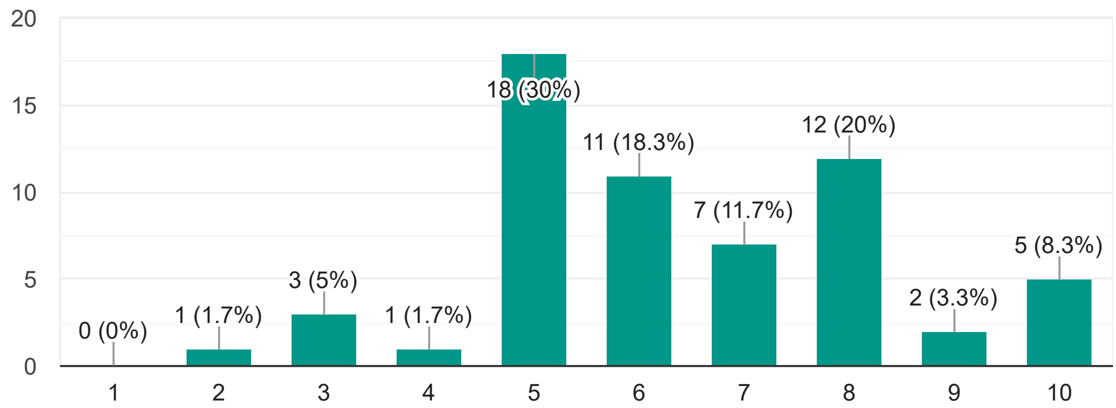
D) Majority of the relatives are positively disposed towards home AAL

60 responses



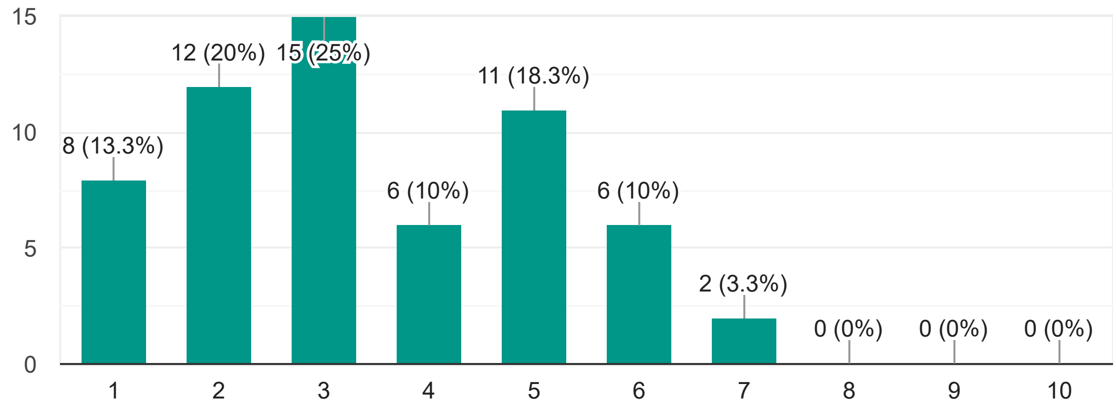
E) Some of the relatives are concerned about a number of specific problems in home AAL

60 responses



F) Majority of the relatives have a negative attitude towards the home AAL

60 responses

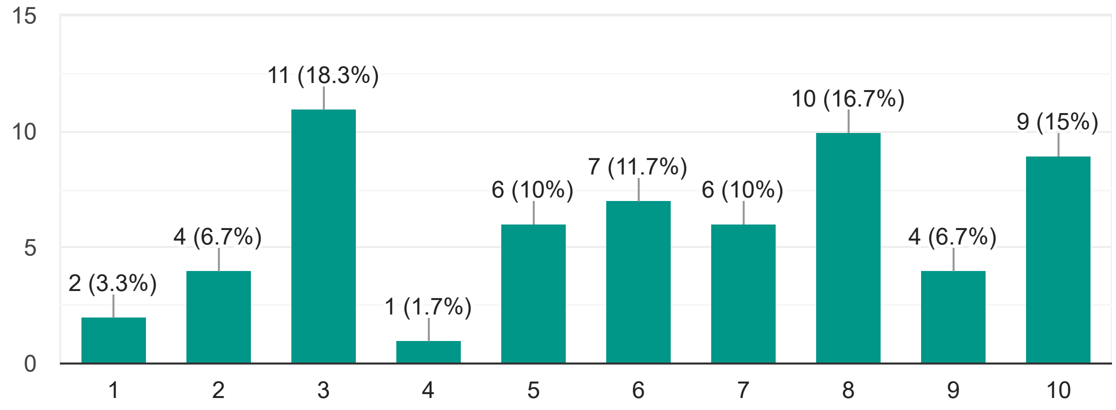


AAL system for patients with Mild Cognitive Impairment . Administrative and financial questions

Please, mark the most appropriate answer in accordance with your experience and professional opinion.

