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Abstract

This report is presenting the feedback collected from the users involved in testing the INCARE platform. The report is focusing on aspects such as: (a) the perceived usefulness of the solution and its integration into everyday life; (b) the usability as well as acceptance over several months (including reliability and security issues); (c) economic aspects. An important element of the report is the evaluation of the initially defined KPIs and the additional ones defined during the course of the project. These are presented in the conclusion section based on the input from the 4 pilots in Poland, Romania, Hungary and Slovenia.

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1. General information on the pilot study

The INCARE pilot studies lasted 6 months and it consisted of three stages: the pretest (in the beginning of the study), the midterm and the post-test (final) evaluation.

The aim of the pilot research process was to collect feedback from INCARE system users on aspects such as: (a) the perceived usefulness of the solution and its integration into everyday life; (b) the usability as well as acceptance over several months (including reliability and security issues); (c) economic aspects.

An important element of the pilot studies was to observe potential changes resulting from the use of the INCARE system. The main areas of potential change have been defined as KPIs presented below in Table 1.

Table 1 – KPI descriptions and targets.

KPI description	KPI target
user satisfaction	user satisfaction is not lower than 7 out of 10 (70%) by the end of the pilots. No more than 15 – 25 % dropouts after half a year.
caregiver burden	reduction of the burden of the caregiver
acceptance of robotic platforms	70-75% acceptance rate
frequency of physical activity	daily - either indoor (INCARE platform) or outdoor (e.g., walking)
adherence to medication and medical appointments	90% due to INCARE reminder module
non-appropriate emergency calls	1% (falls, home alerts, health alerts)
competitive market position	10% decrease in costs for end-users care over prolonged time

The project team developed new targets in the process of working on the project:

1. **level of interest in purchasing the solution once it becomes commercially available -** 10% of the pilot users interested in purchasing the solution once it becomes commercially available.

2. **level of interest to continue using the solution after the end of the project** - 5% of the pilot users interested to continue using the solution after the end of the project and willing to provide further feedback.

3. **general impact of the INCARE solution on health practices/routines** (frequency of engaging in brain exercises, health monitoring),

4. **general impact of the INCARE solution on quality of life,**

5. **general impact of the INCARE solution on technology acceptance.**

With the above in mind, our main research objective was first of all to **measure and describe the potential change in the respondents' lives as a result of using the INCARE solution,** in the following areas listed in the project:

1. in the case of seniors – INCARE's impact on:
   a) subjectively perceived quality of life,
   b) technology acceptance,
   c) level of physical activity,
   d) frequency of engaging in brain exercises,
   e) frequency of health monitoring.
2. in the case of caregivers – INCARE's impact on the subjective sense of burden related to taking care of the senior (caregiver burden)

Moreover, another significant part of the study was **diagnosing the subjective benefits following from using the INCARE system, in the case of seniors and their caregivers,** including the perceived usefulness of the solution in daily life. What was also evaluated was **the level of acceptance of the robotic platform,** which was one of the system's important components. Another, separate area of interest was also the respondents' declared intent to buy the system (if it is launched to the market), as well as the price they would be prepared to pay for it. Questions regarding this problem were part of the final evaluation, but the conclusions were shown in a separate report dedicated to the business model of the solution (D3.1c).

Methodology

The INCARE solution was tested in 4 end-user countries (Poland, Hungary, Slovenia and Romania) with 3 types of users:

- **Individual primary end-users** - elderly (seniors) living in an independent apartment (alone or with their caregiver and/or other family members). They took part in an in-home pilot study.

- **Institutional primary end-users** - elderly (seniors) living in a facility*. They were engaged in pilot study in institutions.

- **Secondary end-users** (caregivers of the elderly participating in the pilot study):

    › informal (mostly family members) - engaged in an in-home pilot study

    › formal (employees in facilities) - engaged in a pilot study in a long-term or in a day-care institution. Facility could be a seniors' nursing home (providing long term 24/7 care) or day care institution (where seniors spend up to several hours a day). Facility can be public or non-public (private).

The feedback from all types of users was collected by a structured individual interview and a semi structured interview conducted by an expert from an end-user organization on every stage of the research (pretest, midterm, post-test).

In order to measure a change in such research areas as quality of life, technology acceptance and caregiver burden, we applied reliable and widely used tools suggested by the INCARE project evaluators

(the WHOQOL short version questionnaire for elderly people, 14-item Senior Technology Acceptance index proposed by Chen (2020)[1], Burden Scale for Family Caregivers- short version[2]).

The Robotic platform assessment is an integral part of the INCARE system pilot study. Therefore, primary and secondary users engaged in in-home testing and testing in institutions assessed the INCARE system (application) as well as the robotic platform. However, it was decided to also invite some additional primary users that meet the project's criteria for testing the robotic platform alone to get wider feedback of this component. Testing was based either live demonstrations (in lab sessions) or demo videos presented during the focus or individual interview. The form of testing is strongly related to local COVID-19 constraints - in Poland for example, visitors are not allowed to enter the Warsaw University of Technology lab since the start of the pandemic. In this case, focus group interviews took place in a focus studio. In Romania, the number of people gathered together indoors was restricted and users were invited in small groups. However, some users were afraid despite precautions and were providing their feedback based on the improved videos prepared following the midterm input.

2. Report structure

This report aims to present key findings from the study, in an order based on the KPIs assigned for the project in advance or during the fieldwork. The report also provides a summary evaluation of specific system components, as well as the perceived benefits resulting from testing the solution, and observations and recommendations that emerged during the trial stage.

The report opens with a general summary of the findings on the consortium level (see point 3). Afterwards, conclusions are discussed in detail on the level of each country (see point 4). Each of the parts describing the study on the domestic level also includes short characteristics of the test's users in every end-user country.

When reading the presentation of the findings, it needs to be noted that due to the small number of research participants and their non-random selection, we are not reporting statistical significance of the results.

3. Post-test evaluation results on the end-user country level

The testing took place in 4 countries: Poland, Romania, Slovenia and Hungary. There were 3 moments when the participants were interviewed or requested to answer to a questionnaire: pre-test, mid-test and post-test. Here we will be analyzing the post-test results and comparing them to the previous answers.

3.1 Poland

The midterm evaluation of the INCARE product was carried out with two types of users: individual users (seniors and their caregivers testing the solution at home) and the institutional user (formal caretaker).

According to the assumptions of report D1.2b, the main user of the INCARE solution in institutions is the formal caretaker of the senior, tasked with evaluating the system's usefulness in the everyday

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[1] Chen K, Lou VWQ. Measuring Senior Technology Acceptance: Development of a Brief, 14-Item Scale.Innov Aging. 2020 Jun 27;4(3):igaa016. doi: 10.1093/geroni/igaa016. PMID: 32617418; PMCID: PMC7320876
[2] https://www.psychiatrie.uk-erlangen.de/index.php?id=11049

operations of the institution in which they work and organizing tests with the institution's patients. Therefore, it is the caregiver – as the person who can provide the broadest feedback on the product- who the midterm evaluation focused on during the test.

Additionally, the robotic platform evaluation was conducted with Focused Group Interviews (FGI), according to a discussion guide agreed on in advance. In every meeting, respondents were shown three videos presenting the two, different features of the robotic platform (fall assist, transporting objects, being a companion for the elderly, showing medical measurements) performed by two different kinds of robots. After these were shown, respondents participated in a conversation focusing on three main research problems: how the robot looks, how it communicates, how useful are the presented features, strengths and weaknesses of the solutions presented, and approval of the solution shown. The same scenario for robotic platform evaluation was used in post-test interviews with individual users testing INCARE at home.

3.1.1 Sample description – Individual testing

Individual users testing the solution in their homes took part in the study (15 seniors and 15 caregivers). Both groups meet the recruitment criteria of the project. Presented below are the characteristics of the research participants.

Seniors

- **Demographics**

All the individual seniors taking part in the test are over 60 (the age criterion for INCARE test participants in Poland). The youngest participant is 69 and the oldest one is 79. The average age of the participants was 70 years old. There were 10 women and 5 men participating in the test.

Seniors participating in the test mostly have secondary education, 4 people have higher education. A vast majority of the respondents have general education or are educated in humanities. Only 3 participants had science degrees.
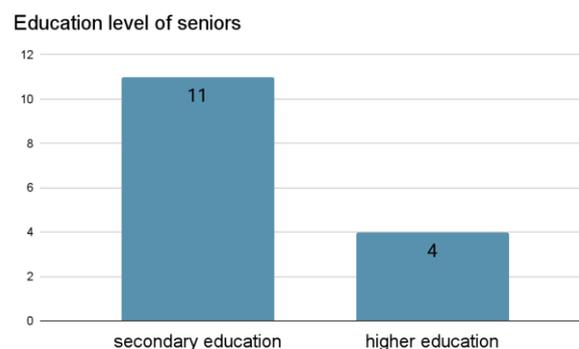
Figure 1 - Chart 1, Education level of seniors, individual seniors, n=15.

All the test participants live in Warsaw on a daily basis (city with over 500k residents).

- **Tech savviness**

Nearly all of the seniors had prior experience with using new technology, with 13 of 15 seniors also experienced in using touchscreen devices. However, their experience was most commonly with

smartphones. Only 5 test participants had used tablets before (the device that was part of the tested INCARE sets).

It needs to be stressed that the seniors' past experience with technology does not translate into high-level tech savviness. Based on the course of the study and the difficulties some respondents had using the devices they were given (described in the rest of the report), we determine that their digital competences are mostly quite basic.

- **Health condition**

In accordance with the recruitment criteria, each senior participating in the test needs to regularly test their health parameters (minimum one of the following: blood pressure, sugar levels and saturation levels). Research participants were recruited in such a way, so that their health monitoring needs correspond with the type of device they were given in their INCARE test set. Each set contained a blood pressure monitor and 1 to 3 additional devices, depending on the needs of the respondent (pulse oximeter, glucometer and thermometer).

Therefore, the people recruited for the tests need to monitor their blood pressure (all respondents). At the same time, 14 people declared to be checking their blood oxygen saturation levels, and 5 people were measuring their blood sugar levels. Apart from the mentioned parameters, most of the recruited seniors declare a need to check their body temperature.
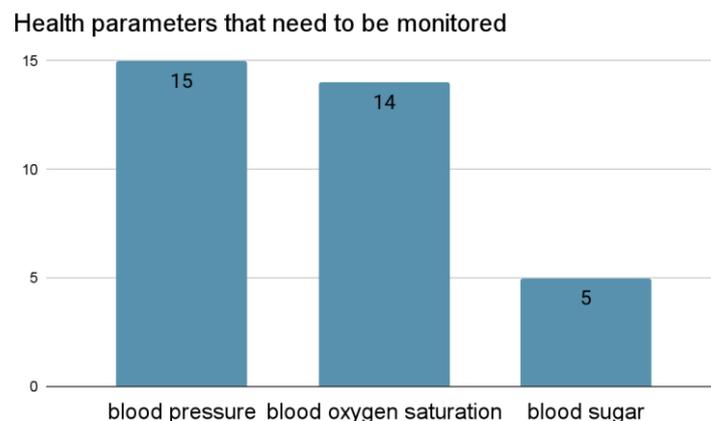
Figure 2 - Chart 2, recruitment screener, individual seniors, n=15.

The necessity to regularly control the above-mentioned health parameters is due to the respondents' chronic somatic conditions. They most often suffer from cardiovascular diseases, hypertension, and diabetes. Moreover, the ongoing coronavirus pandemic has resulted in the participants checking their oxygen saturation levels more often.

Despite the requirement to regularly monitor their health, seniors had mixed success in fulfilling that responsibility before they took part in the test. Only a little over one third of them declared that they did so regularly. Other respondents admitted that before the test started, they monitored their own results only from time to time, or less.
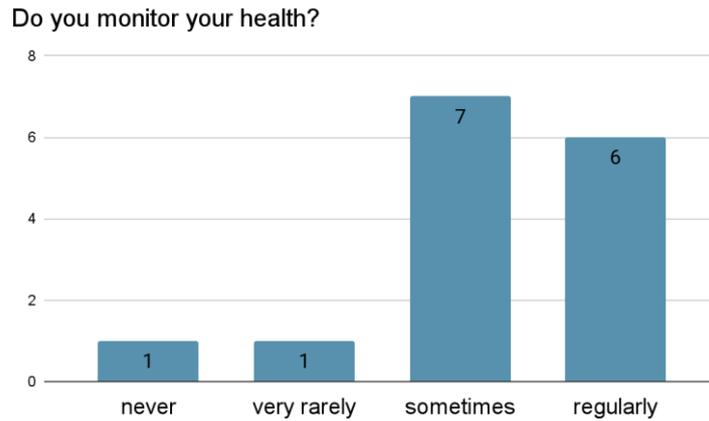
Figure 3 - Chart 3, frequency of health monitoring, individual seniors, n=15.

Due to the state of their health, nearly all seniors participating in the test need to regularly use medicines. Respondents were much more diligent with regards to taking medicine than with respect to health parameter monitoring. However, over two-thirds of the participants admitted that they sometimes forgot to take their medicine at the time they were supposed to.
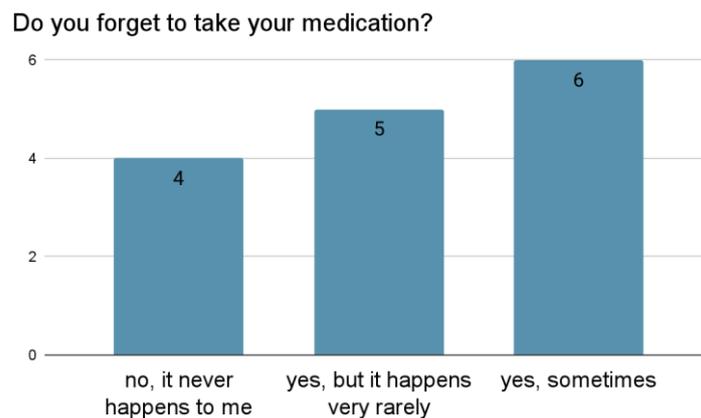
Figure 4 - Chart 4, Do you forget to take your medication?, individual seniors, n=15.

- **Seniors' independence**

Based on the research assumptions, seniors participating in the test were meant to be relatively independent. INCARE is intended to extend the seniors' independence, by providing them with a tool for self-monitoring their health and a tool for their caregivers to remotely monitor the seniors' situation.

All seniors participating in the study meet the independence criterion. Each test participant can move on their own and perform simple at home activities, such as cleaning. A vast majority are also able to do their own shopping and prepare their own meals. Seniors most often declared they need some support from the caregiver with regards to preparing medicine, but they are mostly able to use them at a specific time of day by themselves.

The level of seniors independence

yes ■ no

Do you participate in any housekeeping tasks?	15
Do you take care of all shopping needs independently?	13 2
Do you plan, prepare, and serve adequate meals independently?	12 3
Do you need to have medication prepared in advance in separate	8 7
Are you responsible for taking medication in correct dosages at the	14 1
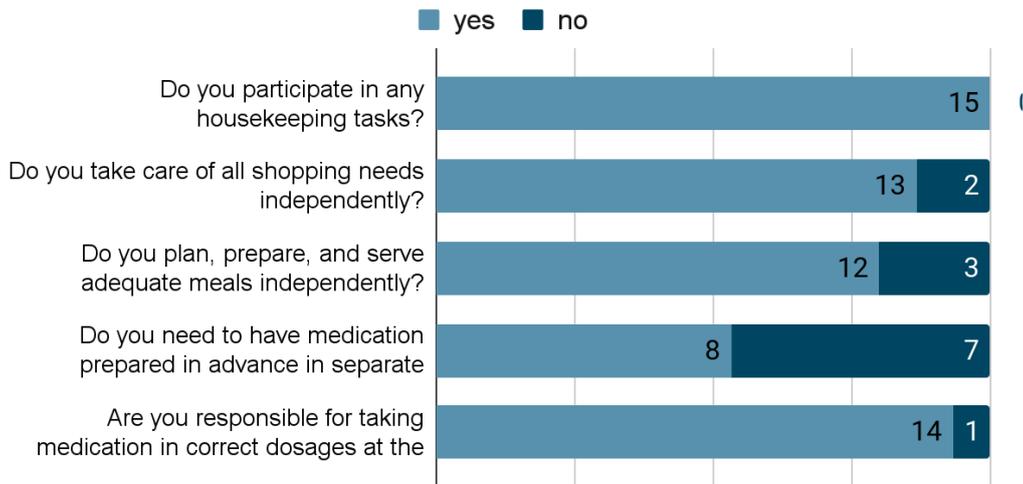
Figure 5 - Chart 5, The level of seniors' independence, individual seniors, n=15.

Caregivers of the seniors also rated their independence on a quite high level (4 or 5 scores on a five-point scale in several areas). The area in which they most often saw deficiencies of independence was health monitoring.

Informal caregivers

Based on the research design, seniors with their informal caregivers were invited to the tests. Caregivers are the people who provide seniors with unpaid and informal support to a degree that corresponds with their needs and their independence levels.

The group of caregivers participating in the study included 10 women and 5 men. They are members of the seniors' families (most often their children), or close friends of the family. Caregivers are most often between 30 and 50 (average age is 42 years old).

Caregivers' age

Age	Count
20-30	2
31-40	4
41-50	6
51-60	3
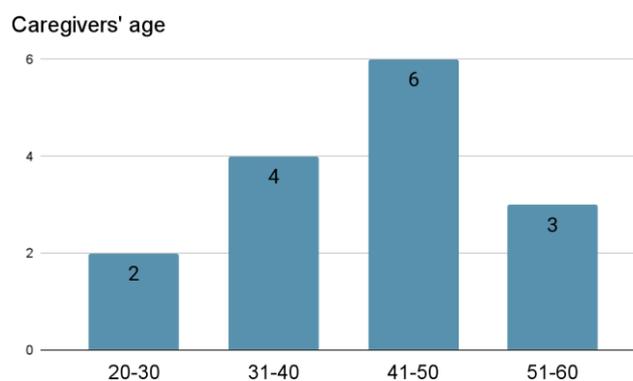
Figure 6 - Chart 6, Caregivers' age, informal caregivers, n=15.

A vast majority of the caregivers are not living with the senior – only two of the fifteen pairs participating in the study are living together. This corresponds with the research assumptions, because INCARE is among others intended to enable caregivers to remotely monitor the seniors' situation. However, all

caregivers are living in the same city as the seniors (allowing for a quick response in the event of an emergency).

The support of the caregivers depends on the health and needs of the seniors. Caregivers most often support seniors in areas such as health (setting up doctor's appointments, taking them to the doctor, buying medicine, caring for them when they are ill) and everyday responsibilities (first of all shopping, much less often cleaning and cooking). Some of the caregivers help seniors with formalities (taking care of legal matters, organizing a sanatorium stay, paying bills online) and support them in using new technologies. Part of the caregivers' support is also to give seniors company (spending time together, going on walks).

Apart from providing help in specific activities, caregivers generally oversee the seniors' situation (they are in regular contact with them, react in emergency situations, i.e., if the senior is feeling poorly, if they have problems in the apartment).

Caregivers declared that they spend about 8 hours a week helping the seniors (for less than two-thirds of them, helping the seniors takes 4 to 8 hours, whereas for the others – 1 to 3 hours per week).

3.1.2 Sample description – Testing in a care institution

Seniors

The test involved 10 seniors (patients of the center) chosen for testing by a formal caregiver. The formal caregiver chooses seniors with different health levels for the test (different physical and cognitive health levels), but only the ones who can consciously participate in the test of the solution.

According to the profile of the care home, all people involved in the testing require ongoing, all-day-long care due to their health. This is both due to advanced age, as well as other underlying conditions (often multiple ones). These most often include hypertension, diabetes, coronary disease and atherosclerosis. Four research participants also had diagnosed neurological disorders (Alzheimer's or dementia). Half of the participants have severe mobility limitations (need support when walking or getting up from bed). All respondents regularly use medicine.

Seniors from care homes participating in the tests usually have very little experience with new technologies. Most of them only use a traditional mobile phone (no touchscreen, often a version dedicated to seniors). Individual people use more advanced devices, such as the smartphone or tablet.

Formal caregiver

The formal caregiver is an employee of an institution recruited to participate in the study. Their everyday duties include care over the institution's patients.

The institution where the test takes place is a private care home, which offers in-patient care to persons who do not require intensive care hospitalization but require the use of all-day or partial care-medical services.

The institution has no experience using new technologies in caring for seniors, but the director declares to be open to such solutions (notices potential advantages with respect to increasing efficacy of the care provided).

Robotic platform evaluation

The evaluation of the robotic platform - as a component of the INCARE solution - was carried out in two forms. Firstly, three focus group interviews (FGIs) with 12 seniors and 8 caregivers of the elderly were conducted. Senior respondents were divided into 2 groups: 6 people aged 60-70 and 6 people above 70. All of the respondents lived alone or with another elderly person. Every meeting was dedicated to a separate age group, but there was an equal 50% mix of men and women in every group.

Caregiver respondents (4 men and 4 women) took part in one FGI group. All of them look after the elderly on a daily basis (at least 5 times a week).

Second form of the robotic platform evaluation was a post-test interview with individual users (senior testing INCARE at home and their caregivers) and a post-test with an institutional user (the formal caregiver and the director of the facility).

3.1.3 Main results

User satisfaction - KPI

The user satisfaction KPI at the end of the INCARE solution test was set at no less than 7 out of 10 (70%) by the end of the pilots. Another target assumed was no more than 15 – 25 % dropouts after half a year. **Both of these conditions have been met.**

Satisfaction was measured with 2 types of questions. Firstly, for our study we used a question frequently applied for measuring the Net Promoter Score - a widely used market research metric. It assesses the user's satisfaction with a product or service based on willingness to recommend a product or a service to others on the scale of 1 to 10. At the same time, for the needs of the project and its KPIs (user satisfaction is not lower than 7 out of 10 - 70%), we have decided not to use the standard NPS calculating methodology (it focuses on the difference between the "promoters" and the "detractors"). Instead, we have calculated an average of all the scores given by the respondents, on a 1 to 10 scale.

The average score in all of the tested groups was above 7. This means that the users would be willing to recommend INCARE solution to others. The score was highest among seniors testing the system at home (average 8.5). It was slightly lower for informal caregivers (7.8 average). A nearly identical satisfaction level was declared by two representatives of an institution where INCARE was tested.

On a scale from 1 to 10 how likely are you to recommend INCARE to a friend or a colleague? Rate your opinion on a scale from 1 to 10, where 1 means "Definitely not" and 10 - "Definitely yes"
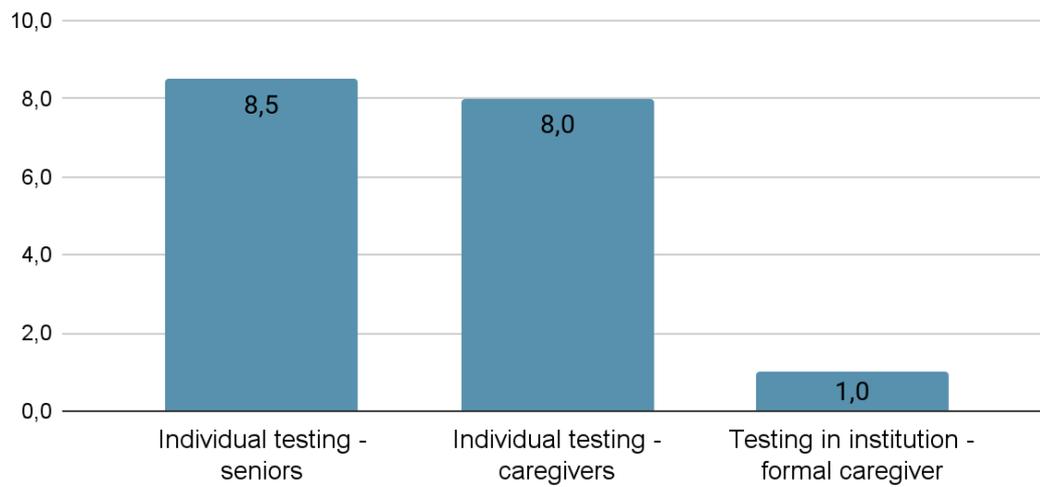
Figure 7 - Chart 7. Net Promoter Score, individual seniors n=15, informal caregivers n=15, formal caregivers n=2.

Additionally, participants were asked to rate their satisfaction on a 1 to 10 scale. The satisfaction measured with this question in all of the groups scored below the intended level (over 7). In the case of individual users in the senior group, satisfaction with the tested solution was 8.2 on average, and in the caregivers group it was 7.8 (however, nobody declared satisfaction below 6). In the case of the test at the institution, satisfaction with INCARE was rated at 8.

How much are you satisfied or dissatisfied with the INCARE service? Rate your satisfaction on a scale from 1 to 10, where 1 means "I'm not satisfied at all" and 10 - "I'm fully satisfied"
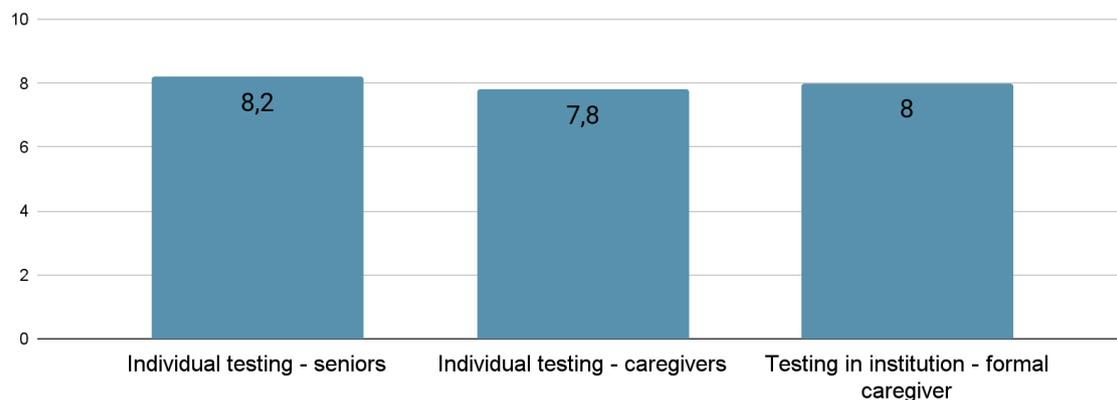
Figure 8 - Chart 8. Satisfaction. Individual seniors n=15, Informal caregivers n=15, Formal caregivers, n=2.

None of the users dropped out of the test, so the dropout rate was 0.

User satisfaction: usefulness of specific features

Evaluation of the health monitoring app – perspective of individual seniors

The feature that allows monitoring health via dedicated medical devices was evaluated positively by the participants. Nearly all of the seniors participating in the test declared that they found it useful.

Was the health monitoring module useful or not useful for you?
Rate your opinion on the scale from 1 to 5, where 1 means
"Definitely not useful" and 5 - "Definitely useful"
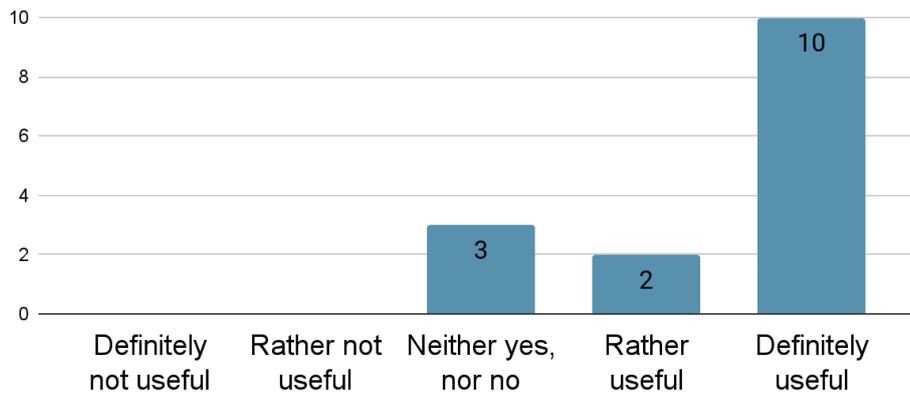
Figure 9 - Chart 9. Health monitoring usefulness, Individual seniors, n =15.

A vast majority of the test participants rated highly the idea to develop a tool that supports the elderly in looking after their health; motivating them and making monitoring easier.

The main advantage of the solution is definitely its simplicity. A vast majority of the seniors describe it as intuitive and simple to use. Using the feature does not require – according to the respondents – any special effort, because it saves the data automatically, right after taking a given reading with the device. For this reason, there were cases of app users who abandoned their habit of writing down results on paper, and they switched exclusively to the app. Users also pointed out that together with the modern medical devices, the app motivated them to check and take care of their health more often and more regularly. This translates into an increased sense of control and safety – seniors and caregivers declared that they feel more confident, knowing that if their health parameters worsen, they will be able to respond accordingly.

What lowered satisfaction with the features were the problems with app reliability during the test, and according to some respondents, the way in which the app relayed results.

First of all, most respondents experienced technical issues tied to the app's running (the app would stop working at times, there were problems logging in with the NFC reader, the measurement results were not always saving). These errors caused user frustration and reduced their trust for the tool. The trial participants all agreed that if the app is to become their main healthcare monitoring tool, it needs to be stable. Otherwise, the app may fail to play its role when necessary – i.e., during a consultation with the doctor it should be running without any issues.

Secondly, respondents thought that their test results' history is unclear and difficult to understand:

- The results are shown in the form of graphs. To many older people (as well as some caregivers), such a form of data presentation is not intuitive and difficult to figure out. Respondents are not accustomed to reading graphs. Moreover, the labels on the graphs are too small for the seniors, making it difficult for them to "tap" the right place on the screen and to read the result. According to some, it would be much better to use bar graphs or to show

results in the form of a table with dates and values of the readings. It is also recommended for the app to allow the user to choose the data presentation method (table or graph).

- The panel does not allow highlighting or comparing results from a longer period of use. The graph only shows the last 2-3 readings, which are connected with a trend line – this is mostly not very useful. Following a trend line would be helpful, if there were more results.
- The role of the colors is unclear – some results are displayed in red, others in green or black. The participants don't know what a given color represents (one of the respondents was wondering if the color indicates results that deviate from the norm – which is not as the author's intended it). What they also considered incomprehensible were the colors of the arrow in the section showing current results (the grey color wrongly implies that they are inactive).
- As for the blood pressure monitor, the results of a single reading (diastolic, systolic and pulse results) are shown alongside one another, so close, that it makes them illegible. Moreover, the results sometimes overlap, i.e., in the case of blood pressure, it is possible to have the same values of systolic pressure as the pulse reading. In such a case, the points with the results overlap, making them impossible to read.
- On the other hand, in the case of the pulse oximeter, it is unclear when to stop the reading. The first values are usually lower than after several seconds. In the meantime, the device sends data to the app continuously and shows all the results alongside one another on a graph. As a result, about a dozen dots are shown (with various results), which are all from a single reading, making it impossible to know which reading is the last one.

Thirdly, the tool lacks extra features that, according to the respondents, would significantly increase its usefulness. These include notifications about going over the norm and reminders about the necessity to carry out a reading according to the schedule saved in the app. The lack of such features means that the senior needs to analyze the results (and whether they fit within norm) by him/herself every single time. This requires much self-discipline in doing the tests. Moreover, respondents lacked a feature that would allow them to save the results in the form of a file, which can be then sent or/ and printed (i.e. to show it to a doctor).

Evaluation of the caregiver app – perspective of informal caregivers

In the second half of the test, caregivers were able to view the senior's results via the caregiver's panel accessible from the Internet browser. Even though the caregivers agreed that it is important and useful to have access to the senior's results, they had mixed feelings about the tool. Only 4 out of 10 caregivers regularly testing the app[3] were happy with how it works.

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[3] 5 of 15 caregivers did not familiarize themselves with the app or used it in a too limited degree to allow assessing its usefulness

Was the caregiver application useful for you?Rate your opinion on the scale from 1 to 5, where 1 means "Definitely not" and 5 - "Definitely yes"?

Category	Value
Definitely yes	2
Rather yes	2
Neither yes, nor no	3
Rather no	1
Definitely no	2
Respondent haven't used the	5
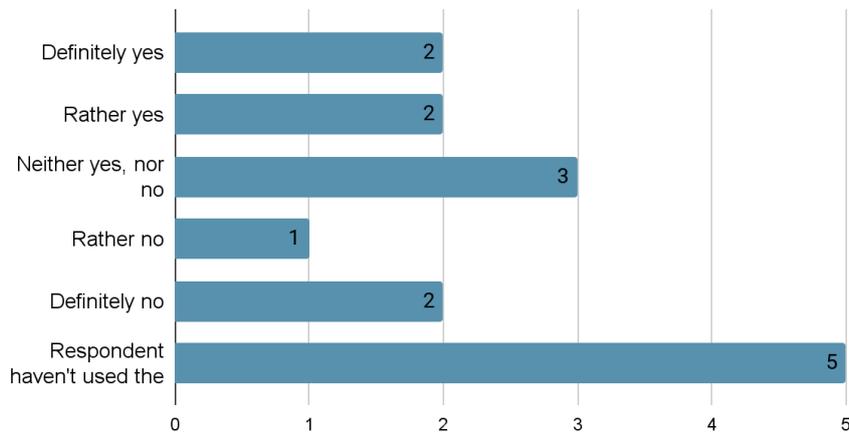
Figure 10 - Chart 10. Caregivers' application usefulness, informal caregivers, seniors, n =15.

There are several explanations for this ambivalent response. First of all, the caregiver app contained the same history of results that was available in the senior's app. Many caregivers were used to checking the results in the senior's app, and had no need to examine the caregiver's panel. Moreover, this was also because many users found the browser singing-in process inconvenient, as it required them to open a website every time, to type in a complicated login and password. As a result, only some caregivers regularly used the panel. Our interlocutors pointed out that they would have preferred to download a phone app, which would give them fast access (or they would prefer to be able to log into the app via already existing private accounts, i.e. Google).

Our respondents also pointed out that such an app would be much more useful if they received notifications/ alerts every time that some results are causing concern. One person believed that the app should give the caregiver the possibility to add comments, or even to add different test results (i.e. blood test results), to create a library of medical data of a given senior.

Evaluation of the health monitoring app – formal caregiver's perspective

Formal caregivers (caregiver employed in an institution, responsible for testing INCARE and institution director) were positive about the tested solution. When asked if they could be using the INCARE system every day in the institution, they both stated that it would be possible. For this purpose, the INCARE system would need to be introduced on a central level for all the residents and would need to be used by the whole staff. In such a case, the paper documentation kept thus far could be replaced by an electronic record of the patients' health (based on INCARE). According to our respondents, especially the head of the institution, this would make work much easier for the staff, and it would be their key motivation to implementing such a system for good.

It needs to be added that even though the caregiver does see potential in using INCARE as a central system for keeping records on the seniors' health, there are many concerns involved. These concerns are mostly related the system's reliability (during the test, there were sometimes situations when the system did not work properly – difficulties signing in patients), there is a need for a good Internet connection (there are places in the institution where Internet coverage is weak) and the staff's motivation to learn to use a new technology in patient care (according to the caregiver, not all employees are open to new solutions, some have their habits and routines that they may refuse to change).

It also needs to be added that in the tested institution, the caregiver took all the necessary readings by herself. This was due to the patients' health, and her worries that they would not handle such an activity on their own, or that they could accidentally damage the device, i.e., by breaking it. In such a case, it would be better to have a single interface (instead of two, separate apps for the senior and caregiver), which would allow taking readings on one hand (as in the case of the senior's app), on the other hand it would give an overview of all the patients' results and allow analyzing them.

Evaluation of the games – perspective of individual seniors

We asked the seniors participating in the test to evaluate (on a 1 to 5 scale) each of the games available under the INCARE app. **The average satisfaction with the games among seniors testing the solution at home was 3.2. The highest-rated game was "Memory" (4.3) and the lowest-rated game was "Maze" (1,9).**

Average rating of satisfaction with the games

Game	Rating
Match Game	4,3
Collecting objects	3,9
Organise Numbers	3,6
Solve a Puzzle	3,4
Make a Pie	2,9
Get Differences	2,8
Maze	1,9
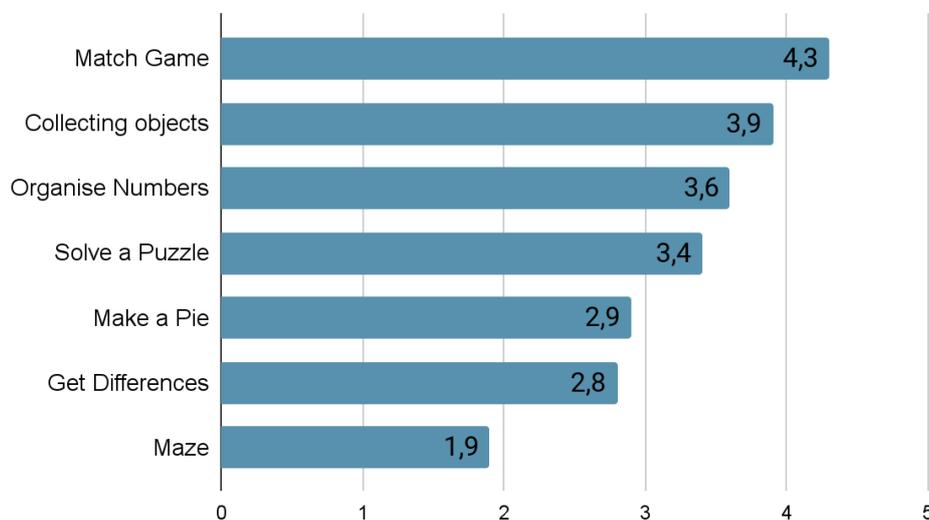
Figure 11 - Chart 11. Average rating of satisfaction with the games, individual seniors, n =15.

Based on the conversations with the participants, one can easily establish that the response to the games largely depends on individual preferences and the capabilities of a specific person. As such, there was a group among our interlocutors, who didn't like games that require acting quickly in a limited amount of time (just like with games such as "numerical puzzle" or "collecting items"). However, there were also other people who loved practicing their agility and reflex. Another, separate group were also seniors skeptical about the games installed on their phones or tablets, who thought that they are childish entertainment. These people strongly preferred more classic forms of entertainment such as crossword puzzles, chess or bridge.

Some respondents also criticized the games for being too easy (such as "Differences"), whereas others were frustrated about games they considered too complicated (most often "Numerical puzzle", sometimes "Maze"). Based on the high scores, it seems that "Memory" appealed to the needs of both these groups the best.

What all seniors had in common, was their expectation that the games would motivate them to make intellectual effort. According to most, this expectation was met at least to some degree (most of our respondents found at least one game they enjoyed and that required them to focus, to be patient or to

practice their memory). **The average from the responses to the question "How do you assess the usefulness of the games when it comes to practicing memory and mind?" was 4.3 on a 1 to 5 scale.** Also, most of our respondents had no difficulties navigating the games and using them. Some also simply enjoyed playing them. They helped them fight boredom and brought more variety to their daily life.

Some of the most often mentioned reservations regarding this component included:

- Game difficulty levels are barely varied depending on how advanced the player is. Respondents therefore ask for more games, for them to fall into different categories (i.e. games that help practice reflexes, memory, relaxing games) and also different difficulty levels in each game.
- Some users thought that the objects in the games (i.e. in the "cake baking" game) were too small and unclear. Respondents are asking for the images to be larger.
- Some respondents are also asking for the graphics to be made less "childish" (as it currently reminds of games for little children).
- Individual people who prefer classic forms of entertainment postulate adding such games as Sudoku or crossword puzzles.
- Respondents also suggest adding reminders that inform the senior about the possibility to play a game.
- It is also advisable to consider a different pathway for moving from one game to another, so that it's not necessary to return to the Menu panel.

Response to the games – perspective of seniors living in care homes

In the case of seniors living in assisted living institutions, only 4 of 10 participants had a chance to try out the games installed on the app. Their overall rating of the games[4] installed on the system was the maximum score (on a 1 to 5 scale). Respondents appreciated the ease of using this component of the app (including easy use of touchscreen) and the fact that the games stimulated them to undertake intellectual effort. Respondents first of all liked the "Memory" game, what they found very useful were the clear, large elements shown on the board.

The other 6 people testing solutions in the institution were not interested (according to the caregiver) in playing the games, as they thought games are for children, or they had barriers to using the tablet. In some cases, the caregiver made the decision that they won't be able to play the games by themselves, due to their overall health condition.

Evaluation of the calendar – perspective of individual seniors

The calendar feature was given to the Polish users in the final weeks of the testing and it was available only to the seniors testing the solution due to technical reasons. This meant the calendar had fewer features, as it did not allow the caregivers to play the senior's activities in the calendar. As a result, the calendar was tested by fewer than 1/3 of the users (4 seniors).

The participants described the calendar as not useful. Such a response was due to two factors. First of all, they described the calendar as complicated (seniors did not know what activities this concerns). Secondly, the calendar did not have reminders about upcoming events – as a result, the feature didn't

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[4] In the case of seniors residing in institutions, who were testing the INCARE solution on different terms than individual seniors (more on that in the report D1.2b), we have decided to ask 1 general question on their response to the available games (instead of single responses to each game).

appear especially useful (you can write in activities in the calendar, but you still need to remember to check your day schedule).

Impact of the INCARE solution on quality of life

The senior users' quality of life was measured with an abbreviated version of the WHOQOL (short version) questionnaire for elderly people. Originally, the questionnaire consisted of 25 items. For the purposes of INCARE testing, it was further reduced to include only those aspects of quality of life which were assumed to be connected in any way with a possible impact of the tested solution. The reduced scale addressed to individual primary users consists of 9 items, which jointly form an index ranging from 0 to 100%, where 100% means the best possible quality of life. For each participant, the index was derived by summarizing individual item scores (weighted equally) and transforming the summarized score so that it ranges between 0 and 100% (max-min transformation)

For institutional primary users (seniors living in nursing homes), due to their poorer health, the number of questions asked was reduced to 4 items.

Impact of the INCARE solution on individual primary users' quality of life

The data does not reveal any significant difference in the general quality of life of INCARE users pretest vs. post-test. The average score in post-test was 71%, compared to 70% in pre-test. However, this does not mean that the solution failed to generate such an effect, given the external and uncontrollable factors which could have influenced their quality of life (ex. the pandemic). These effects could not be taken into consideration due to the lack of control group in the study design.

It is also worth noting that some change can be observed on the level of individual users. 53% surveyed seniors in the post-test exhibited significant improvement regarding the quality of life. On the other hand, another 40% declared lower scores than in the pretest.

We have also identified a positive influence of using INCARE at the level of individual statements (QoL indicators) such as "having opportunities for leisure activities". In the case of this statement, we have witnessed a 13p.p. increase between pretest and post-test. It is possible that cognitive games available on the INCARE app turned out to be an attractive way of spending seniors' leisure time.

Quality of life Index

■ pre-test ■ post-test
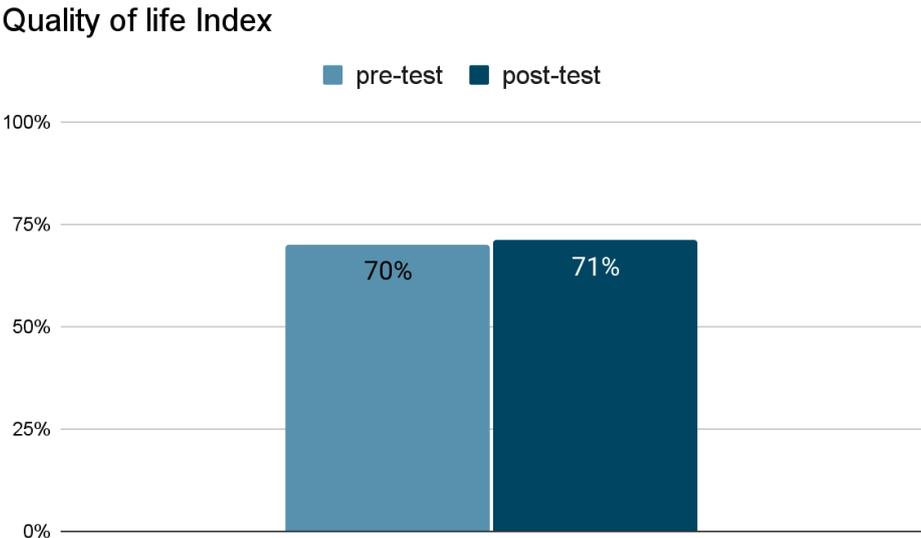
Figure 12 - Chart 12. Quality of life Index, individual seniors, n =15.

Impact of the INCARE solution on institutional primary users' quality of life

In the case of institutional residents, **the average score in post-test was 38.75%, compared to 44.5% in pre-test**. The declared lower quality of life level of institution patients vs. individual users can be likely explained by their worse general state of health. What can also be relevant is the fact that they start in an institution on a daily basis (and not surrounded by their close family), as well as the fact that the study is taking place during the pandemic – which completely or very significantly reduces the amount of contacts patients can have with the outside world. This is why the deterioration in their quality of life does not have to be connected to the INCARE app trial. Considering that the pandemic restrictions most likely significantly impacted the quality of life of the test participants, one needs to assume that INCARE solutions did not significantly influence this aspect.

Impact of the INCARE solution on technology acceptance

The technology acceptance was measured using an abbreviated version of the 14-item Senior Technology Acceptance index proposed by Chen (2020). The index was reduced to 9 items (in the case of institutional seniors - to 6 items), to account only for those aspects of the phenomenon which were assumed to be connected in any way with the possible impact of the tested solution. The index ranges from 0 to 100%, where 100% means the highest technology acceptance. For each participant, the index was derived by summarizing individual item scores (weighted equally) and transforming them (max-min transformation).

Impact of the INCARE solution on individual primary users' technology acceptance

The testing results show no significant increase in the overall technology acceptance levels within the testing period. **The average score in post-test was app. 78%, compared to 76% in pre-test.** However, this is partly due to the overall high level of technology acceptance among test participants. More detailed analysis shows considerable increase in the technology acceptance among those users who exhibited relatively lower levels of acceptance in pre-test and considerable decrease in acceptance among those who declared high levels of acceptance in pre-test.

This means that the INCARE solution might have positively influenced the level of technology acceptance among those with low ICT skills, but at the same time (perhaps due to frequent errors and technical problems with tested equipment or apps) discouraged those who initially had more faith and positive feelings about technology.

In total, in post-test as much as 43% participants declared a higher level of technology acceptance than in the pre-test. The same percentage of respondents exhibited just the opposite (their level of acceptance was lower than before).

The measurements suggest significant improvement at the level of individual indicators including opinions such as:

- "I could be skillful at using technology" (20 p.p. increase),
- "Using technology would enhance your effectiveness in daily activities" (11 p.p. increase),
- "I like the idea of using technology" (10 p.p.),
- "I find technology useful in my daily activities" (7 p.p.).

Technology Acceptance Index

pre-test   post-test
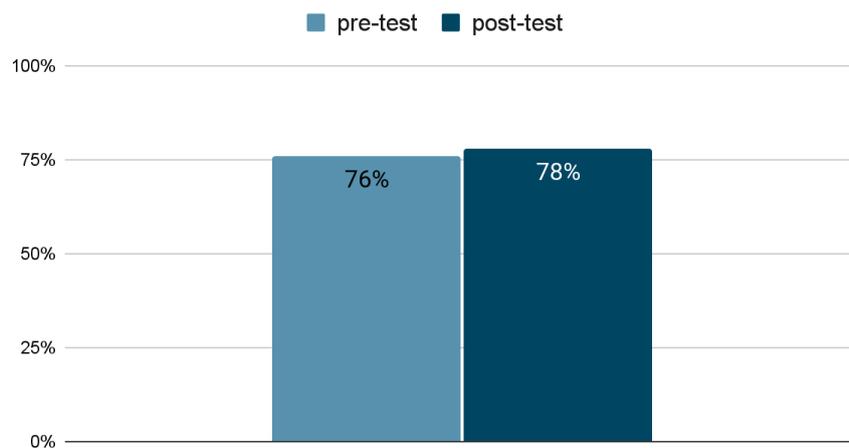
Figure 13 - Chart 13. Technology Acceptance Index, individual seniors, n =15

Impact of the INCARE solution on institutional primary users' technology acceptance

In the case of the institutional primary users **the average score in post-test was 52.3% compared to 60% in pre-test**. Considering the small size of the tested sample, and the fact that some of the seniors skipped some of the questions from this area when filling out the questionnaire, the difference between the start and end measure needs to be deemed insignificant.

Much like in the case of the quality of life measure, one also has to keep in mind the multitude of external factors impacting the truthfulness of the findings – these being worse health condition or less independence – because of these aspects, patients in institutions have much lower access to new technologies vs. seniors testing the solutions in their homes.

Impact of INCARE solution on health practices/routines

The tests included an assessment of the INCARE solution impact on some health-related activities, namely:

- Frequency of health monitoring routines,
- Level of physical activity,
- Frequency of engaging in brain exercises.

The results show that having access to INCARE considerably improved the level of users' activity connected with health monitoring (although it is hard to judge to what extent this effect is independent from the fact that the users were actually recruited to use the solution and obliged to perform regular health monitoring). **Similarly, but to less extent, INCARE improves the frequency of brain exercises. INCARE doesn't seem to affect the levels of physical activity** (although the changing pandemic circumstances may have exerted impact on the measurements in this respect). However, the increase concerned especially those who didn't engage in such activities a lot at the time when the pre-test was performed. In other words, users who didn't exercise before they got the INCARE solution have considerably improved, while those who did exercise before didn't change their behaviors.