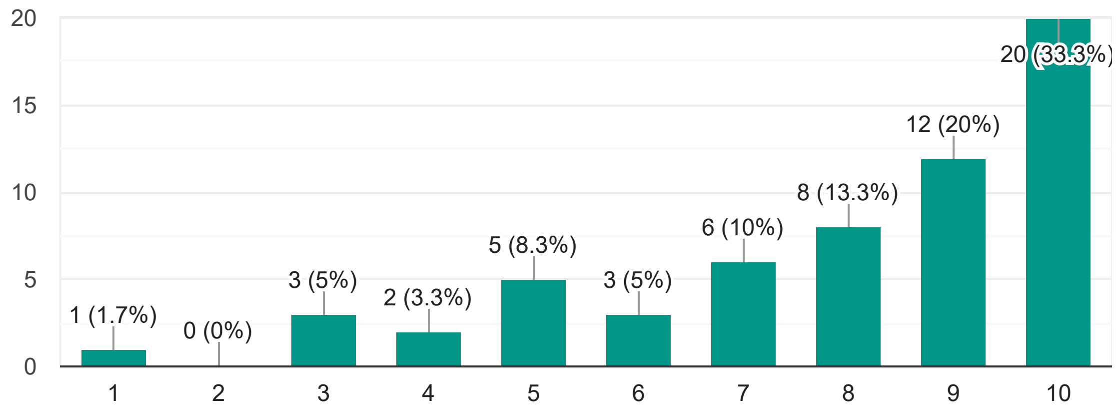
A) AAL for patients with Mild Cognitive Impairment is difficult to organize

60 responses



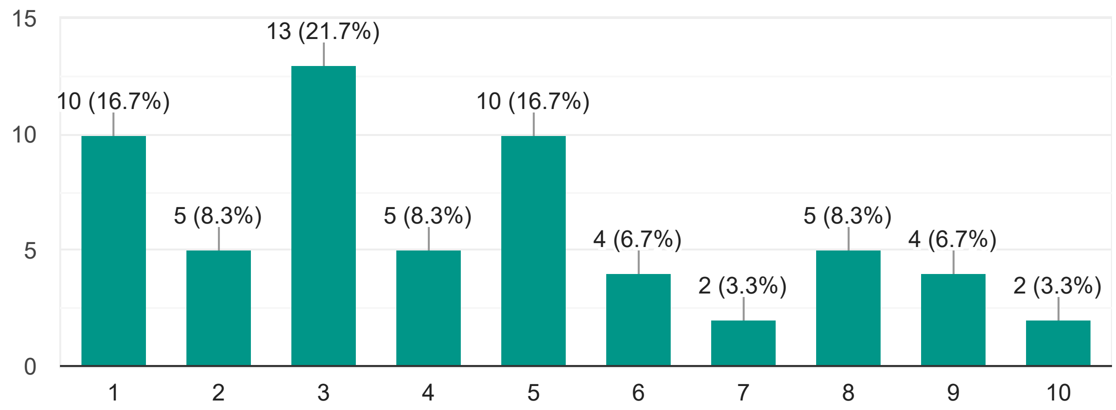
B) AAL for MCI patients is expensive

60 responses



C) AAL for patients with Mild Cognitive Impairment is easy to organize and finance

60 responses



Reflect your opinion about Ambient Assisted Living System for patients with Mild Cognitive Impairment

In my opinion, the Ambient Assisted Living System for patients with Mild Cognitive Impairment (please, write down your answer)

60 responses

Would provide great safety option in expense of mild privacy invasion

is the nearest future

Too expensive and complicated

This is a great idea, but it is very difficult to implement it, due to the lack of education of our patients and lack of funds.

I believe that this is an Achievable Far Future (AFF)

May be effective.
To unload hospitals and clinics.