Incare impact on health monitoring practices, physical activity, frequency of engaging in brain exercises
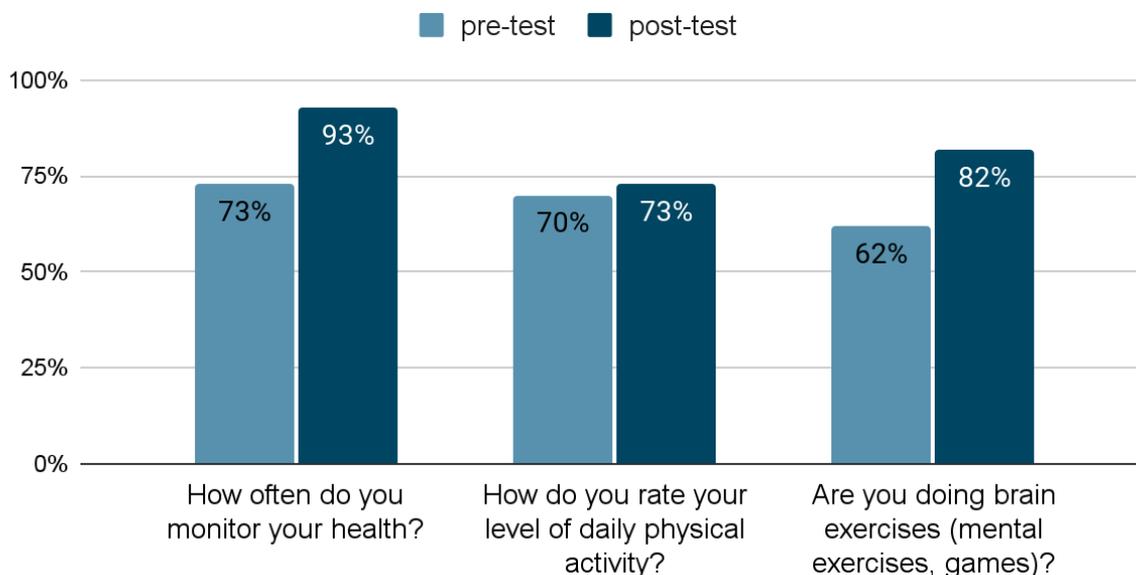
Figure 14 - Chart 14. INCARE impact on health monitoring practices, physical activity and frequency of engaging in brain exercises, individual seniors, n=15.

Reduction of burden of the caregiver and other caregiver benefits

To measure caregivers' burden, we adopted the widely used Burden Scale for Family Caregivers- short version[5]. The scale consists of 10 items related to different aspects of caregiver experiences and ranging between 0 and 3, where 3 indicates the highest burden possible. The aggregate burden indicator was calculated by summing up the scores for all items and transforming the result so that it ranges between 0 and 100% (max-min transformation). **Generally, no significant change in the level of caregiver burden was recorded between pretest and post-test. On average, the burden level has increased by 1% (where 100% is the maximum possible change),** which is too small to allow for any conclusions given the small sample size.

For 40% surveyed caregivers, the burden rose within the testing period, while for 33% it has been reduced. However, for 80% users' the absolute change did not exceed 13% of maximum possible change. Surprisingly, the burden rose more for those caregivers who declared higher levels of burden in the pretest. However, similarly to the quality-of-life measures, this does not mean that the solution did not exert such an effect, given the external and uncontrolled factors which could have influenced their quality of life (ex. the pandemic). These effects could not be taken into consideration due to the lack of control group in the evaluation design.

Additional questions in this area indicated that use of the INCARE system brought significant benefits to the caregivers. A vast majority of the caregivers (80%) declared that using INCARE's solution increased their sense of peace and control over the senior's health. This was due to the perceived positive impact that using INCARE had on the health and wellbeing of the seniors under their

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[5] https://www.psychiatrie.uk-erlangen.de/index.php?id=11049

care (87%), and improved their cognitive abilities and wellbeing (73%). Caregivers noticed that using the solution motivates seniors to regularly monitor their health (93%) and increases their sense of calmness and control over their health (87%). At the same time, caregivers noticed that using the system encouraged more frequent conversations with the senior about health-related matters (87%). In summary, the INCARE system increases caregivers' wellbeing and the effectiveness of the care they are providing.

Benefits of using Incare
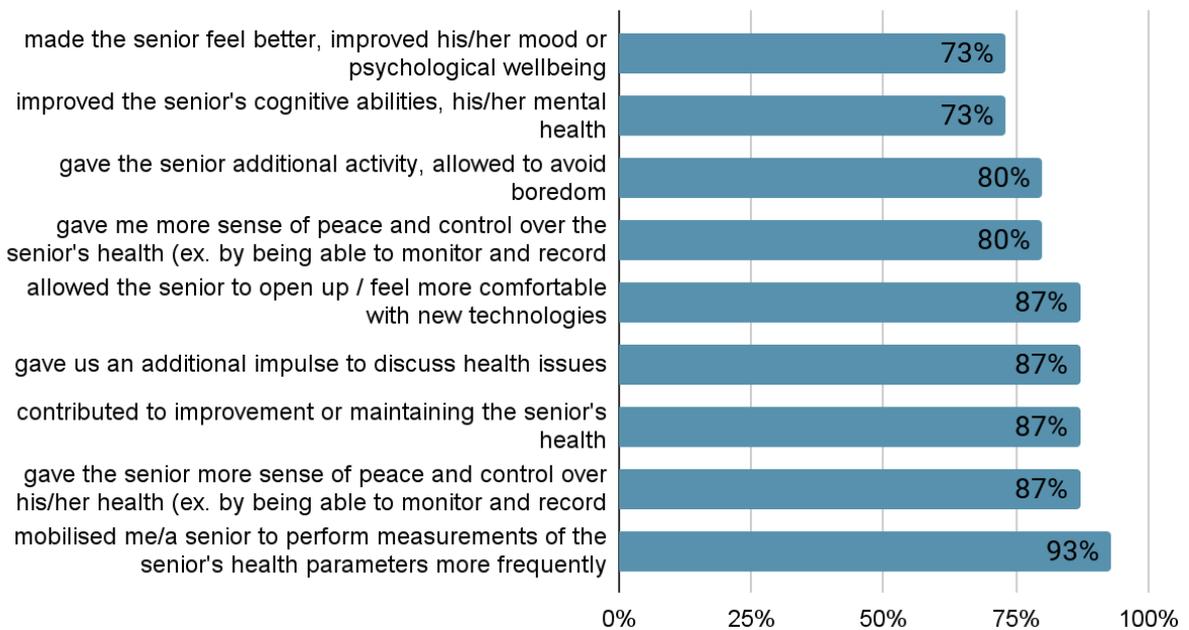
Figure 15 - Chart 15. Thinking of the entire period when you have been testing INCARE, do you think that it has brought any of the following benefits to you or the senior person you are taking care of - either for the entire period or at least at some point of the tests? Check any that apply, informal caregivers, n =15.
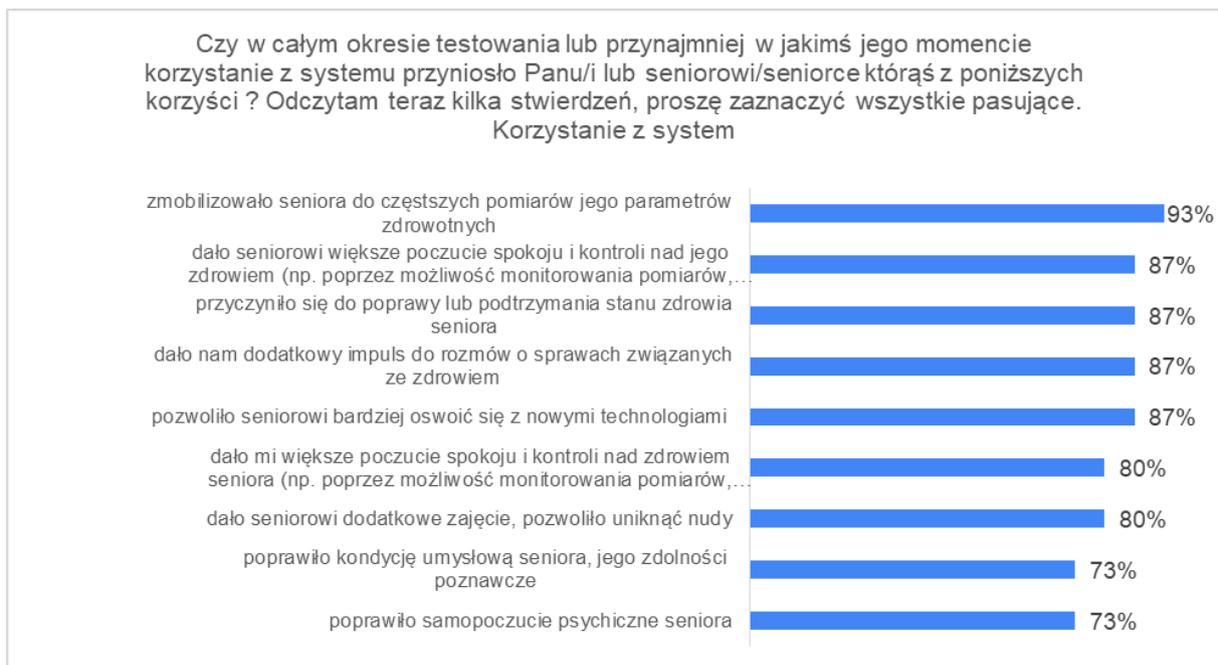
Figure 16 – The original version of Chart 15 (in Polish).

Evaluation of the robotic platform

The main criterion for evaluating the robotic platform used was the acceptance level of the proposed solution. The anticipated value of this indicator in the project was set on 70-75%. This means, that for the criterion to be met, 70-75% of the respondents evaluating the robotic platform should declare they would accept using such a solution in their daily life (now or in the near future). This is why at the end of the interview (after a detailed discussion of what the robot looks like with its specific features) participants were asked the following question:

> *If you needed extra support in different life situations that you saw on the video, would you be willing to use the INCARE robotic solution[6]?*

Respondents were asked to answer on a 1 to 5 scale, where 1 meant "I would definitely not want to use that solution", and 5 meant "I would definitely like to use such a solution". Participants justified their choice.

We asked 5 groups of respondents about their acceptance of the presented robotic solution; seniors and caregivers testing INCARE in their place of residence, representatives of nursing homes testing the INCARE app in the institution, as well as seniors and caregivers participating in group interviews dedicated only to the evaluation of the robotic platform. The acceptance for the presented solution is presented in total for all caregivers participating in the study (23 people) and seniors (28 people).

As such, as many as 70% seniors and 74% caregivers participating in the study[7] would be willing to use the robotic solution in certain, specific life situations (hence if they had none or limited support from the caregiver, and if the senior's health were poor). **The acceptance target of 70-75% chosen for the study (KPI) was therefore reached.**

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[6] Question to caregivers: If a close and elderly person needed additional support in various life situations, would you be willing to take advantage of such a solution?

[7] In accordance with the D1.2b methodological report, acceptance meant scores of 3, 4 and 5 (on a 1 to 5 scale).

Level of the robotic platform acceptance
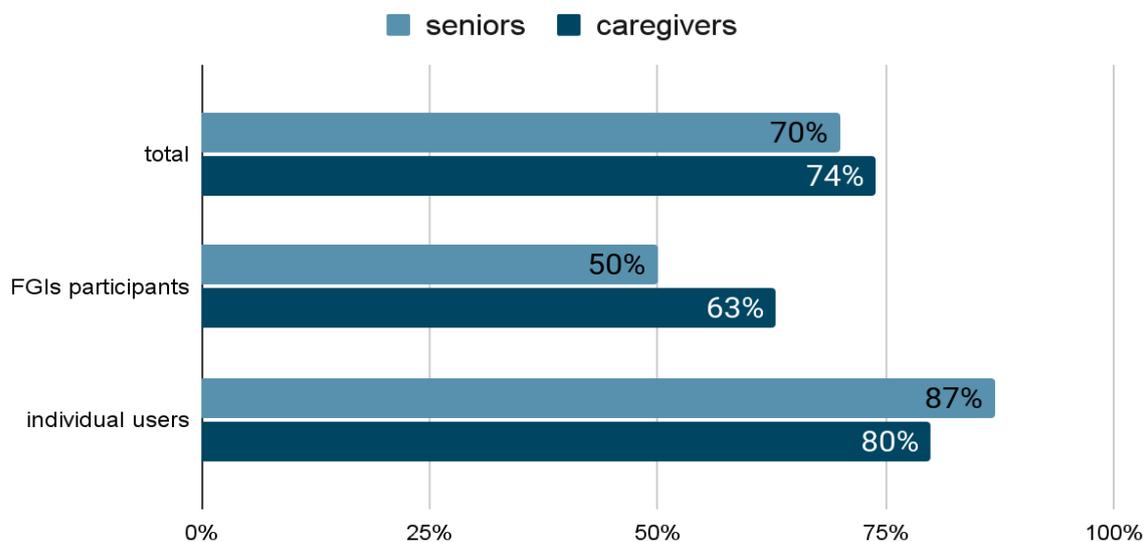
Figure 17 - Chart 16, Level of the robotic platform acceptance, seniors in total n=27 (15 individual users, 12 FGI participants), caregivers in total n=23 (15 informal caregivers, in-home testing, 8 FGI participants).

It is important to point out that highest acceptance for the presented solution was declared by seniors (87% acceptance) and caregivers (80%) who have been testing INCARE in their homes for the past several months. A clearly lower acceptance level is displayed by people participating only in the group interviews dedicated to the robotic platform (only 50% acceptance for seniors and 63% for caregivers). The difference between these two groups could be explained by the context in which they formulated their opinions. Contrary to the FGI participants, individual users were personally familiarized with the INCARE system and they were able to evaluate the robotic platform from the perspective of the whole solution (as part of a larger whole that they knew). Respondents who didn't have that context were much stricter in their feedback. It is also worth noting that seniors participating in the two group interviews were shown slightly different videos than to the other groups, which could also explain the differences in the score[8].

In the meantime, the robotic solution was not met with the acceptance of the care home representatives testing the INCARE solution in their institution (score of 2 on a 1 to 5 scale), more on that in the "Weaknesses of the presented solution" section.

Advantages of the presented solution

The people who declared potential openness and desire to use the presented solution in the future **thought that it is above all a chance to increase the sense of security of a lonely person, or someone struggling with limited mobility.** The biggest advantages of the robot include the possibility to connect with the caregiver if they fall, and the possibility to support people walking on crutches to transport objects, meals etc.

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[8] This group of seniors was shown two videos showing Tiago assisting a person in case of a fall, and how it was carrying objects. During the project, technical partners developed new videos that were added to the presentation on future interviews.

I'd be willing to use such a device, assuming that it offers all the features they mentioned here. It would be better than if I'm just supposed to manage by myself (...) first of all it gives me a sense of security. That's probably most important. (FGI, Seniors 60-70)

My grandma, she is basically fit and walking, we were living next door and she had a cell phone – but she slipped and broke her hip. She was waiting half a day for someone to come and check on her (...) That's why I think that such devices... they provide safety to the person that's at home and to their family. (FGI caregivers)

Some caregivers also pointed out that the robotic solution could have an advantage over the currently available bands with a fall-detect feature and the classic phone call. In the event of a fall, the senior may not have access to a phone. In the meantime, the bands inform only about a fall. Therefore, one doesn't know how serious the event was and whether it requires much attention. In this case, the video call can put the caregiver at ease or help them take the right steps.

I think it's a very good solution, because if there's an app that allows me to talk to them at a given moment, then it's very important, as dad doesn't carry his phone at all times (FGI caregivers)

Individual respondents also noticed the entertainment potential of the device – the fact that it could be a curiosity and can bring variety to everyday life (especially in the case of the Pepper robot that looks like a human being). According to the respondents, for the people who want such "novelties", it could be sufficient motivation to have such a device:

There's a group of people that will say they need to have it, even if they don't really need it. Because it's new! (FGI Seniors 70-80)

Respondents also noticed the social benefit, as an older person would not feel so lonely:

Its biggest strength lies in the fact that it's there for you every day. The robot provides entertainment, helps lonely people. It would be great if it asked questions so that the patient has someone to talk to (IDI post-test with senior)

The look of the robot also impacts the level of acceptance. Pepper was the robot that met with the highest level of acceptance. Compared to Tiago, Pepper is visibly smaller, it has (according to the respondents) more delicate and pleasant shapes, making it more trustworthy (and less scary). Another significant point is also that the robot has hands and eyes, which seniors and caregivers associate with living human beings. However, many respondents stressed that they understand that the look and size of the presented types of robots impact their capabilities (the smaller and seemingly less stable Pepper won't transport things). This is why our respondents postulated for a combination of the functions of the Tiago robot with the design of Pepper.

Weaknesses of the presented solution

People who are reluctant to the presented robotic platform justified their score using different arguments.

Some seniors declared that they would not trust a machine and they were clearly reluctant about the possibility of being with a robot on a daily basis. Those people saw the robot as an "unwelcome guest", which is "artificial" and will never replace a person. This group of respondents would rather avoid a situation in which the only support they can count on, is the support of a robot. Especially in life- or health-threatening situations. Such people were also concerned that the robot would replace their relations with their dear ones (family members could start feeling "relieved" from the necessity to visit the elderly person, because there's a robot living with them).

Another weakness of the robot was the unpleasant, artificial look – especially in the case of Tiago. Although there were also people who thought that Pepper looked like a fake, scary doll (because it looks a bit like a person). Many respondents also had negative feelings about the "unnatural", "mechanical" and "monotonous" voice that Tiago uses to communicate with people (Pepper's voice was rated better, although not by all). To many, it seemed unnatural and excessive when the robot was naming the activities and asking for confirmation of the command. Respondents also fear that the robot may misunderstand commands stated by elderly people (who may have slurred speech).

However, most of our respondents, caregivers and seniors alike, were concerned first of all about the potential malfunction of the robotic solution, as a result of which, the senior will have no assistance whatsoever.

> *I would not trust this machine, it's only a mechanism that can fail. People respond quickly, call the neighbor, help each other out. And what can a machine do? (...) No machine can replace a person! (FGI, Seniors 60-70)*

> *What if the robot fails? Which could always happen. There should be some alarm button that informs all parties that the device is not working. (IDI post-test seniors).*

Our respondents also pointed out that operating the robot (turning it on, charging etc.) could be too complicated for the seniors. Repairs would also most likely require much organizational effort (it is unknown if repair shops for such devices are readily available or not) and too high a price. **Another, very clear obstacle noted by the respondents was that it is not suited to the seniors' living conditions –** they live in places that are often small, with thresholds, carpets, stairs or other obstacles making it impossible for the robot to move.

> *Well, it moves just like these round vacuums. It needs to have smooth floors, no thresholds, no carpets, nothing on the floor. It needs open space. And that's something you don't have in Polish apartments. (FGI Seniors 60-70)*

> *One corridor with a bathroom and such a huge robot. What about me? I would not fit in anywhere. (FGI Seniors 70-80)*

Nearly all of the respondents had doubts about the high costs of purchasing such a device. Some caregivers thought that there are already cheaper and smaller devices in the market that can deliver on the robot's monitoring features, these being bands, sensors, tablets or apps (especially to check the weather or to show results of health measurements).

> *If you have a phone, you can practically look it all up in Google, you can check the weather and it'll just tell you everything you need to know. (FGI caregivers)*

> *I think that you can just as well use motion sensors and notify the caregiver or healthcare providers via the app. Best if you inform the caregiver. You could install four cameras at home and then you can see live whether someone's fallen or not. (FGI caregivers)*

> *All you need is just to install a motion or noise detector that reacts in the same way as this one does, but it won't move, it won't have these lights and all these costly gimmicks, (FGI, Seniors 60-70)*

Considering the above limitations, the support that the robot provides is insufficient according to many respondents. Indeed, the robot can call a caregiver, but it won't open closed doors to the medical staff if they don't have the keys. It cannot prepare a warm meal or beverage and won't move it from the kitchen counter to the tray. And it cannot lift a person who's laying down.

Carrying things is valuable only to a small group of people. Someone needs to put things on the robot – this doesn't solve the issue for people who are not mobile, or people with very limited mobility. (IDI post-test, seniors)

It can't do this or that, it can actually only do very little. (FGI, Seniors 70-80)

Therefore, respondents postulated that the robot's features be expanded with some activities that are of course very far-fetched, such as i.e., cooking, cleaning, lifting objects, help in getting up (after a fall or when getting up poses difficulties), reading books and informing about news from the country and abroad. Considering the likely cost of the robot, its limited functionality and mobility, some skeptics of the solution thought that it would be more effective (and cheaper) to hire a private nurse.

Nursing home representatives were strongly against the use of the robotic solutions presented. According to the director and employee of the institution, their residents above all need closeness, affection, physical and mental contact with people. The caregiver would not like robots to do the job for her, because that personal contact is very important for the residents. Both respondents also saw no need for the robot to assist them in their work – neither transporting medicine, nor alarming them about a possible fall of the patient. They were convinced that the staff can handle their everyday activities well, they are also always close to their patients (so any fall will definitely be noticed). The director of the nursing home also expressed concerns that older people suffering i.e., from dementia could be scared of the robot, they could behave aggressively or lose control in the vicinity of the robot. Instead of the presented robots, the director would be interested in a diagnostic robot (which diagnoses the patient's muscle condition, does proper exercises or follows the therapists' commands).

3.1.4 Recommendations for optimization the INCARE solution:

Based on the interviews with the respondents, the following recommendations have been formulated regarding the robotic INCARE solution in the future:

- A robot directed to seniors should have a smaller size (more compact), so that it doesn't take up too much room in a small apartment

- The robot should look friendly and seem kind and warm. It should have delicate, streamlined shapes and needs to be built from warm materials that are pleasant to the touch.

- The robot should communicate with a voice that is as similar to the human voice as possible. The voice should be warm, with a gentle and informal tone. At the same time, seniors may differ with respect to their preferred voice (i.e., some prefer a male, others a female voice). It would be good if the user had a chance to choose a preferred voice, i.e., several available voices.

- The default form of communication with the robot should take place via voice commands.

- The robot should move freely around the apartment – should move across any possible thresholds, should open closed doors (inner doors, but also the door to their apartment).

- In future, we recommend considering connecting the robot to the public or private healthcare system, so that it can also contact medical staff (useful especially when the senior is not cared for by anyone close to them). In health-risk situations, the robot should be able to notify the emergency services (even without talking to seniors, since the robot may misunderstand them).

- The robot should be able to give objects.

- The robot should first of all have an alarm button, which would inform close people or medical centers about the device malfunctioning.

- The robot could be equipped with a hook for hanging things on it (i.e., grocery bags) and a handle to rest on if they lose balance.

- The robot should have more features, such as: preparing a meal and /or beverage, lifting objects, help getting up, monitoring health condition without the need for using medical devices.

- The robot platform should be introduced into the senior's apartment with a simple, but thorough instruction manual, as well as a set of answers to the senior's most frequent questions, regarding i.e., charging, its reliability and the place where it can be given out for repairs or where one can ask for assistance.

3.2 Romania

The midterm evaluation of the INCARE product in Romania was carried out by CITST with two types of users – the seniors and the informal caregivers – living in their own homes. They are called individual users. We gathered data from our participants by the use of questionnaires. The questionnaire is a quantitative technique of research consisting of an ensemble of written questions and, eventually, graphic pictures, ordered logically and psychologically, which, by being administered by the investigation operators or by auto administration, determines from the respondents' answers what will be recorded in writing[9]. Our questionnaires contained different types of questions, from the simple sociodemographic type (age, gender, place of living etc.) to the specific ones we need for our research: questions regarding physical and mental health and activities, independence, everyday routines and digital experience.

Our questionnaires were initially designed in Word format (.docx), but we converted them in Google Form format. These were filled by the CITST personnel responsible for the pilots and for conducting the interviews. The interviews were conducted personally either face-to-face or via phone or online communication tools.

3.2.1 Sample description

There were 14 participants in the Romanian study, 10 of them were elderly people and 4 of them were informal caregivers for their elderly relatives. All participants met the recruitment criteria mentioned in the project: age and physical issues relevant to the project for seniors and the necessity of having a senior in care for the informal caregivers. However, not all informal caregivers agreed to participate in the pilots. Thus, 4 seniors participated alone and offered input from the perspective of a senior which is using the INCARE platform to maintain her/his independence for a longer time but without the help of an informal caregiver. The next sections are presenting these criteria and other important characteristics of the participants.

In addition, to the above participants, 8 more formal caregivers were involved for the evaluation of the robotic platform. These were involved from among the members of A.D.I.V which is one of the collaborators of CITST in several projects. A.D.I.V. is a professional association of managers / directors of Romanian long-term care institutions for the elderly.

Seniors

- **Demographics**

All senior participants were retired, so they were over 65 years old. The ages of the participants were between 65 and 93 years old, with the average age at about 78.3 years old. Thus, we can say that we had representatives for all the 3 main age groups recognized in Romania: groups: elderly (65-74 years), old age (75-90 years) and longevity (over 90 years).

The gender of the seniors was almost balanced, having 6 males and 4 females participating in our study. They all lived in the urban area, in either medium-sized cities (2 out of 10 participants) or large cities (8 out of 10 participants). The medium-sized cities have a population of 100 000 to 500 000 residents, while the large city, in this case Bucharest, has a bit over 1.8 million residents. All seniors had tertiary education, and were specialized in a variety of fields (see Figure 18).
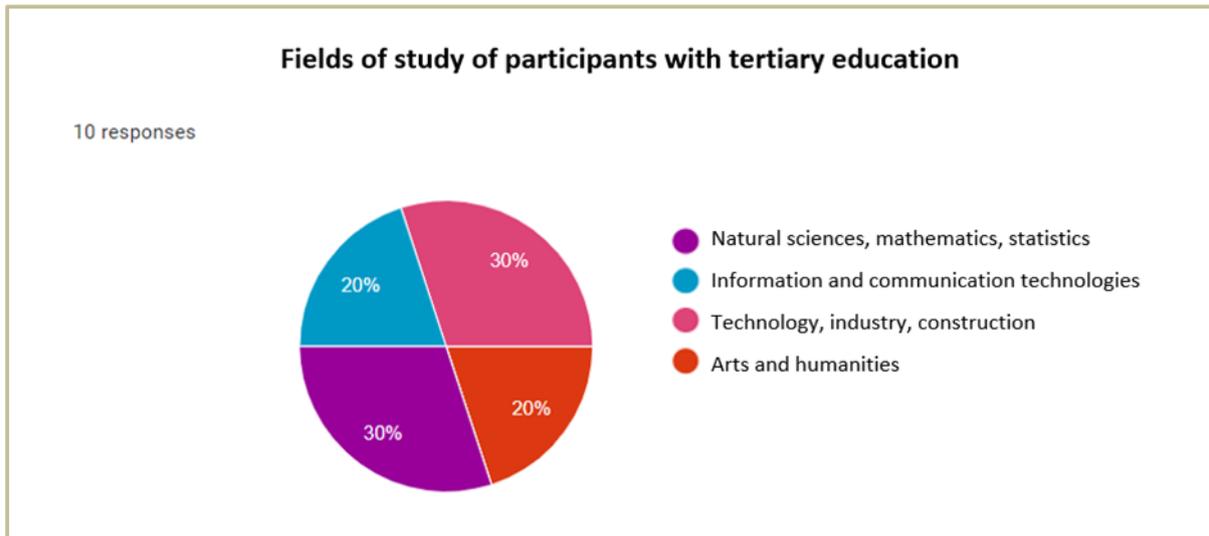
Figure 18 – Fields of study of senior participants with tertiary education.

Given this information, we were able to draw a couple of conclusions, one of the most important ones being that the majority of our elderly participants either had constant contact with technology or worked with technology on a regular basis. This was further investigated in the questionnaire.

- **Digital skills**

Even though technological literacy was not a criterion for the participants in the INCARE project, the majority of our seniors used either a smartphone, a laptop, or both on a regular basis. Their preference regarding the usage of technology is presented in Figure 19.
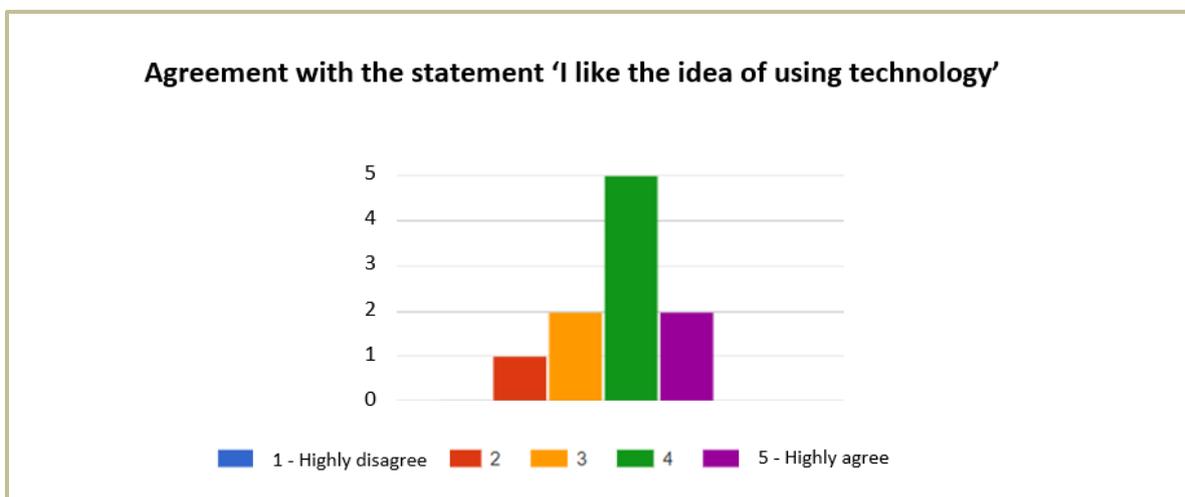
Figure 19 – Level of agreement of senior with the statement 'I like the idea of using technology'.

As we can see, 7 of 10 participants liked the idea of using technology, because they believed it to be useful. Being asked about the effectiveness of technology in their daily activities, the seniors were either neutral or pro technology, considering that it would increase their efficiency in completing daily tasks.

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which [9] Chelcea, S., 2007. *Metodologia cercetării sociologice*. București: Editura Economică, p.140.

More than half of the participants also agreed about the utility of technology in everyday life and its accessibility for them. Financial situations did not seem to be a reason why the elderly did not use technology more.

Hesitation and fear of using technology did not seem to be an issue among the majority of our respondents, who believed that any mistakes they might make involving technology can be easily solved. But, regarding the skills needed in order to perform certain activities with the use of technology, the seniors were not very confident, more than half of them believing they might not have the needed skills even if someone is willing to show them how to do it.

● **Health condition**

The senior participants had one or more physical conditions or disorders. The most encountered conditions were diabetes and cardiovascular diseases, followed closely by hypertension. Diabetes is a condition from 5 of our participants suffer, one of them being in constant need of insulin shots. Cardiovascular diseases also affected 5 of the participants, and hypertension affected 3 of the seniors. Other physical disorders mentioned by the seniors were metabolic disorder, cancer, scoliosis, arthrosis, spinal deformity, cataract and reduced mobility because of a broken leg bone.

An important factor that can preserve, or even improve, health, is the level of everyday physical activity.
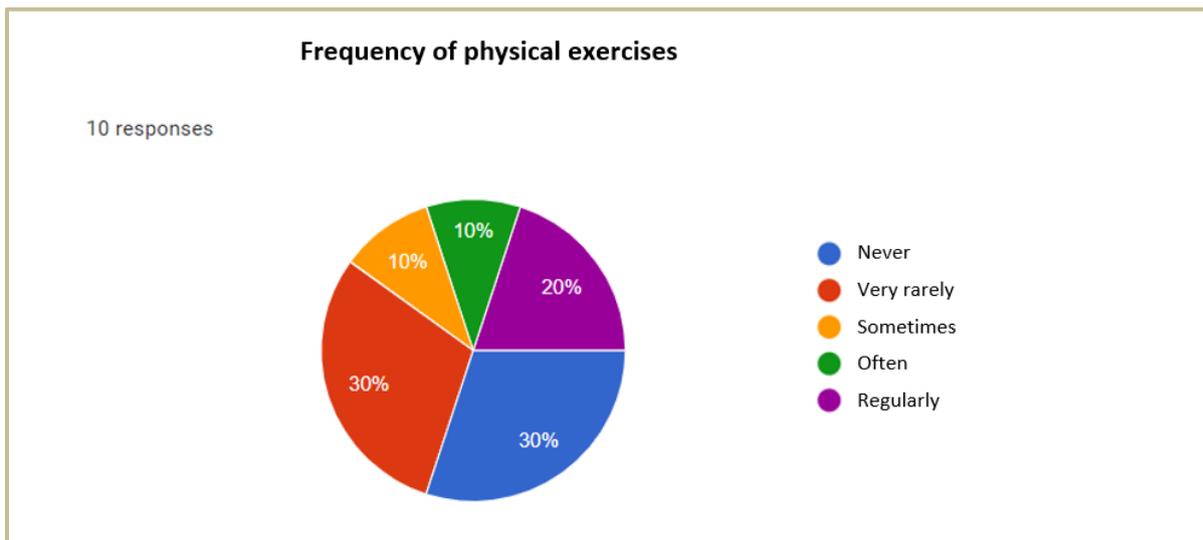
Figure 20 – Frequency of seniors doing physical exercises.

Even though the seniors' answers were divided in this matter, with more than half of them considering that they don't do enough physical exercise, all of them mentioned physical routines that improve overall health. Examples are: work inside the house and in the garden, walking in the park or to certain places where they have to perform routines, such as the market or the doctor and gymnastic exercises.

Mental conditions were not as encountered as physical ones, 6 out of our 10 seniors having no mental impairments or issues. One of our participants had depression, a fairly usual issue among the elderly, and the rest of them had a condition that leads to decline of cognitive ability, such as dementia or Parkinson's disease. In order to see how the seniors preserved their cognitive functioning, we asked about cognitive games. We discovered that the majority of our participants, 8 out of 10, play some kind of cognitive game or exercise to keep them busy. When we inquired about their kind, most of the elderly mentioned Sudoku, but other activities were also popular: crossword puzzles, Scrabble, reading books and computer games.

Regarding issues that can be perceived as disabilities, one of our older participants mentioned advanced arthrosis and Parkinson's disease, another mentioned hand arthrosis, one mentioned deformity and compression of the spine and the last one mentioned insulin dependency in order to survive. The rest of our participants considered that they had no disability.

In order to function on an everyday basis, the majority of the seniors said they need to follow a certain long-term medical treatment, which always consisted of medicine. The medicine mentioned was used to treat the illnesses specified earlier. With regards to taking the medicine, most of the respondents said that they very rarely forget to take it.

In an effort to preserve their health, all of our respondents monitor their health, although the frequency varies.
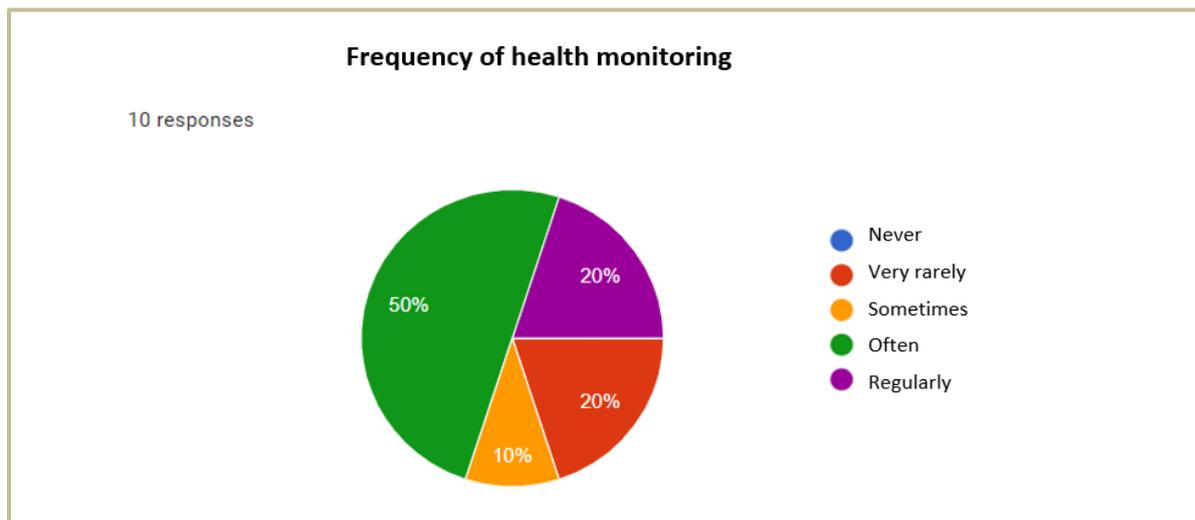
Figure 21 – Frequency of seniors monitoring their health.

Most of them do it often or regularly, using devices such as the blood pressure meter, the glucometer, the scale or the pulse oximeter. Not one of our participants mentioned the thermometer, as, in our country, it is usually used when someone has a cold or the flu, not on a regular basis. The seniors' need to constantly monitor their health parameters stems from, just as in the case of medical treatment, the various health problems they have to live with.

● **Independence**

Independence is composed of several different elements, some of which we managed to quantify during our study. Mobility is one of the most important ones. The mobility levels of our participants were divided into 2 categories: able to go outside the house by themselves and able to get out of bed with help.
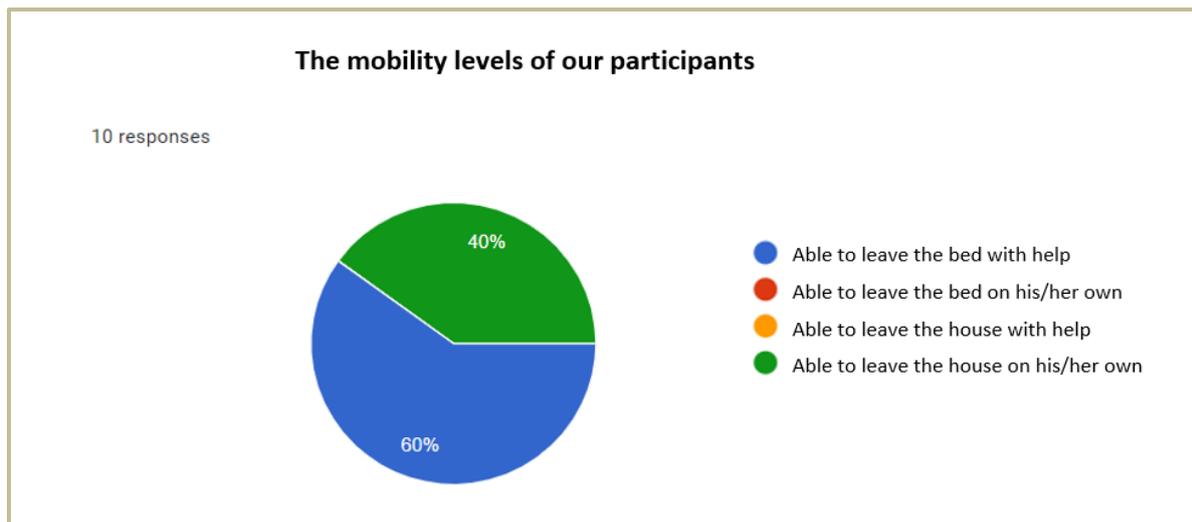
Figure 22 – Mobility levels of our senior participants.

Given this data, we can conclude that 4 of our senior participants are quite independent, having the ability to walk outside without needing or requiring help, while 6 of our senior participants are completely dependent on their informal caregivers, as they cannot get out of bed without requesting exterior help and support.

Concerning independence in everyday activities, the majority of our participants said that they take care of their shopping needs on their own, without exterior help from an informal caregiver. With regard to the planning, serving and eating of adequate meals, only 4 out of 10 participants said that their meals are prepared by them and are healthy. The rest of the participants mentioned that either their diet is not adequate or their meals are not prepared by them. Almost all of the participants said that they participate in householding tasks, some can only do simple ones, such as folding the laundry, while others can even do complex ones.

As for medical treatments, our seniors are mostly autonomous, being the ones responsible for taking the medicine in the right dose and at the right time. Only 2 of the participants admitted that they help in this particular matter, the informal caregivers being the ones responsible for preparing the right dose of medicine and giving them to take it at the right time.

Informal caregivers

- **Demographics**

The informal caregivers were mostly old adults, between 40 and 71 years old. The average age was approximately 54 years old. Regarding the gender division, we had only women caregivers, an explanation being that, in our country, mostly women take the role of caregiver. They are relatives of the seniors they take care of, being either spouses, children or grandchildren. All of the informal caregivers lived in the same city as their elderly relative, half of them in the same house as the senior, and half separately. Two of the caregivers were each helping two family members.

- **Caregiving**

The caregivers offered help in a variety of household activities, which cannot be performed by their elderly relatives alone. Our participants mentioned activities which can be divided into 2 categories: for dependent and for mostly independent seniors. For the dependent seniors users mentioned: helping them

get out of bed, helping them reach the bathroom/toilet and preparing food; for the independent seniors we had paying their bills, shopping, driving them by car to certain places and keeping them company.

Regarding the number of hours participants usually devote to caring for their elderly during one week, 25% were helping 1-2 hours, 50% were helping 9-20 hours and 25% were helping more than 20 hours (see Figure 23.)
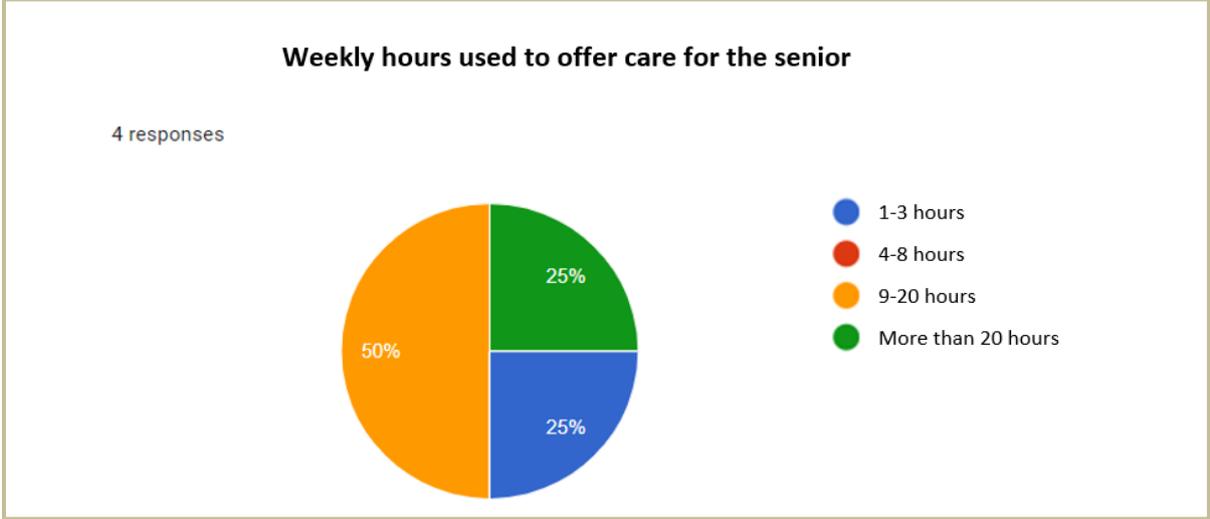
Figure 23 – Weekly hours used to offer care to the senior (caregivers).

The number of hours is mostly high, and, based on the received input, the caregivers feel that they need to spend more time with their elderly so they won't fall victim to accidents or have health crises which they won't be able to solve. In a lot of these cases, it is hard, or even impossible, for seniors to ask for help. What is more, the caregivers had different opinions when it came to the sufficiency of the number of hours devoted to the seniors, some considering that the time they spend with the elderly was enough to satisfy their needs, some not. The areas in which the participants believed the elderly would need more help were: walking outside the house, physical exercises, cleaning and cooking.

Caregivers agreed about the types of activities where seniors were independent and the types of activities where they needed help.
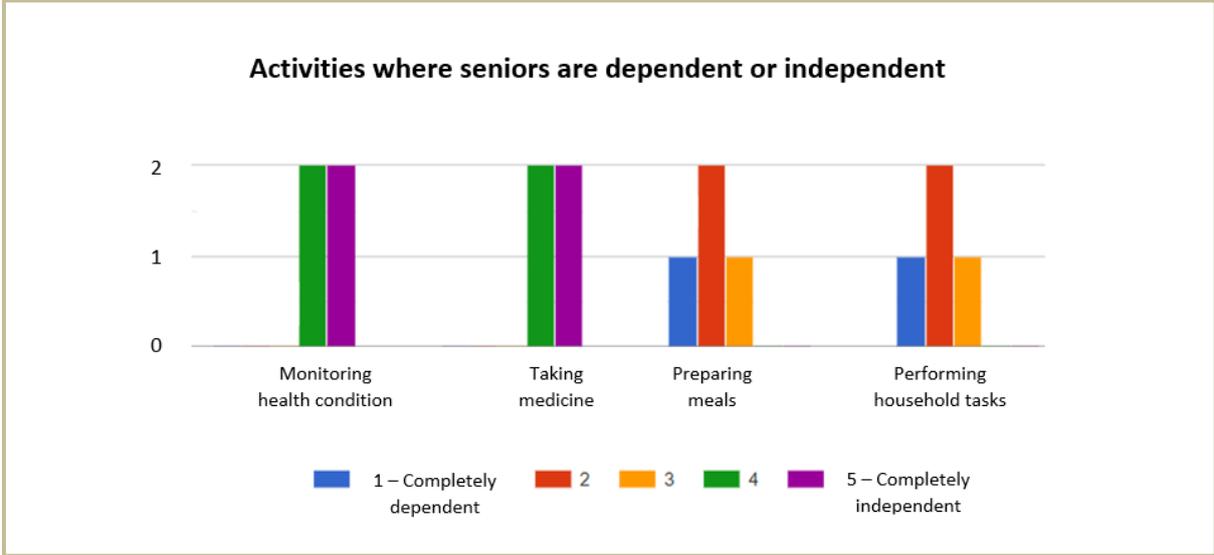
As we can see, seniors are mostly able to monitor their health and take their medicine, as they are simple tasks, which do not require mobility or extraordinary skill. On the other hand, it seems that this does not apply to activities such as preparing their own meals or executing household tasks, as these activities are more complex and require a higher level of mobility, both in their feet and their hands. Cleaning and cooking were also mentioned earlier, when we asked the caregivers what are the tasks where the elderly would need more help.

- **Satisfaction with life**

Another factor that we have to take into consideration when we think about the INCARE platform is the impact of the caregiving on the caregivers' lives and how we can ease its effects. This being said, our caregivers were asked about different parts of their life and how caregiving is affecting them. Two of them revealed that they are unhappy with how they live as a result of the constant support they need to offer. They mentioned a permanent feeling of exhaustion, the steady need to escape their situation and the feeling that they are not the same person as before the caregiving. They also specified that their quality of life decreased as a consequence of the care they constantly have to give. Concerning the social aspect of their lives, the 2 caregivers said that they feel torn between their environment requirements, such as family, and the senior care requirements, and, likewise, their relationships with their relatives, friends and acquaintances suffer because of the care they give.

Robotic platform evaluation

For the robotic platform evaluation, we had 13 users, of which 9 were elderly persons, and 4 were the caregivers of some of the seniors. The elderly participants were between 65 and 78 years old, while the caregivers were between 50 and 58 years old. Six participants (4 seniors and 2 caregivers) evaluated the Tiago and Turtlebot robotic platforms directly, in life demos, while the rest of the participants have evaluated the robotic platforms by using of movies prepared with three robotic platforms (Tiago, Pepper and Turtlebot). While Tiago is a service robot capable of offering support in the daily life activities, Pepper is more of a companion robot while Turtlebot can offer help with carrying items and hazard detection. In addition, 8 formal caregivers have also evaluated the robotic platforms based on the prepared movies and have provided their feedback via the relevant questions selected from the overall questionnaire.

3.2.2 Main results

In the next section we are presenting the main results of the Romanian pilots, while also highlighting the key performance indicators (KPI).

User satisfaction

The first KPI we targeted concerned the user satisfaction with a threshold of 7 out of 10 (70%) by the end of the pilots. Thus, the average score given by the seniors and caregivers regarding their satisfaction with the INCARE solution had to be at least 7 in order to meet this target. Satisfaction was measured with 2 types of questions, as described previously in section 4.1.3. Another target assumed was no more than 15 – 25 % dropouts after half a year**. Both of these conditions have been met.**

Both these requirements were met and far exceeded by the pilots involving senior participants. As can be seen in Figure 25, all senior participants were satisfied with the INCARE platform, several of them giving ratings of 9 or 10. **The average score given by the elderly was 9.** Among the advantages observed by the senior participants regarding the INCARE solution, we had a better planning of the day due to the daily schedule and a more attentive approach to the health parameters. The health monitoring part was the most appreciated feature of the solution, all of the seniors considering that their lives, and their caregivers' lives, were simplified by the existence of this functionality. The feature of keeping track of health parameters was considered useful when going to the doctor or for following the possible changes in their health condition.

No senior participant has dropped from the trials. A singe senior participant did not participate in the evaluation of the robotic platform. Even if we consider this as a dropout, we **had 10% dropouts** which is below the target value.
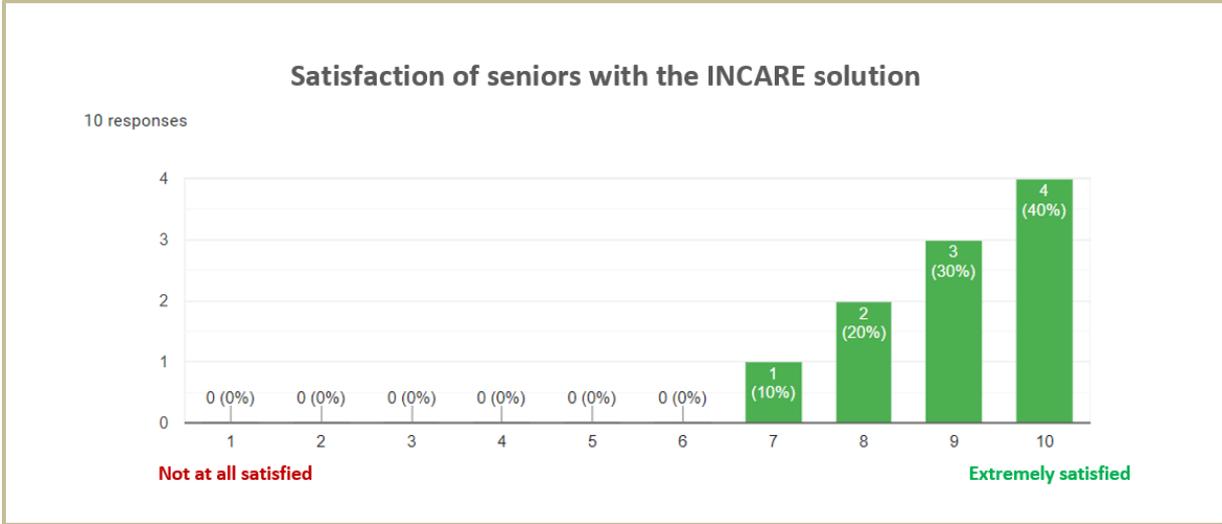
Figure 25 – Level of satisfaction of seniors with the INCARE solution.

The caregivers were mostly satisfied with the INCARE solution, believing that the health monitoring platform brings real benefits to their caregiving activity. They mentioned advantages such as reduced stress levels, more control over the health condition of the elderly relatives, the lack of necessity to always be with the senior etc. **The average score of the platform, given by the caregivers, was 8.5 out of 10, which is a decent rating given the available functionalities. No dropouts were registered.**
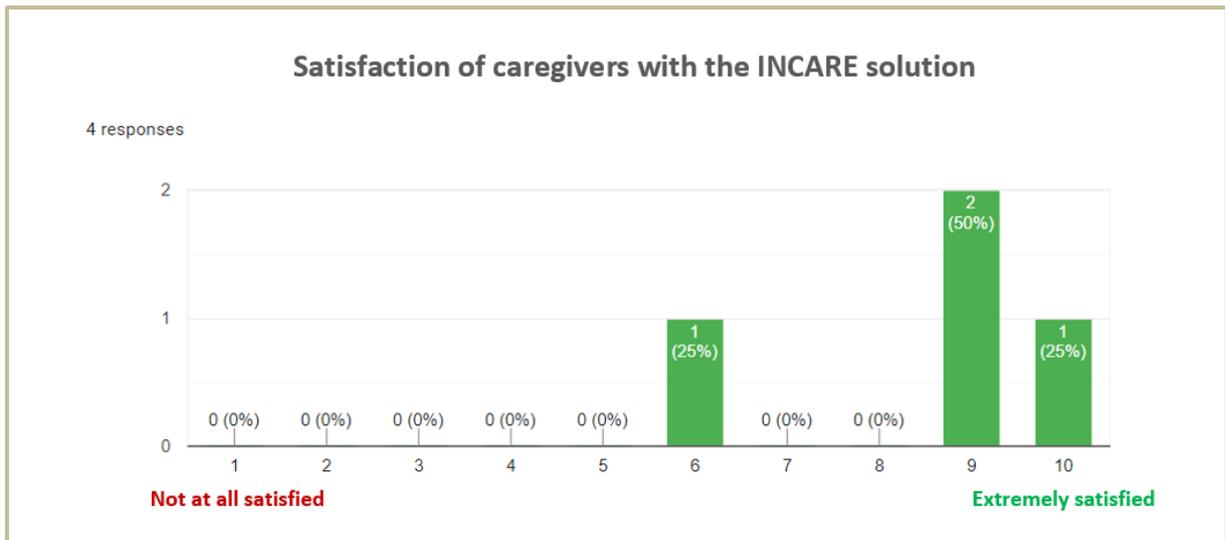
Figure 26 – Level of satisfaction of caregivers with the INCARE solution.

Out of all participants, one informal caregiver gave a 6 points rating. The main objection was that the platform usage had triggered even more complains about the health of the senior. The caregiver reported that it more difficult even at work since the INCARE solution had been implemented in their house, because the senior calls all the time to discuss about the health measurements.

Another question we asked in order to discover if the participants were satisfied with the INCARE solution was related to their willingness to recommend the INCARE platform to a friend or an acquaintance.
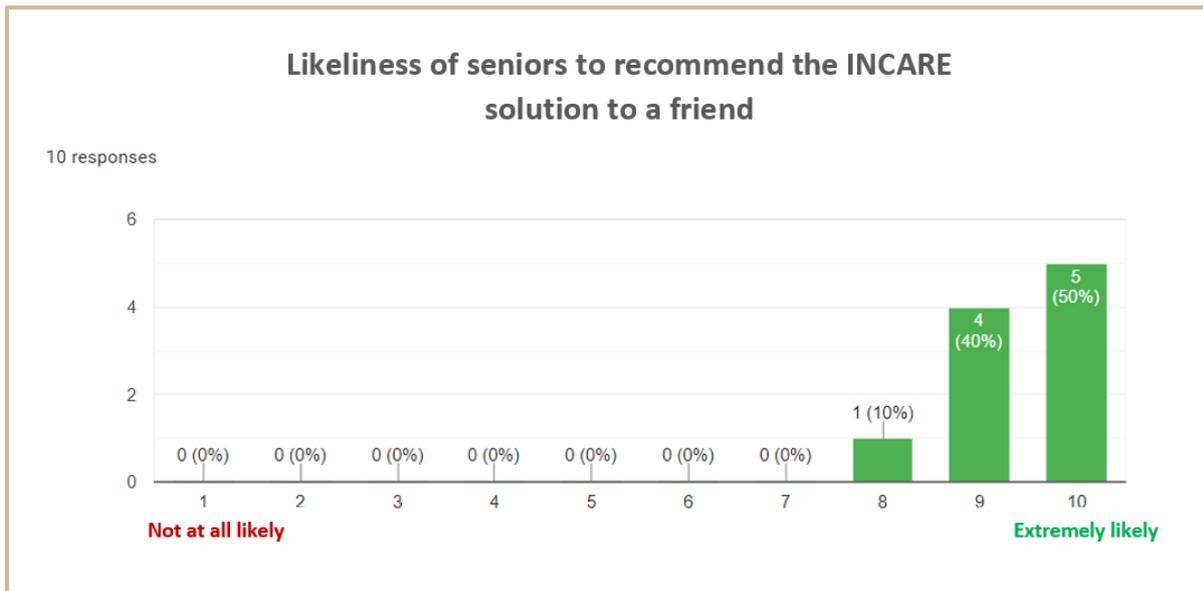
Figure 27 – Likeliness of seniors to recommend the INCARE solution to a friend.

As we can see in the chart above, all seniors were likely or extremely likely to recommend INCARE to a friend. This means that the elderly participants were satisfied with the advantages brought by the platform, considering that it is a good choice also for their pierce. The average score given by the elderly was 9.4, a value close to 10.

The caregivers were also likely or extremely likely to recommend the INCARE solution to a friend or acquaintance. The average rating given by the caregivers was 9, which means they trust the platform enough to present it as a solution to other friends having a senior under their care.
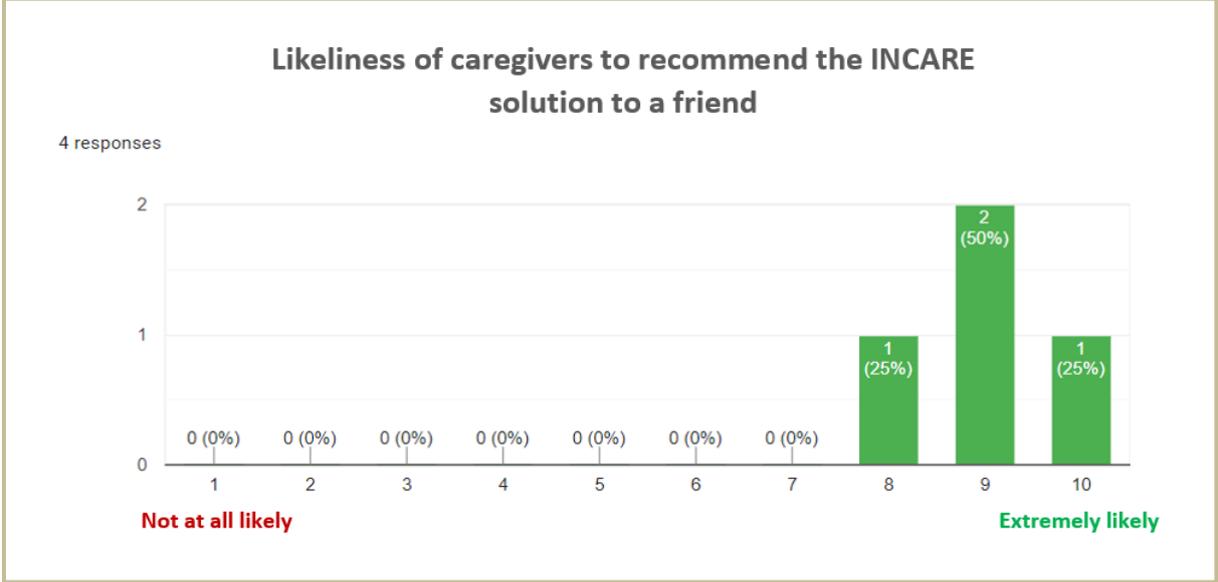
Figure 28 - Likeliness of caregivers to recommend the INCARE solution to a friend.

User satisfaction: usefulness of specific features

Evaluation of the health monitoring app – perspective of individual seniors

As we mentioned earlier, the health monitoring platform was the most popular feature of the INCARE solution, both among the seniors and the caregivers. Many seniors mentioned the history feature of the health monitoring platform as being very useful, especially when going to the doctor. For the elderly with several age-related illnesses, the possibility of recording their health parameters and accessing them at will made their lives easier.
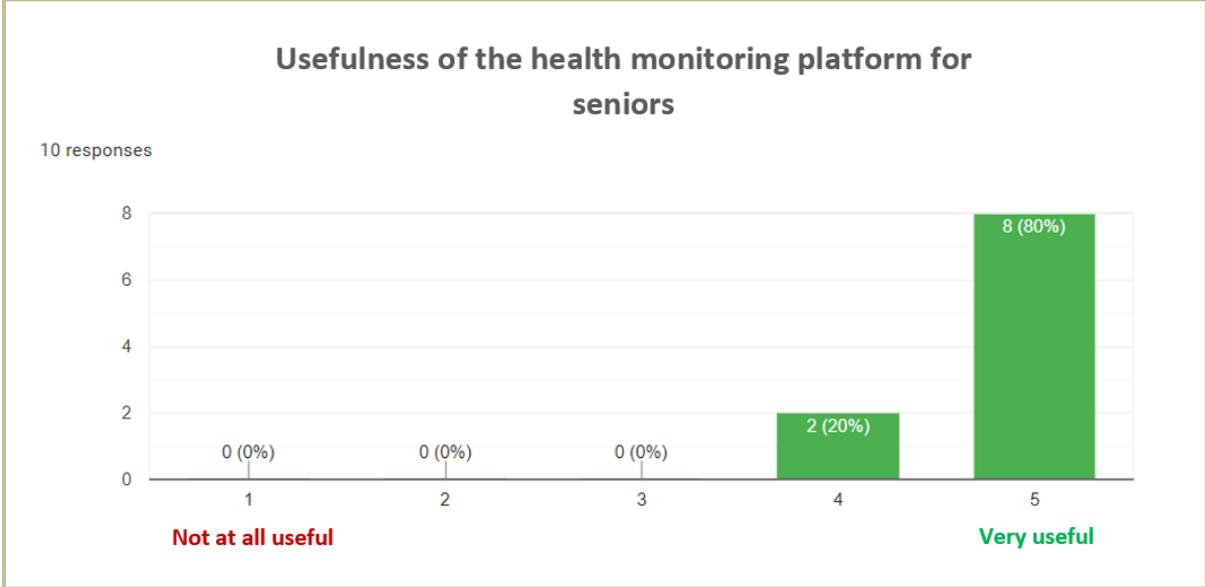
Figure 29 – Usefulness of the health monitoring platform for seniors.

As we can see in the chart above, the usefulness rating for the health monitoring platform was very high, with the majority of the elderly participants giving the maximum rating. The average rating was 4.8 out of 5, or 9.6 out of 10, the INCARE health solution was considered very useful.

Advantages perceived by the seniors when using this solution:

- Easy-to-use medical devices, very similar to the ones the participants already had at home, in both design and functionality.
- Very quick recording of measurements with the majority of the medical devices (besides the thermometer).
- Easy-to-use interface of the app, with visible buttons and intuitive steps to record health measurements.
- Quick response of the app to commands; lack of lag.
- Simple login with the NFC tag, some participants mentioned that they would probably not be able to log in using a password due to arthritis or other hand mobility problems.
- Reliability in transferring the health data to the caregiver web interface.

Given the previous observed advantages, we can say that the health monitoring app works well, it brings a lot of benefits to its users and cand simplify their lives. At the same time, seniors suggested several improvements for the platform following the problems or shortcomings encountered during the pilots.

Disadvantages perceived by the seniors when using the app:

- Various errors appeared during the testing of the platform and its regular use by the participants, which prevented the participants from employing all its features.
- The necessity of using the tablet in order to access the interface; some seniors would have preferred their own smartphone.
- Inability to have 2 accounts active at the same time on one tablet, the necessity of logging out in order to let their spouse use the health monitoring platform.
- Small writing on the main screen of the app, hard to read.
- The design and functionality of the calendar feature: the lack of sound signals for alerts, the necessity of opening the app and logging in in order to see the reminders written in it (for the senior couples who used the same tablet).
- Hard to understand health history axis and very small writing on it.
- Lack of warning messages for the senior or for the caregiver if the usual health measurements are outside the normal parameters.

There are several improvements to be made to the INCARE app, some of them more urgent, affecting the general usage of the app, while others are simply perceived as annoying or a minor inconvenience. Regardless the level of importance of the issue, they must all be solved in the commercial INCARE platform.

Evaluation of the caregiver web interface – perspective of informal caregivers

The caregiver web interface permitted the informal caregivers to access the results of the health monitoring platform remotely, on any browser, by using their own devices (smartphone, tablet, laptop etc.). This was a greatly appreciated feature, as the caregivers are usually worried about what might happen with their elderly relative while they are not home with them. This feature allowed the caregivers to monitor the health parameters of the seniors, while also showing them the number of steps they make in a day. The functionality of sharing the health content with the caregiver, via de caregiver web

interface, was, likewise, appreciated by the seniors, for several reasons. One of them is that it controls certain unhealthy habits:

'I don't have to tell my wife the glucose levels. She can check them
on the platform but I can't cheat either and eat something sweet
without telling her. She will see it immediately'

Senior participant suffering from diabetes

Thus, the simple idea that the caregiver knows what is happening at home makes the seniors act more responsible towards their own health needs. The caregiver of the participant also mentioned this advantage:

'I can check to see if my husband has been moving around the house and if his blood sugar
is in range (he is often cheating with food). I can also figure out from his values if he took
his medication and remind him to do it. I am still working and he is retired'

Caregiver of senior participant suffering from diabetes

It was mentioned that a trained caregiver eye can figure out a lot of what the senior is doing at home just by looking at the INCARE interface. The physical activity can be measured by the number of steps the senior is usually making in a day, while certain health parameters can tell the caregivers if the seniors' health condition is stable or not, if they took their medicine or ate something they shouldn't have.

In terms of usefulness, the caregiver web interface was considered effective in keeping track on what the senior is doing and how they feel, both physically and mentally. As we can see in Figure 30, the caregivers gave mostly positive feedback.
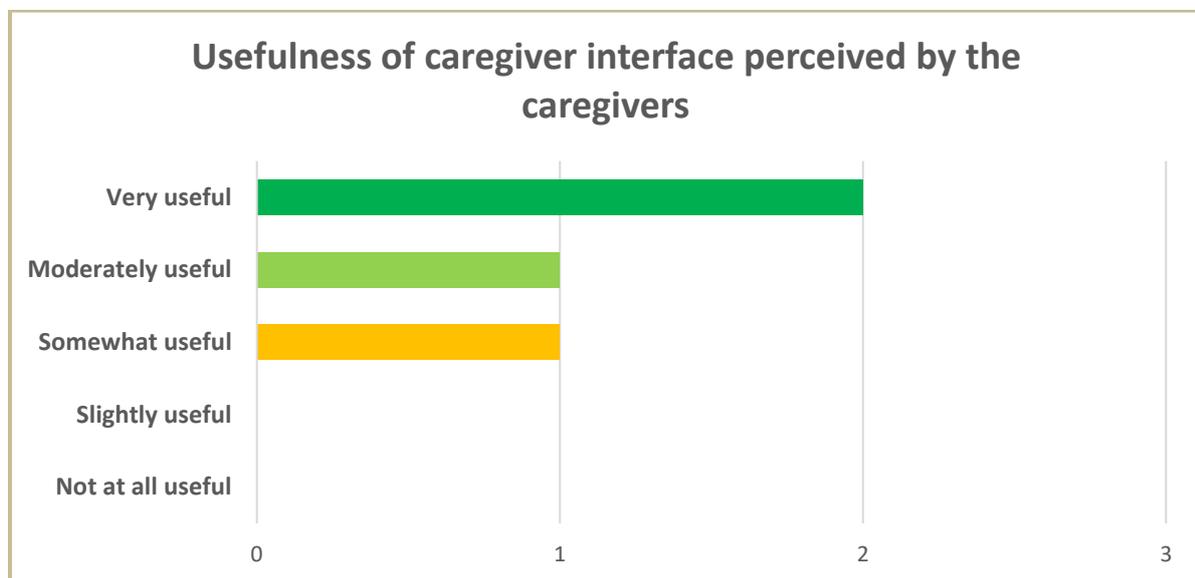
Figure 30 – Usefulness of the caregiver interface perceived by the caregivers.

The average score given by the caregivers was 4.25 out of 5 or 8.5 out of 10. The interface was especially valued for its ability of 'communicating' to the caregivers if the seniors move inside the house or outside, as a lot of the caregivers believe that their seniors spend all their days in bed, being sad and depressed.

For one caregiver, the realization that their mother is actually doing tasks around the house and not spending all her time in bed was a relief.

The ease-of-use of the caregiver interface was considered very high. The caregivers find it very intuitive, saying that the functionalities are easy to figure out. There is nothing complex about it, requiring minimal digital skills from the users and being easy to keep open on the smartphone or the laptop at all times. One caregiver mentioned that they liked the colors used in the interface. However, another one was mentioning that colors were a bit confusing because he was wondering if they have a meaning.

Despite this, there were some functionalities which the caregivers would have liked to have access to while using the web interface such as:

- The addition of a messaging function, something similar to WhatsApp.
- Larger graphs for health history, as they are hard to see when using a smartphone.
- The addition of notifications about the health measurements, the number of steps etc. and the possibility of configuring these notifications.
- The addition of alerts when something is abnormal with the health parameters of the senior.

Evaluation of the games

Games were a popular part of the INCARE solution, with seniors playing them and recommending changes to be done in order to be more enjoyable for them. Several elderly participants asked for more levels, more complex games, or simply games that they know and love (Sudoku, Chess etc.) to be implemented in the INCARE solution. The number of players per game was between 6 and 10 seniors.
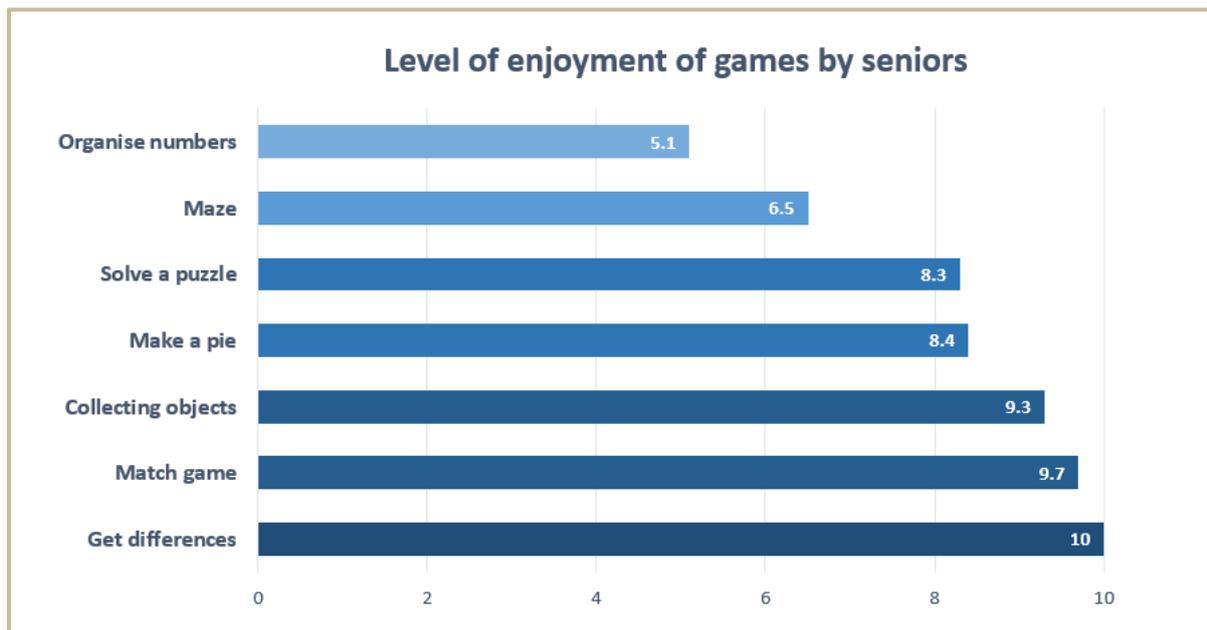
Figure 31 – Level of enjoyment of games by the seniors.

As it can be seen in Figure 31, some games were preferred by the seniors, while others were not very popular among them. There were conflicting opinions regarding the game with the lowest rating, the 'Organise numbers' one, because some seniors were not able to play it at all, due to its complex nature, while others enjoyed it very much. One of the participants who complained about this game said that he/she would have liked some tips about how to play it, as it was hard to understand the rules. Out of the 3 participants who liked the game very much, one was a mathematics teacher, and enjoyed complex

games, and the other said it reminded them of one of the games they played in their childhood. Thus, it would be hard to say if the game was actually bad or not, as it depends a lot on what the players like.

'Make a pie' was popular among participants who were passionate about cooking. It was a simple and fun game which did not require a lot of attention or skill. As one of the participants put it:

> *'I am not a game lover but I liked the pie game because I like cooking.*
> *I would have liked to have adjustable speed when moving on the field,*
> *I would have also liked to have more recipes'*

> *Senior participant*

The benefits of playing cognitive games were acknowledged by the majority of the elderly participants (only one participant gave neutral feedback, the rest gave positive feedback). Some believed that they enhance cognitive capabilities, some mentioned the benefits they can bring to memory training and coordination, and some mentioned they can also help with orientation. Fine motricity was also considered a possible result of constantly playing cognitive games. One participant said that they choose to play games in order to get used to the touchscreen, because they have a smartphone and they find it hard to use.

The majority of games were highly appreciated, several of their advantages being highlighted by the seniors, who believed they are well made and intuitive. The interface was considered friendly, and the games were mostly perceived as easy to play and fun. Despite these advantages, there were a lot of comments regarding how they could be improved in order to be more entertaining for the seniors. As we already mentioned, there were seniors who wanted to play games they knew and enjoyed for quite some time now, such as Chess, Scrabble and the very popular Sudoku. Other seniors wanted more levels for the existing games, so they could enjoy their favorite games for a longer period of time. This was mentioned constantly throughout the study, especially by the elderly participants who enjoyed playing games. One participant said they would be more willing to play games if they got rewards. Another participant wanted to be able to play the games on their personal smartphone. Several users mentioned the addition of settings for speed and time, as they are not able to play because they are not fast enough. The last thing mentioned was the addition of a word or number game, and we believe the senior meant something that would be similar to Sudoku or Crossword Puzzles.

Evaluation of the calendar – perspective of individual seniors

The Calendar was the least appreciated functionality of the INCARE solution. It had several great disadvantages, which were highlighted by many seniors. As we can see in the following chart based on the feedback of the seniors, the Calendar was rather perceived as lacking utility.
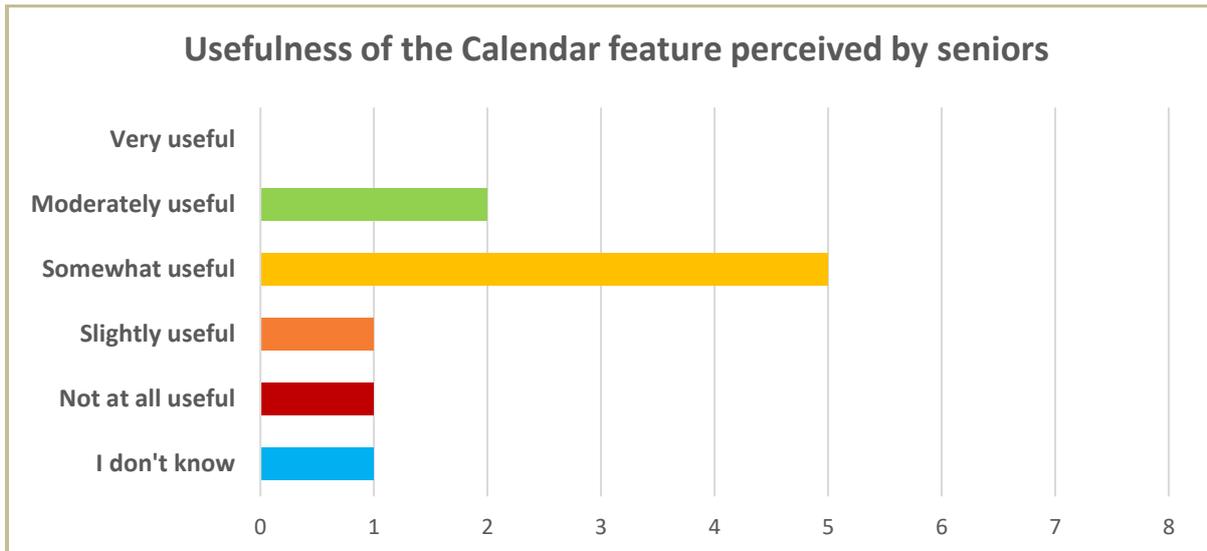
Figure 32 – Usefulness of the calendar feature perceived by seniors.

Most of the elderly participants gave neutral feedback regarding the Calendar feature. There were no users who considered this functionality very useful, because it had some characteristics which made it hard to use it. Some neutral feedback was due to the lack of necessity of this feature in the lives of the seniors. Some lived with their caregivers, who took care of reminding them about doctor appointments or about taking their medicine. Others lived alone, but they had no issue remembering what they had to do. One participant mentioned that they already have a calendar app on their personal phone, which reminds them about all they need to do; despite this, they appreciated the feature of INCARE which allows them to share the calendar with the caregiver or their doctor.

A real disadvantage to this feature was considered the constant need to log into the INCARE app in order to access the calendar and check out the reminders. A lot of the participants believed this is annoying and it hinders the whole aim of this functionality. If you have to remember to log in in order to see what you have to remember, what is the point of this feature? Sound alerts were requested as a way for the calendar to present reminders to the users. Also, users said that the manual input of reminders is very hard to do, due to the difficulty of using the touchscreen.

Thus, the Calendar feature was not considered easy to use and also not very useful in its current implementation.

Impact of the INCARE solution on quality of life

The INCARE solution was designed to improve the quality of life of elderly participants, making their life easier and more enjoyable. We asked the seniors about their quality of life before and after the testing of the INCARE solution in their homes, expecting to see an increase in their perception. As we can see in Figure 33, we were able to see an increase in seniors' perceived quality of life by comparing their answers in the beginning and in the end of the pilots.
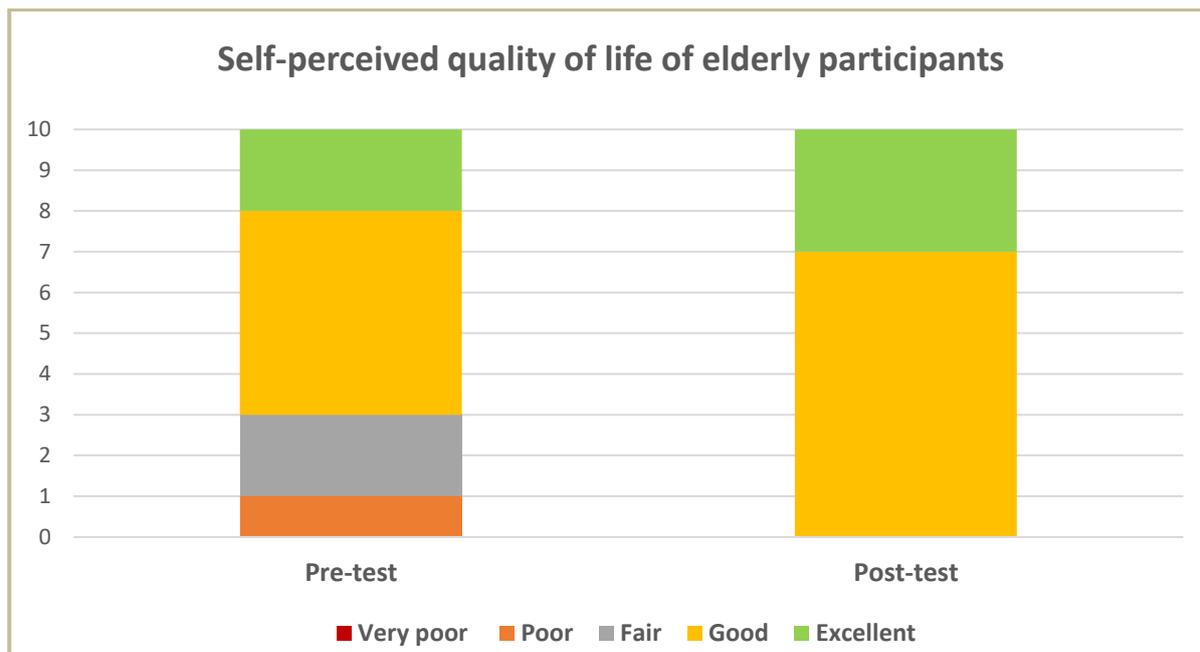
Figure 33 – Self-perceived quality of life of seniors.

Three seniors perceived their quality of life to be "poor" or "fair" at the beginning of the pilots testing. However, all participants scored above this level in the end of the pilots. In the end of the pilots, all participants scored "good" and "excellent". The possibility of being constantly aware of the health parameters and their potential changes, as well as reminders about taking medicine and doing certain required activities, helped the seniors realize that their lives could be easier to manage. The platform, if implemented with regards to the users' individual needs, can make the seniors' lives more enjoyable, and can take part of the worries and responsibilities from the shoulders of their caregivers. However, one has to keep in mind that the increase in life quality could have originated also from the extra attention which the seniors received during the pilots.

Impact of the INCARE solution on technology acceptance

Given the high level of education of the senior participants (all of them had higher education), the digital literacy was somewhat high, with a lot of the users using often either a smartphone or a laptop. The attitude towards technology and technological advancement was neutral to positive in the majority of cases. Despite this, there is a clear difference between what people believe and what they do when they are actually face-to-face with a certain situation, so the participants sometimes adopted the typical view of the elderly generation towards technology. Our initial assumption in INCARE was that the constant interaction with technology, due to the permanent use of the INCARE platform, will be able to change these stereotypical attitudes and encourage seniors to utilize technology in their daily lives.

As can be seen in Figure 34, the elderly users were more likely to agree to the statement 'Using technology would enhance my effectiveness in daily activities' after the end of the study. The daily contact with the INCARE solution changed a part of the seniors' attitudes towards technology, increasing the percentage of agreement with the aforementioned statement from 74% to 86%.

What is very interesting to observe is the disappearance of the neutral attitude. If part of the seniors did not know if technology can help them be more effective before the study, the constant interaction with it made them realize exactly what it can or cannot do for their lives.
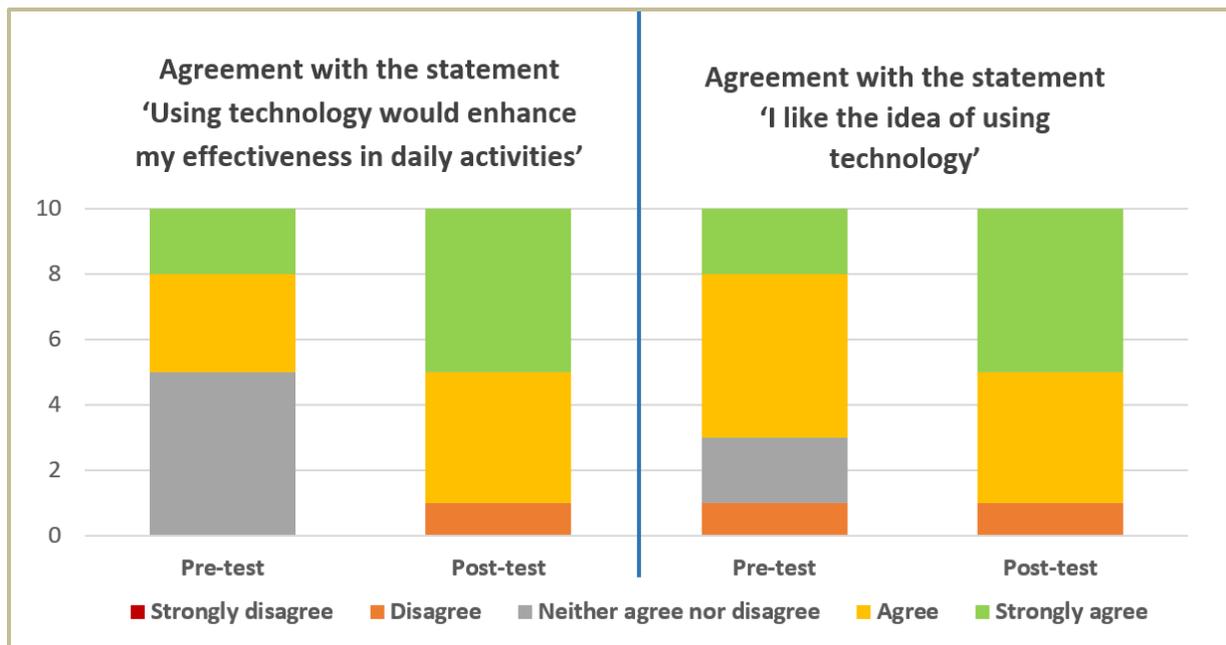
Figure 34 – Level of agreement of seniors with the statements 'Using technology would enhance my effectiveness in daily activities' and 'I like the idea of using technology'.

An increase in positive attitudes was also noticed with regard to the statement 'I like the idea of using technology'. The interaction with the INCARE app and its functionalities helped seniors get closer to technology and its tools, promoting acceptance of the idea of exploiting technology in order to gain the benefits it has to offer. The number of seniors strongly agreeing to the above-mentioned statement more than doubled at the ending of the study. The percentage of agreement to the statement increased from 76% to 86%.

From 'I like the idea of using technology' to 'I could be skilful at using technology' is not a big step, but it is a complex one, as it requires actual involvement. Pre-test, half of our senior participants either didn't know or disagreed with the second statement, the main reason being that they have rarely employed technology in order to achieve routine tasks. In contrast, the post-test answers revealed that 4 out of the 5 elderly participants mentioned earlier changed their attitude towards their own level of digital skills. Due to the constant use of the INCARE app, the elderly users realized that using technology is not very hard, and it can make their lives easier and happier. Thus, 4 out of these 5 users gave positive feedback about their own capacity of using technology in the post-test questionnaire, highlighting the fact that their self-confidence has increased. The average agreement with the statement has increased from 68% to 86%.
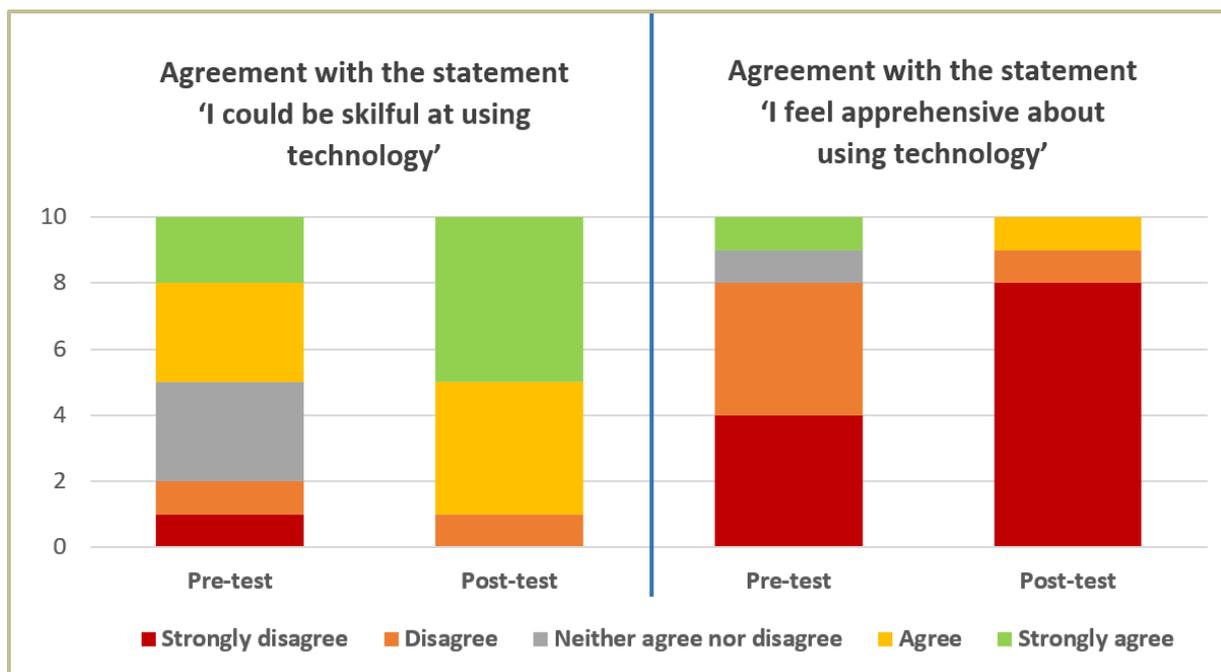
Figure 35 - Level of agreement of seniors with the statements 'I could be skilful at using technology' and 'I feel apprehensive about using technology'.

If the seniors were more confident in their digital skills at the end of the INCARE solution testing, their apprehension towards using technology should have also decreased. Therefore, the disagreement with the statement 'I feel apprehensive about using technology' both increased and became stronger. So, the average agreement decreased from 40% to 28%, showing us, again, an increase in the self-confidence of our senior users when it comes to employing technology.

Thus, the general increase of technology acceptance among seniors was of 15%, from 71% in pre-test to 86% in post-test. For the reasons we presented above we can say that the impact of the INCARE solution on technology acceptance among the senior participants was a relatively high one, the permanent interaction of the users with the platform determining an increase in their trust over their digital skills.

Impact of INCARE solution on health practices/routines

All seniors suffered from age-related illnesses. The most encountered conditions were diabetes and cardiovascular diseases, followed closely by hypertension. Other physical disorders mentioned by our participants were metabolic disorder, cancer, scoliosis, arthrosis, spinal deformity, cataract and reduced mobility because of a broken leg. Because of several health conditions, seniors had to constantly check if their health parameters are in their usual range. Unfortunately, this did not always happen before the pilots, as a part of the participants either considered that they don't need to regularly check their health measurements, or they considered the activity uncomfortable.

With the help of the INCARE solution, the seniors managed to increase their average frequency of health monitoring from 74% to 90%. What determined the users to increase frequency was: the quick and easy way in which the medical devices worked, the possibility of seeing their results on the tablet, the recording of health parameters feature and the possibility of sharing the results via de caregiver web interface. The history feature was a highly appreciated functionality of the platform, as the seniors can easily see how their health condition had been lately, and they can also share this health history with their doctors, making it easier for them to detect a possible deterioration in their health condition.

51
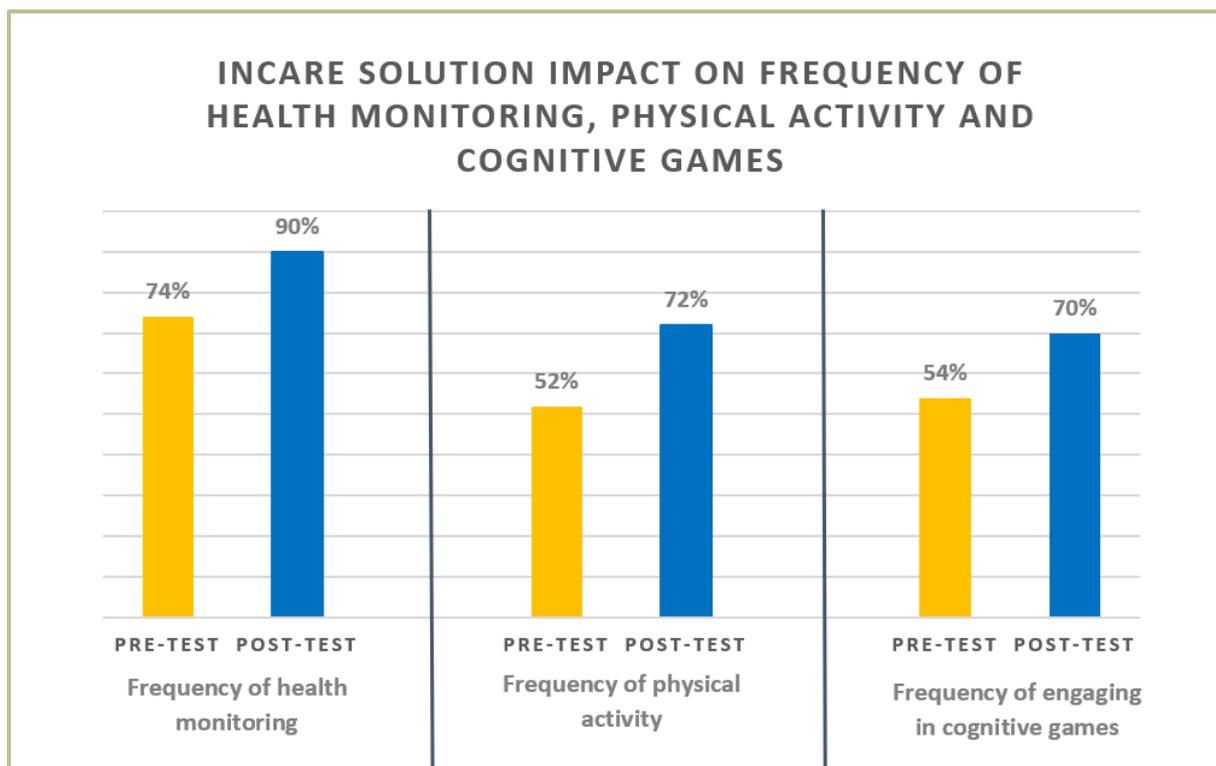
Figure 36 – Differences in frequency of health monitoring, physical activity and cognitive games among seniors (pre-test versus post-test)

An increase in frequency of physical activity was also observed among the seniors. Physical activity was considered an issue by a lot of the caregivers, who mentioned that their elderly relatives spend a lot of time in bed, refuse to make exercises at home or even to get out of the house to go for walks. If the average frequency of physical activity used to be at a low level of 52%, the score has increased quite a lot since the beginning of the project. At the end of the study, the average was at 72%, which means that the seniors were determined to try to take better care of their health condition and their mobility. At least 3 participants increased their frequency of physical activity from very low or low activity to high activity.

Unfortunately, despite the visible increase in interest towards exercise and mobility, the fourth KPI, which concerned the frequency of physical activity, was not met. As the KPI says, frequency of physical activity should be daily – either indoor (with the use of the INCARE platform) or outdoor (e.g.: walking) – by the end of the project. This did not happen, as we still had at least one participant who said their level of physical activity is very low. Furthermore, another 2 participants evaluated their level of physical activity at moderate or medium.

There has also been noticed a change in the frequency of engaging in cognitive games, pre-test versus post-test. Memory training and exercises meant to enhance cognitive capabilities are very important for the elderly, as some of them are at risk of developing cognitive impairments, such as dementia. Cognitive decline is an age-related condition which affects a lot of elderly people. By being challenged and entertained by the games available on the INCARE app, the seniors increased their frequency of engaging in cognitive games from 54% to 70%. Games were one of the most appreciated features of the platform, being perceived as useful for improving cognitive health and memory by all our elderly participants, be they passionate about playing them or not.

As we are talking about health routines and the way the INCARE platform helps seniors manage are respect them, we will also discuss about **the fifth KPI, the one that says that adherence to medication and medical appointments should be equal to or more than 90% due to the INCARE reminder module.** Regarding the medication, we already know that 90% of our senior participants answered with never or very rarely when they were asked if they forget to take their medicine, at pre-test. Thus, we can say that the KPI was met even before the project started. **Unfortunately, we cannot evaluate if this percentage had increased post-test, as the Calendar feature, the one responsible for reminding the elderly users to take their medicine or go to their doctor appointments, had some issues during the testing and was rated negatively by the participants.** Several participants chose not to or were not able to use this function of the INCARE app, because of the lack of audible alarms linked to the reminders. Some elderly couples, who used the same tablet for the platform, found it very troublesome to log in and out in order to check their reminders.

The sixth KPI stated that the number of non-appropriate emergency calls should not be higher than 1% (falls, home alerts, health alerts) of the total emergency calls made. This KPI could not be properly evaluated, as senior participants did not have any emergencies during the development of the study, so no emergency calls were made.

Reduction of burden of the caregiver and other caregiver benefits

The caregivers of elderly people are usually persons with their own lives, jobs and family responsibilities to fulfill. The care they give can consume their time and their resources fast if they are not able to balance the caregiver life with the rest of their duties. Sometimes this is not possible, as a part of the elderly people who require assistance need it on a regular basis, so this is way we aimed to make the lives of caregivers easier through the implementation of the INCARE solution.

In order to evaluate if the burden of the caregivers was reduced by the adoption of the INCARE platform, we analyzed the differences between the answers of the caregivers in the pre-test questionnaires and the answers from the post-test ones. The majority of the answers were exactly the same. There seemed to be improvement when it came to the reduction of burden of the caregiver. But that is not entirely true, as we had 2 questions which received a more negative score in the post-test than it did in the pre-test. In both the statements 'My life satisfaction is suffering because of the care I give' and 'I am worried about my future because of the care I give', the agreement rate increased in the post-test. In each of the statements, one participant changed gave more negative feedback regarding the burden they face on a regular basis.
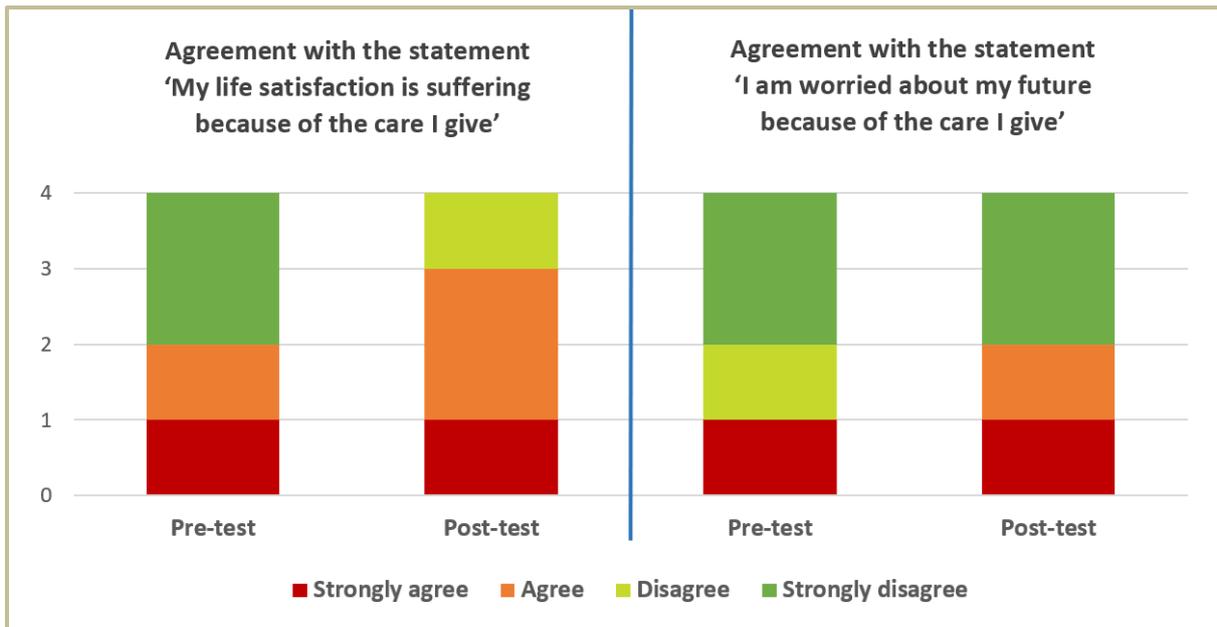
Figure 37 – Level of agreement of caregivers with the statements 'My life satisfaction is suffering because of the care I give' and 'I am worried about my future because of the care I give'.

This can be either a slight worsening of the burden bore by the caregivers, or a simple situational occurrence like the one presented above with increased number of calls from the senior. **What we can say, however, is that, according to the level of agreement toward these statements, the burden of the caregivers does not seem to have diminished. Thus, the second KPI, which stated that there should be a reduction of the burden of the caregiver due to the implementation of the INCARE solution, was not met.**

Benefits of the INCARE solution for the caregivers

Still, a lot of the comments given by the caregivers during the post-test highlight the benefits the INCARE solution has brought to their lives. This can be seen from Figure 38.
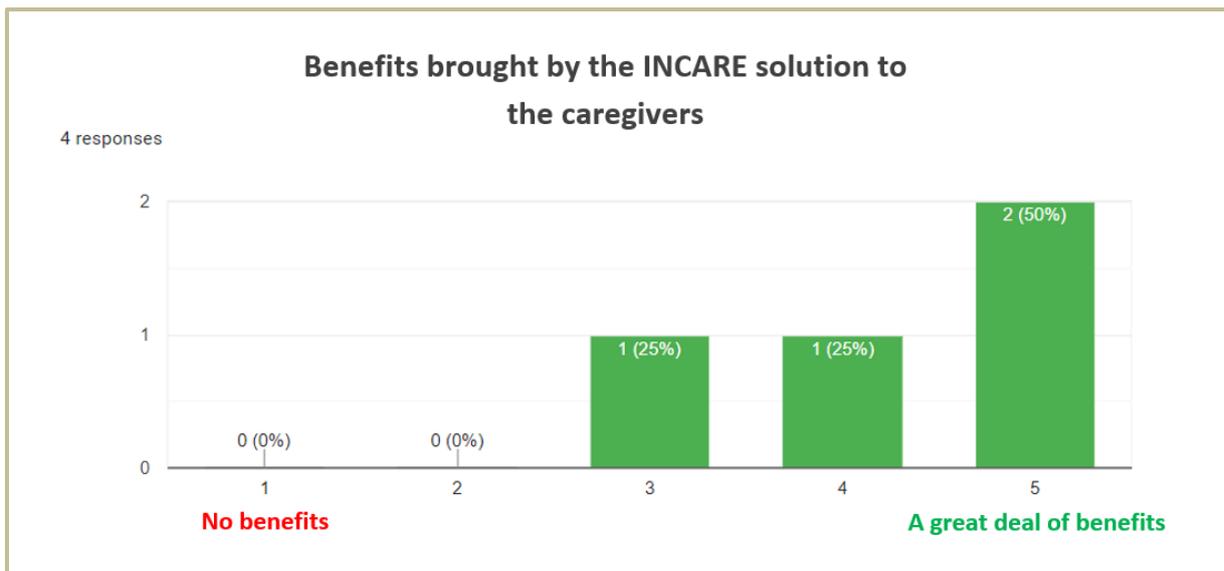
Figure 38 – Number of benefits brought by the INCARE solution to the caregivers.

The caregivers considered that the benefits brought by the INCARE solution are worth implementing the platform in the home of their elderly relative. 3 out of 4 caregivers gave positive and very positive answers, while the one left gave rather neutral feedback. Regarding what kind of benefits the platform brings, caregivers pointed out several:

'It saved time and reduced my stress level. When my father-in-law was calling to say that he was not feeling well, I was able to ask him to measure his blood pressure as usual. However, INCARE allowed me to not only look at the current values but, also, what happened in previous days. In this way, I was able to realize if it is a one-time increase or if it has been abnormal for a while. In the latter case, I was scheduling a visit to the doctor'

Caregiver of senior participant

As we can see from this answer, the caregiver highlighted the decrease of concern and anxiety regarding the possible degrading of health condition of the elderly relative they take care of. They mentioned time saving, a benefit which derives from the lack of necessity to go to the elderly relative's house and check the symptoms themselves. Furthermore, the available history of the health measurements determined if the problem is singular or recurring, so the caregiver can decide if it is the case to make an appointment to the general practitioner. Some other advantages for caregivers were also mentioned by the other participants and they are shown in the next chart with the number of participants who considered them true.
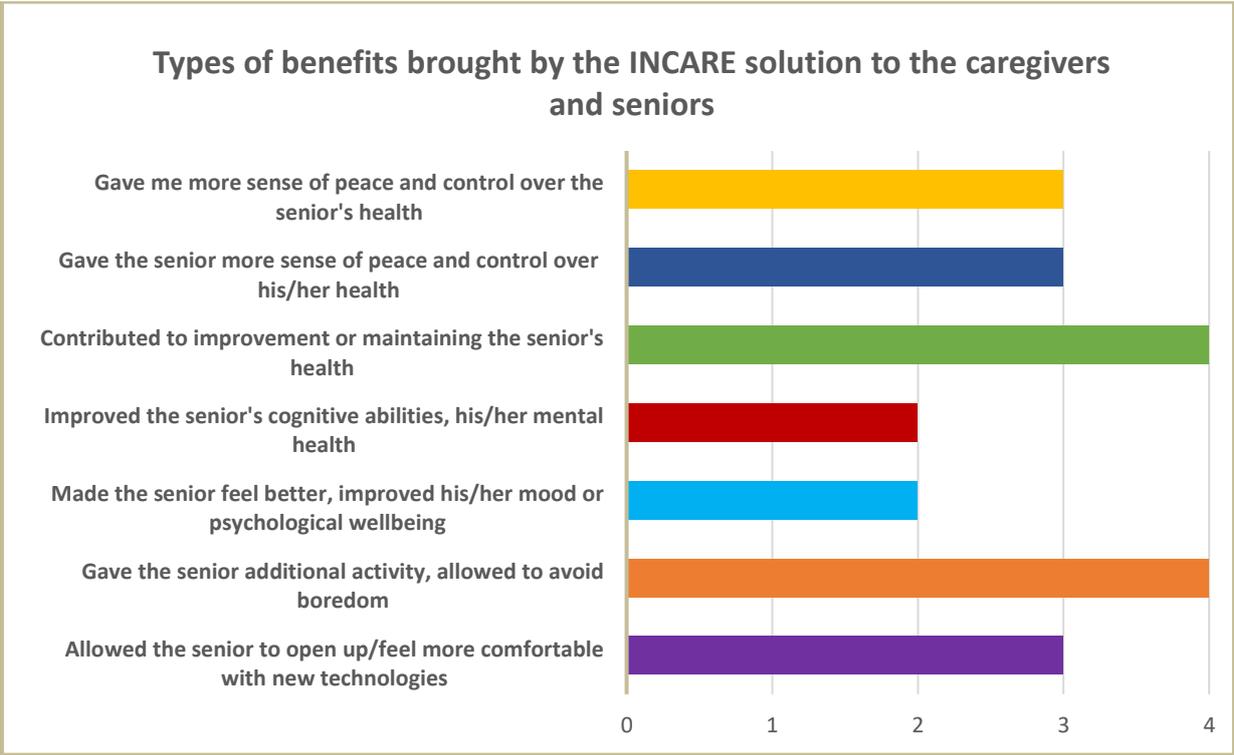
Figure 39 – Types of benefits brought by the INCARE solution to the caregivers and seniors.

As we can see here, the benefits of the INCARE platform have to do with the physical health of seniors, something we already knew, but also with their mental health. The possibility of being in control of your own body and symptoms brought peace of mind to the seniors, who became more relaxed and confident. The games contributed to the entertaining of the elderly participants, who spent quality time improving

their cognitive capabilities and memory, while also having fun and keeping themselves busy and happy. Games allowed the seniors to avoid boredom and improved their psychological wellbeing. The last advantage we are going to extract from this chart is the one which refers to the increased level of comfort of the seniors towards technology. It is very easy to start getting along with technological solutions if you have constant contact with them, and this is the case here. We were also shown this while analyzing the answers from the elderly users' questionnaires regarding technology acceptance. The answers demonstrated that the technology acceptance has increased among seniors, a statement which even the caregivers supported.

Besides the advantages mentioned in this chart and the ones mentioned in the quote we analyzed above, we can also say that the INCARE platform is very useful for chronic illness control and supervision, such as diabetes, cardiovascular diseases and hypertension. Moreover, the solution can make it easier for caregivers to know if the senior has had physical activity (e.g.: walking) or if they took their medicine (by checking the health parameters and comparing them to the normal ones).

Evaluation of the robotic platform by seniors

Seniors were mostly reluctant when it came to the acceptance of robots in their house and their life. The majority found the functionalities of the robots interesting but the idea of a robot in their proximity was mostly frightening. A part of them motivated their hesitation by saying that they have a small apartment and the level of comfort will dramatically drop if they would also have a robot in there. They were also worried about the level of expertise required when owning a robot. The caregivers had a more open attitude which is again to be expected since they were younger and more accustomed to technology.
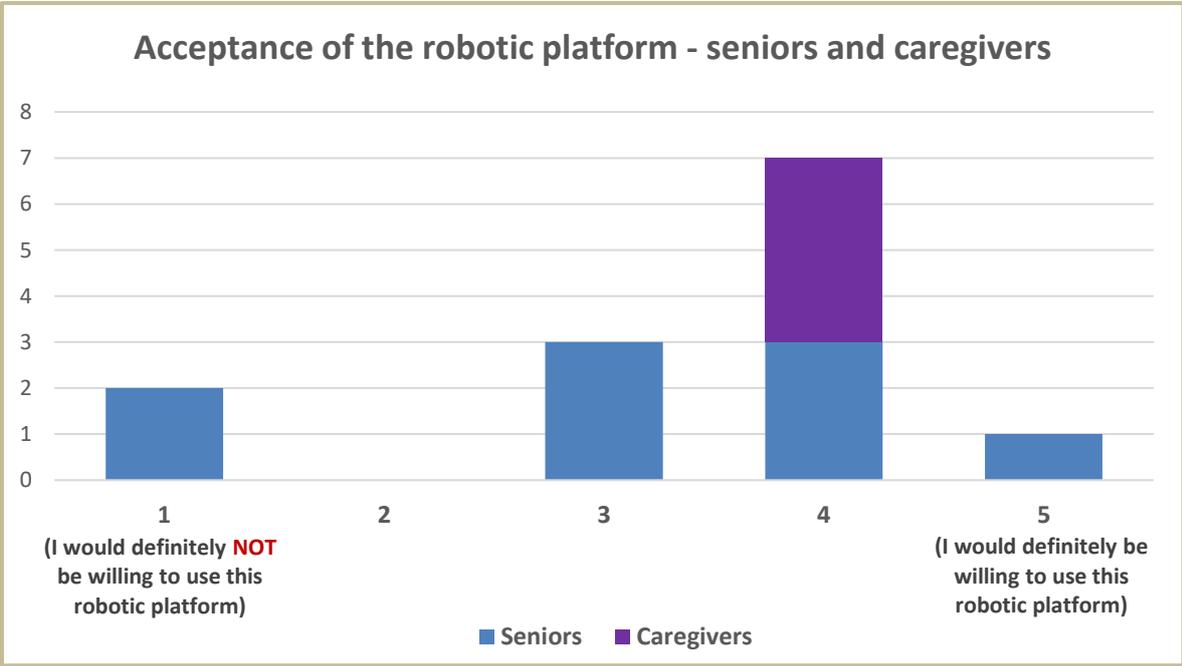
Figure 40 – Level of acceptance of the robotic platform, caregivers and seniors.

We asked all our participants if they would be willing to use the INCARE robotic platform in order to make their or their elderly relatives' lives easier. The answers were on a scale of 1 to 5, where 1 meant 'I would definitely not be willing to use this robotic platform' and 5 meant 'I would definitely be willing to use this robotic platform'. As we can see in the chart above, 7 out of the 9 elderly participants and the 4 caregivers gave ratings equal to or higher than 3. **The third KPI expects that the acceptance rate of**

the robotic platform will be at about 70% - 75% among our participants. Acceptance score of f 3, 4 and 5 were taken into account which led to an **acceptance rate of approximately 85%**

The improvement in acceptance rate was evaluated based on the new movies prepared following the pilot midterm feedback in D1.3a. These were created to show Tiago in a real home environment as opposed to the office environment as can be seen when comparing Figure 41 and 42.

Figure 41 – Tiago reacting to a human fall in a work office (first batch video).

The atmosphere in Figure 41 is cold, unhomely, making it hard to see how such a device could look and act in a living environment. Tiago seems fitting to this place, but not to someone's home.

Figure 42 – Tiago reacting to a human fall in a home (second batch video).

As we can see, the difference in atmosphere is very different, the second video helping us better imagine how Tiago could be of support in a home environment. The robot seems less frightening and more friendly, giving the impression of occupying less space.

A second movie showed Tiago offering support to a person which Tiago accompanies and carries a cup of tea such that the user, walking with crutches, can pay attention where he is walking and not pay attention to the not spilling the tea.
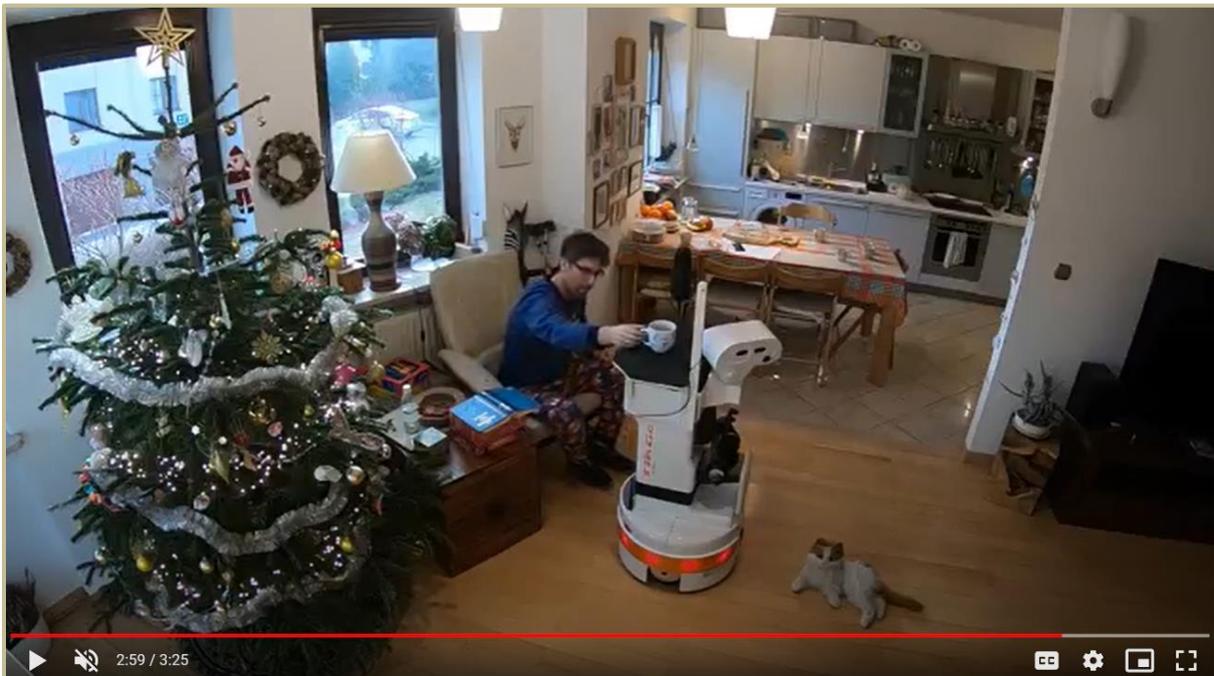
Figure 43 – Tiago helping a person in crutches bring their tea from the kitchen (second batch video).

Evaluation of the robotic platform by formal caregivers

In addition, 8 formal caregivers have also evaluated the robotic platforms based on the prepared movies and have provided their feedback via the relevant questions selected from the overall questionnaire. The users were asked to rate on a Likert scale of 1-5 or 1-10:

- the usefulness of a robotic platform (simple for carrying things and detecting hazards, social and service platforms) in their institution;
- probability of recommending the platform to other institutions;
- select the platform they would be interested to purchase.

Regarding the usefulness of the platform, the participants were asked to elaborate on their motivation and on the barriers which they perceive. Their answers comprise observations such as:

- I love Pepper, it can entertain patients
- Lack of trust
- Tiago could help with many things like the ones shown in the movies
- I can see a potential but it also looks hazardous to be left unattended
- I think that there is a lot of potential in the future
- I believe that this is the future although I am a bit afraid to losing my job if robots are introduced in care facilities
- Pepper can keep patients entertained and the other two could help bed ridden patients by delivering small items

Regarding the acceptance or acquisition barriers, the participants mentioned: purchasing costs and maintenance; required expertise; complicated to use and bulky for Tiago; a long and powerful arm; lack of trust. Nevertheless, the participants were considering recommending a robotic platform to other institutions at least as a future acquisition.
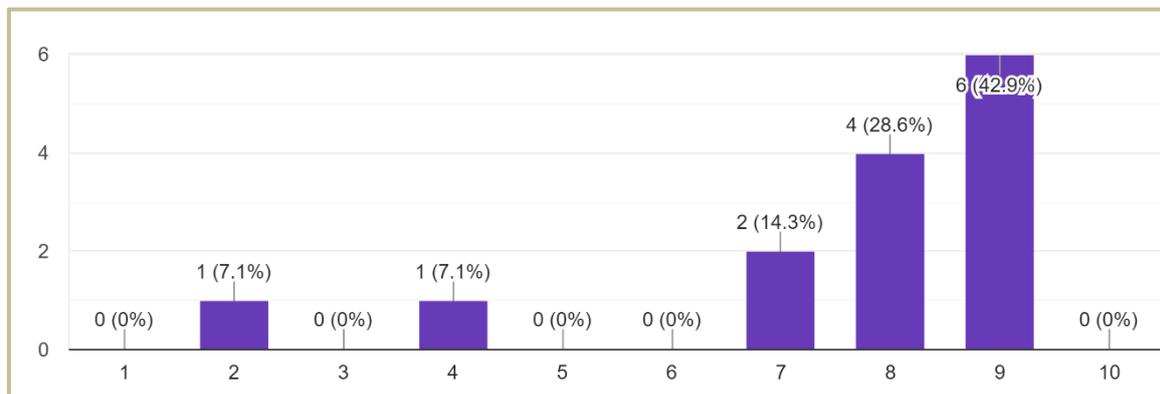
Figure 44 – Interest of recommending in the future a robotic platform to other peers (1 - not at all, 10 - very interested).

The functionalities which were most appreciated based on the presented movies were: interaction and companionship; entertain patients; transport objects; identify hazards; accompanying elderly; patient supervision and fall detection. The willingness to pay was strongly in favor of the basic Turtlebot platform which is also the most affordable. This is further presented in D3.1c.

3.2.3 Recommendations for optimization the INCARE solution

We mentioned several problems regarding the interface and the app functioning in some of the last chapters, so here we are going to also add the solutions we and the participants found for these issues.

- More communication means with other users (for caregivers), so they can easily get in touch with them if there is any problem. The calendar was not considered a good idea in terms of interaction, this is why some of the participants asked if a video meeting feature or a call feature could be developed within the app. If not, something similar to WhatsApp was requested.

- A larger variety of games, which should include Sudoku, and more levels and difficulty settings for the available ones. Also, time and speed settings, as some of the seniors are slow and they are not able to properly enjoy the games.

- The addition of warning messages for the senior and, also, for the caregiver, if the usual health measurements are outside the normal parameters.

- The addition of notifications about the health measurements, the number of steps etc. and the possibility of configuring these notifications (for caregivers).

- Making the app available to also be used on the seniors' personal smartphones.

- A fix for the inability to have 2 accounts active at the same time on one tablet, as one of the users has to log out in order to let their spouse use the health monitoring platform. We recommend adding the possibility of managing 2 accounts on the same app, by switching them faster and being able to see notifications from both of them regardless which one is active at the moment.

- The improvement of the design and functionality of the calendar feature: the addition of sound signals for reminders, the possibility of seeing personal reminders without having to log out your spouse and log in into your account (for the senior couples who used the same tablet).

- The fixing of bugs or stability issues of the app and/or of the platform.

- Larger print on the health history axis, as the dots and their markings are hard to read and comprehend and the majority of the elderly have eye problems and cannot see very good even with glasses. Also, larger writing on the main screen of the app, as it is hard to read for the elderly users.

- Something larger instead of the NFC tag or a clear and visible delineation of the place, on the back of the tablet, where the NFC tag should be placed.

- A more detailed manual for the use of the app, as some features are hard to discover and comprehend by the seniors. If the seniors don't understand how the app works, they become frustrated and are less likely to use it.

- A button for printing the health history, as some of our participants considered that they are very unlikely to take the tablet with them to the doctor.

- (Optional) The introduction of a cheaper and space-friendlier robot companion.

3.3 Slovenia

3.3.1 Sample description – Individual testing

There were 7 participants in the Slovenian study, 5 of them being elderly users living in their own home, while 2 of them were informal caregivers living separately from the elderly relatives they had in their care. All of the users met the recruitment criteria mentioned in the project: old age (65+) and physical issues relevant to the project, for seniors, and the necessity of having a senior in care, for the informal caregivers.

Seniors

- **Demographics**

The seniors were all over 65 years old, as agreed in the end-user recruitment criteria. The youngest senior was 66 and the older was 81. There were 3 men and 2 women, giving a balanced gender division. Their education level was either secondary or tertiary, as it can be seen in the following chart.
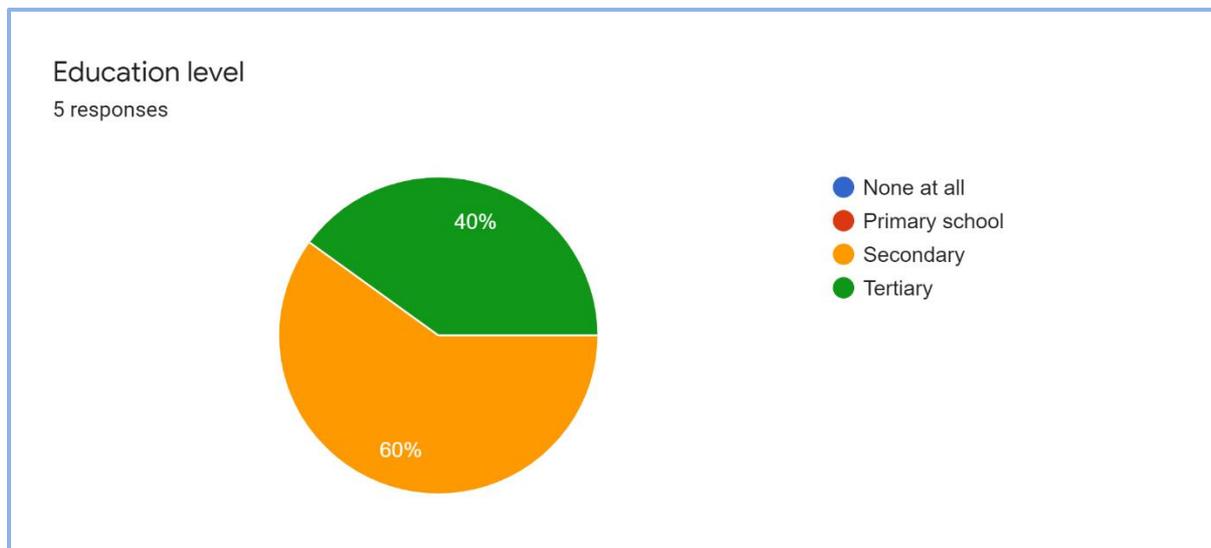
Figure 44 - Senior's level of education.

The 2 elderly participants who had tertiary education were either in the health and social care field or in the technology, industry and construction field.

3 out of the 5 elderly users lived in a rural area represented by a village, while the rest lived in a medium sized city having from 100 000 to 500 000 inhabitants.

- **Digital skills**

All of the senior participants had a level of experience with technology and used either a basic phone, a smartphone or a personal computer. They used these devices for browsing the Internet, online shopping, reading the news, reading and writing messages via email or WhatsApp or making and viewing digital photos.

Despite this, the seniors did not believe technology could be useful for them when it came to fulfilling daily activities and routines.
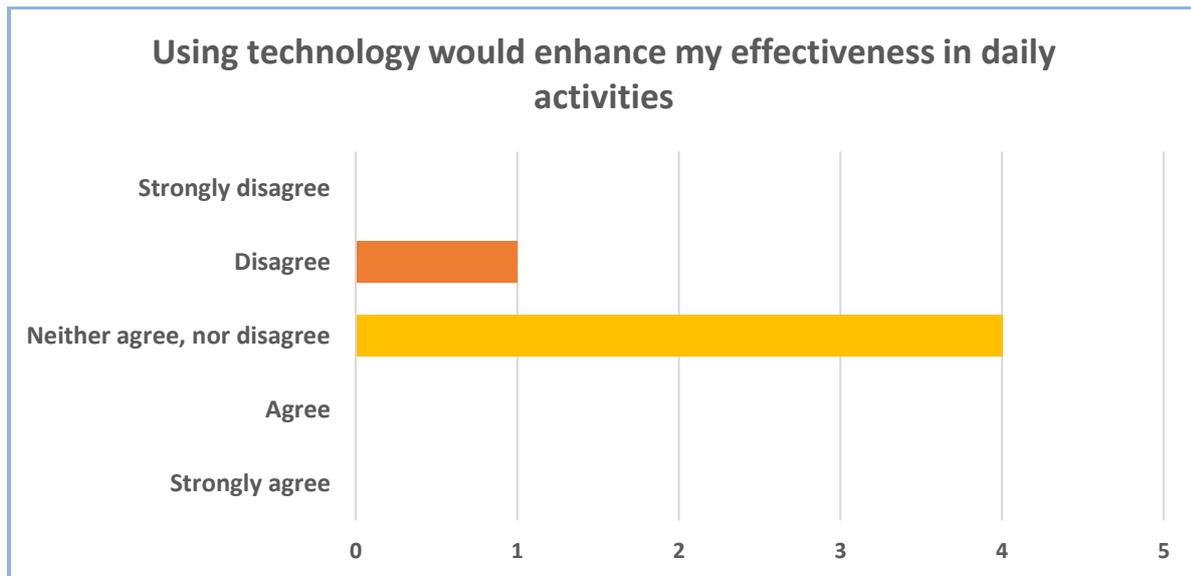
Figure 45 – Technology acceptance by seniors.

As we can see, the seniors were mostly neutral when it came to the advantages technology could bring to their everyday lives. This phenomenon can be seen regarding all the questions we asked concerning technology, the elderly users believing that this modern discovery cannot have a positive impact on their lives. Regarding the usefulness of technology, the seniors gave also neutral or negative feedback. The majority of the seniors felt apprehensive about using technology and hesitated to use it for fear of making mistakes they cannot correct. Despite this, 3 out of 5 elderly users believe that they could complete a task using technology if there was someone to explain to them how to do it.

- **Health condition**

All of the elderly participants had one or more physical diseases. The most common ones were cardiovascular disease and high blood pressure, both of them having the ability of causing, given certain contributing factors, a stroke. One of the users had a stroke in the past, and its outcomes still affected their lives. Another disease mentioned was cancer.

The seniors had age-related disabilities, such as difficulty walking or slowness. In order to function on an everyday basis, the majority of the seniors said they need to follow a certain long-term medical treatment, which always consisted of medicine. The medicine mentioned was used to treat the illnesses specified earlier. With regards to taking the medicine, most of the respondents said that they sometimes or rarely forget to take it.

In spite of the various illnesses the seniors suffered from, only 2 out of the 5 respondents said that they regularly monitor their health by taking their health parameters.
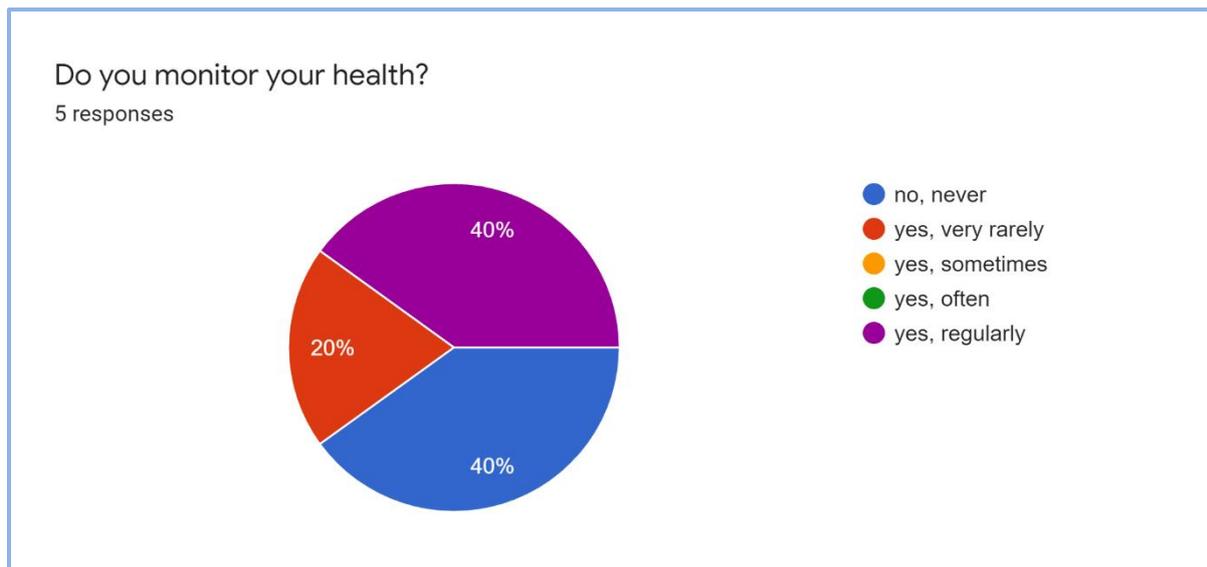
Figure 46 - Seniors' frequency of health monitoring.

The rest of them said that they either rarely do so or they never monitor their health. The medical devices used for this activity were the blood pressure meter and the weighting scale. None of the participants need support in order to take their measurements.

The frequency of physical activity, which is known to help in leading a healthy and happy life, is generally low among the elderly participants. Out of the 5 users, 1 said that they almost never do physical exercises or other type of physical activity, while the other 4 rated their physical movement as medium to low. The routines related to physical activity include walking outside or to the market, household chores and visiting friends.

Regarding the frequency of health exercises, seniors were rather neutral, the majority of them sometimes doing mental exercises. Activities perceived by the elderly users as being brain exercises: crossword puzzles or normal puzzles, reading, watching tv documentaries, Sudoku, board games and games on the smart phone.

- **Independence**

The majority of the elderly participants are autonomous, being able to leave their house on their own and take care of their needs independently. Majority means 4 out of the 5 participants, as one of them uses a wheelchair and needs constant help with moving, shopping, household chores and preparing meals.
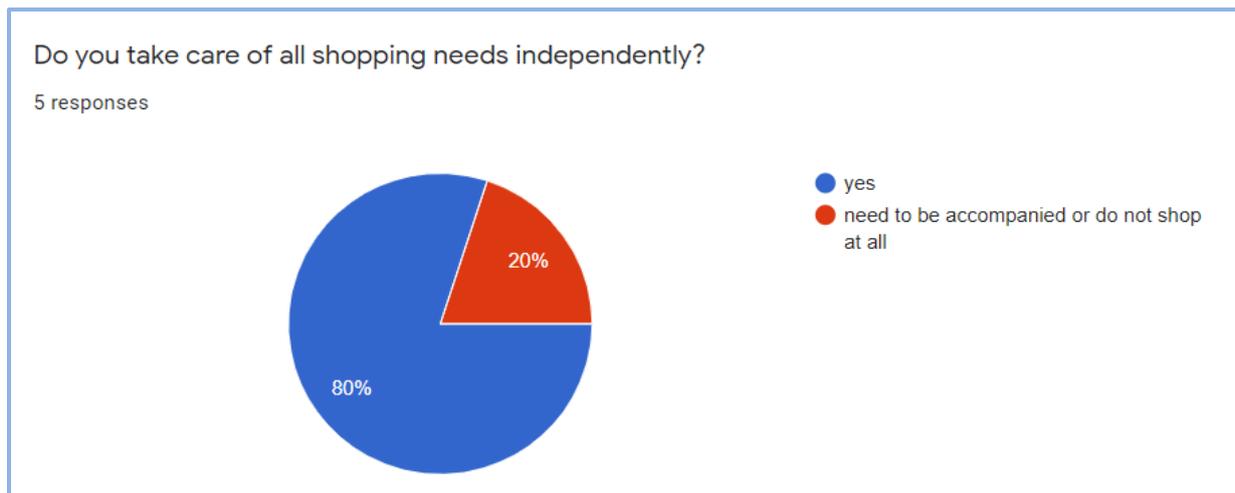
Figure 47 - Seniors' independence in taking care of shopping needs.

As we can see, there is only one person who requires help in taking care of their shopping needs, the rest of the participants being able to do this on their own. Same goes for taking medication in correct dosages at the correct time. Also, there is only one participant who requires medication prepared in advance in separate dosages by someone else. Despite this, it can happen that the users forget to take their medicine at the right time.

Informal caregivers

The 2 informal caregivers participating in our study live separately from their elderly relatives who need care. One of the informal caregivers takes care of 2 elderly relatives. The activities where the seniors need help are care in general, medication overview, taking to the doctor, shopping, some difficult tasks in the house and in the garden, help with technology and eHealth.

The average number of hours per week dedicated to taking care of the seniors are between 4 and 8, but both the informal caregivers believe this amount of time is rather not sufficient for the needs of the elderly. The areas where the seniors would need more help are general monitoring, healthy eating, communicating with the doctor when in need, using eHealth, eGov and similar IKT services. One of the caregivers believe that they do not receive enough support from the medical personnel.

When asked about the impact of caring on their lives, the caregivers mentioned that they usually feel physically exhausted and that they feel torn between the demands of their environment, such as family and work, and the demands of the care they give.

Robotic platform evaluation

All the 7 participants took part in the robotic platform evaluation by watching the robotic movies available in the INCARE app. They did this at our request and, after this, they completed the questionnaire. They watched movies with Tiago, the service robot, and Pepper, the companion robot. The opinions were divided regarding these 2 robots.

3.3.2 Main results

In the next section we are presenting the main results of the Slovenian pilots, while also highlighting the key performance indicators (KPI).

User satisfaction – KPI

The INCARE solution was mostly appreciated by the elderly participants, as it gave them a better control over their own bodies and illnesses. This is why the average score given by the seniors with regard to their satisfaction of INCARE was high, meeting the first KPI we proposed in the project description. **The first KPI we targeted concerned the user satisfaction with a threshold of 7 out of 10 (70%) by the end of the pilots.** This means that the users should give a satisfaction rating over 7, in order to meet this target. Satisfaction was measured with 2 types of questions. **Another target assumed in this KPI was no more than 15 – 25 % dropouts after half a year.**
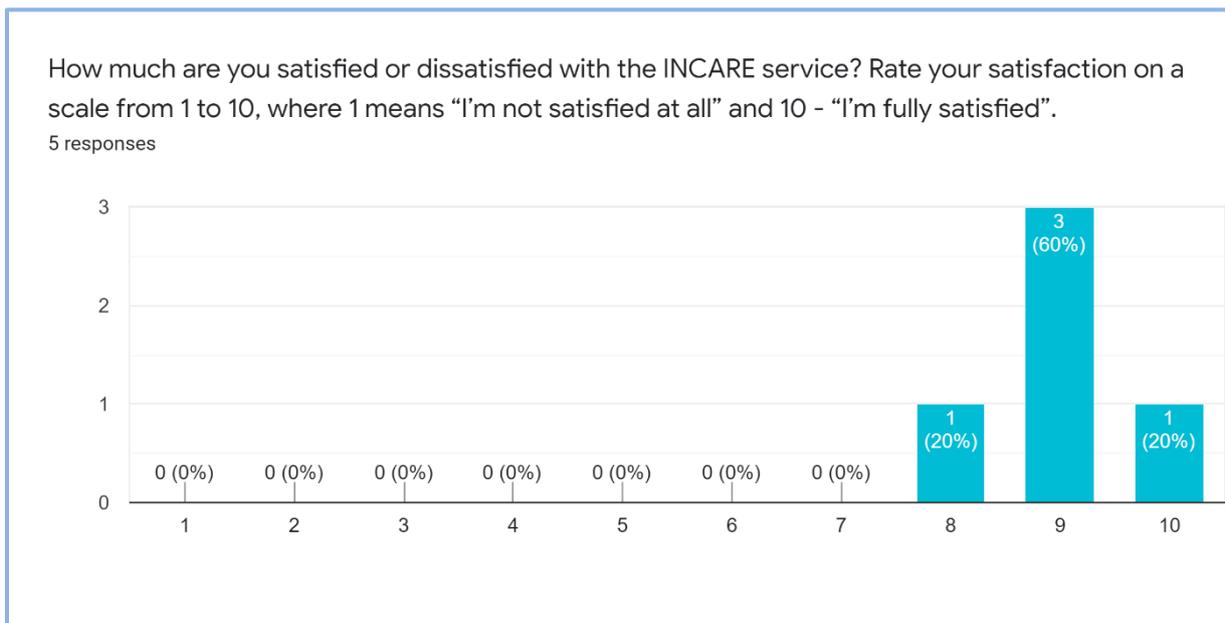
Figure 48 - Seniors' satisfaction with the INCARE solution.

As we can see in the chart above, the senior users gave scores equal or higher then 8, the average rating being of 9. Seniors were satisfied with the INCARE platform as it had a very good design, it was very useful and it offered a great deal of support in their daily routines. **Also, no senior participant has dropped from the trials, all of them giving feedback during all the stages of the pilots.**

The caregivers were satisfied with the INCARE solution, believing that the health monitoring platform is a great way of keeping an eye on the health condition of their elderly relatives.

Figure 49 - Caregivers' satisfaction with the INCARE solution.

As we can see in the chart above, the 2 informal caregivers who participated in our pilots gave a satisfaction rating of 9, the average score being 9. When they were asked why they gave these ratings, one of the participants said that it took some time to integrate the INCARE solution into the daily routine, but, once they did it, it was very good and useful. The other one said that the platform was a good combination of support functionalities and it worked very well. **The dropout rate among the caregivers was 0.**

The other question regarding the user satisfaction concerned the likeliness of participants to recommend the INCARE solution to a friend. The seniors gave scores of 9 and 10 (they would definitely recommend the solution to a friend), most of them being of 10. The caregivers gave ratings of 10, saying that they would definitely want their caregiving friends to have access to the features of the INCARE solution.

User satisfaction: usefulness of specific features

Evaluation of the health monitoring app – perspective of individual seniors

The health monitoring platform was the most appreciated feature of the INCARE solution, as it gave the seniors the ability to know early if their health condition is going to worsen. By constantly checking their health parameters and comparing them with the health history, both seniors and caregivers were able to detect dangerous modifications and take preventive measures such as medicine or an appointment to their family doctor.
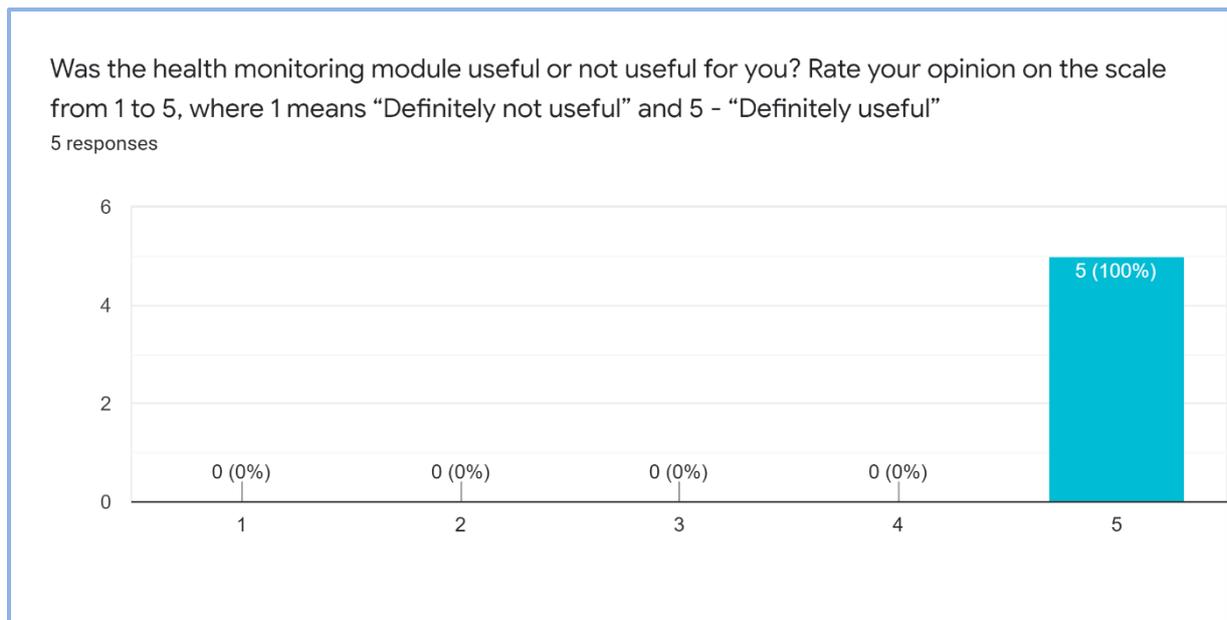
Figure 50 - Usefulness of the health monitoring platform for seniors.

As we can see in this figure, the seniors considered the health monitoring platform extremely useful. Some of the reasons behind this are the fact that the platform is very simple and it makes it very easy to follow the data, the data transfers automatically without assistance from the user, and the daily measurements are a great way of keeping their health in check. Thus, the average score given by the seniors was 10.

Furthermore, the seniors considered the health monitoring very user-friendly and the devices used very reliable. Also, the whole process is seen as fast and very easy to do. The only suggestion of something that needs improvement was that some of the devices could give more loud alarms or more visual ones. We can conclude that it is hard to notice when the medical devices are done taking the measurements and transferring the data to the app.

Evaluation of the caregiver web interface – perspective of informal caregivers

The caregiver web interface allows the caregivers to have permanent access to the health monitoring platform and the health history of their elderly relatives. This can be done using any device with Internet connection, with the help of a browser. This functionality and its ease of use were greatly appreciated by the caregivers, as we can see in the following chart.
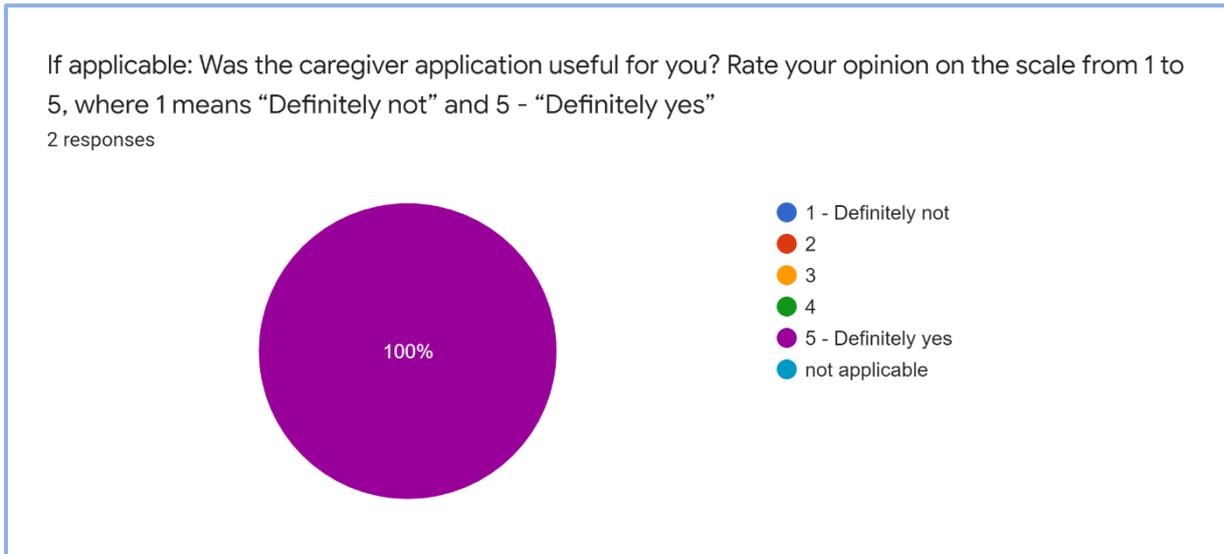
Figure 51 - Usefulness of the caregiver web interface for the caregivers.

The caregivers gave maximum ratings regarding the usefulness of the caregiver web interface. The reasons behind this are an increased sense of control of the caregiver, regularity of health measurements and a relatively good structure of the results, which made it easy for caregivers to read and understand them. Regarding user-friendliness, the caregiver web interface was considered well-structured and useful.

The caregivers did not believe there is anything the developers should change about the web interface design or functionality in order to make it more user-friendly or comfortable to use. Both the caregivers said that they already gave suggestions during the development process of the interface and it had been modified in a way that fits their needs very well.

Evaluation of games

Games were mostly popular among seniors, who considered that playing them was a great way of spending their free time and not getting bored. The caregivers also liked the games, as their elderly relatives were entertained in their free time.
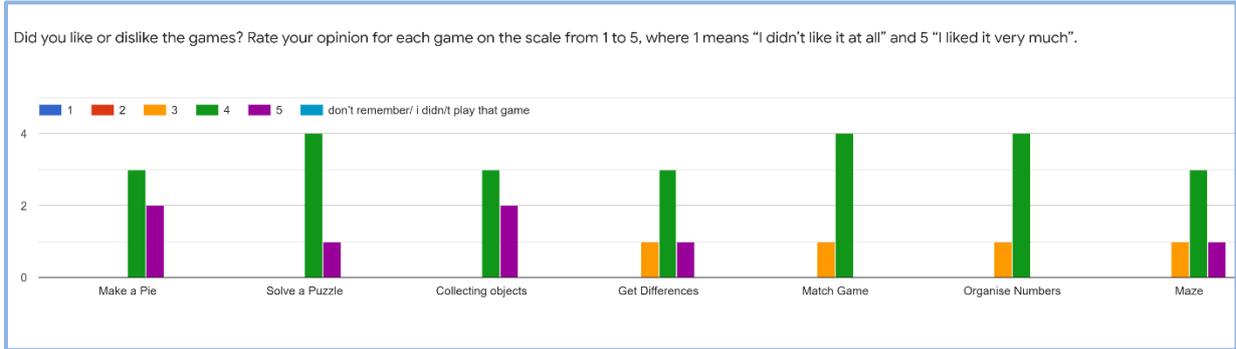
Figure 52 - Seniors' opinion on games.

The chart above shows the ratings offered to each game. Some comments about games were:

- 'I liked the graphics and the pace of the games. Also, I learned some new skills in managing the tablet'
- 'They are all very nice and a good variety of games'
- 'I like the games, but it is a bit difficult to play due to my disabilities'

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- 'I don't play games so much. I have other hobbies. But they are nice to play'

Regarding the general usefulness of games for improving cognitive health and memory, participants gave rather high scores.
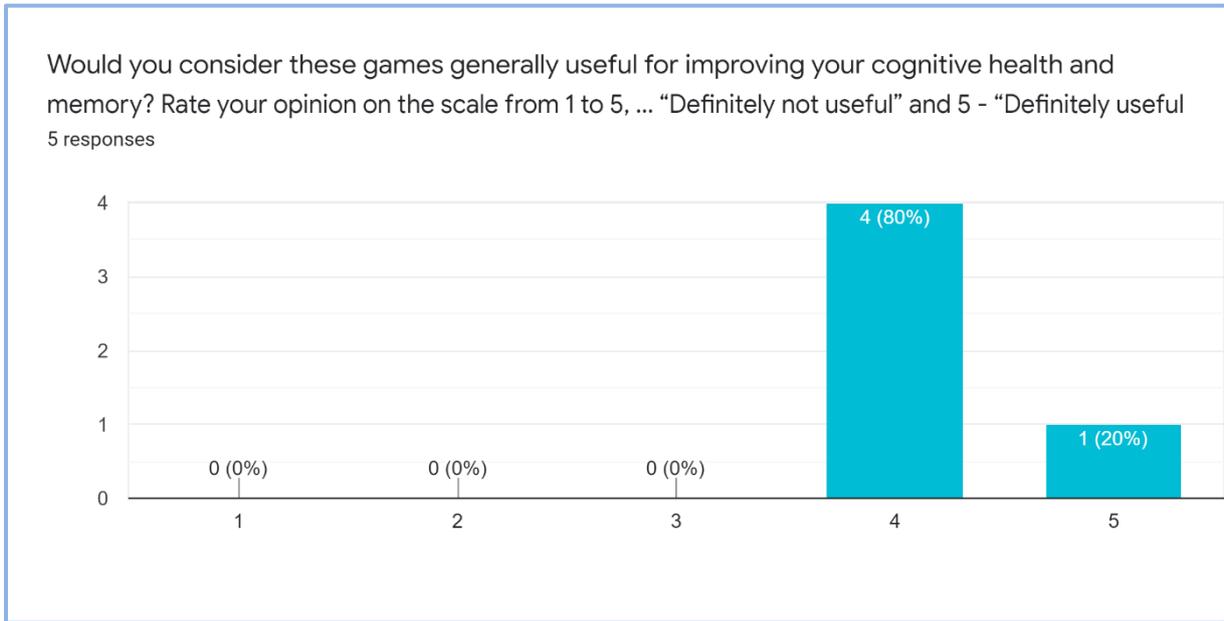
Figure 53 - Seniors' opinion on games and their usefulness in improving cognitive health.

As we can see in the figure above, the seniors considered that the games, if played on a constant basis, can improve or maintain their memory and cognitive functions.

Evaluation of calendar

The calendar feature was mostly appreciated by the seniors, who gave a high rating when it came to its functionalities. As we can see in the chart above, the seniors gave ratings of 4 and 5 out of 5, the average rating being 4.4.
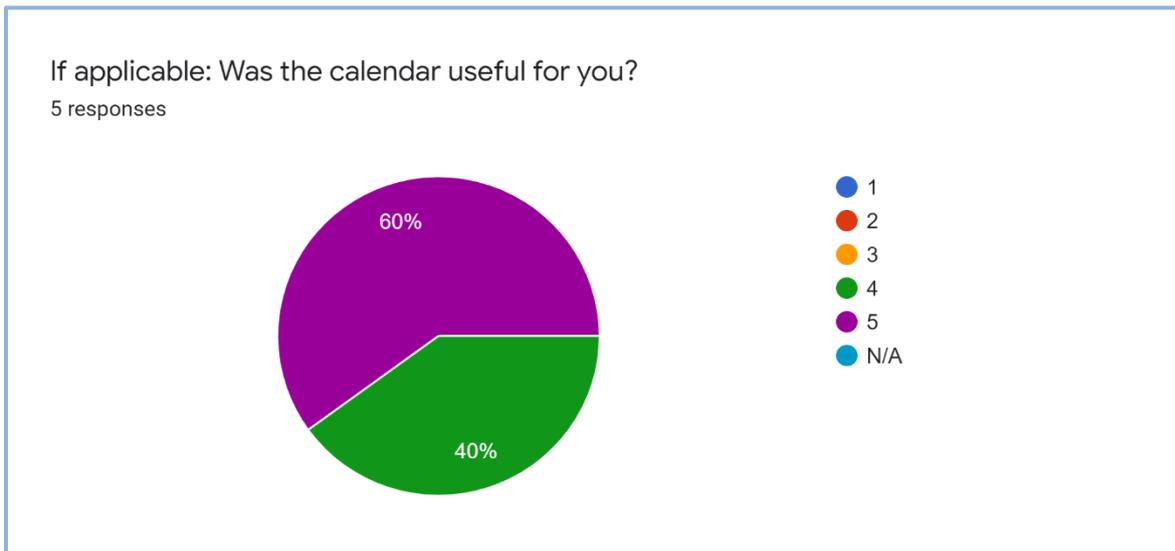
Figure 54 - Usefulness of calendar for seniors.

The seniors considered the calendar useful for organizing and remembering tasks and doctor appointments. The feature guarantees the elderly participants that they will not miss important tasks,

which is very important among people who tend to forget easily. Its user-friendliness was rated as high, the seniors believing that it is easy enough to use once you get used to it. There were no suggestions regarding the improvement of the calendar functionality, as the elderly users considered it was already very simple to use.

Impact of the INCARE solution on quality of life

The quality of life was one of the indicators the INCARE solution was designed to improve. Thus, we asked the seniors about their perceived quality of life pre-test and post-test, in order to be able to detect any changes. The pre-test results are available here:
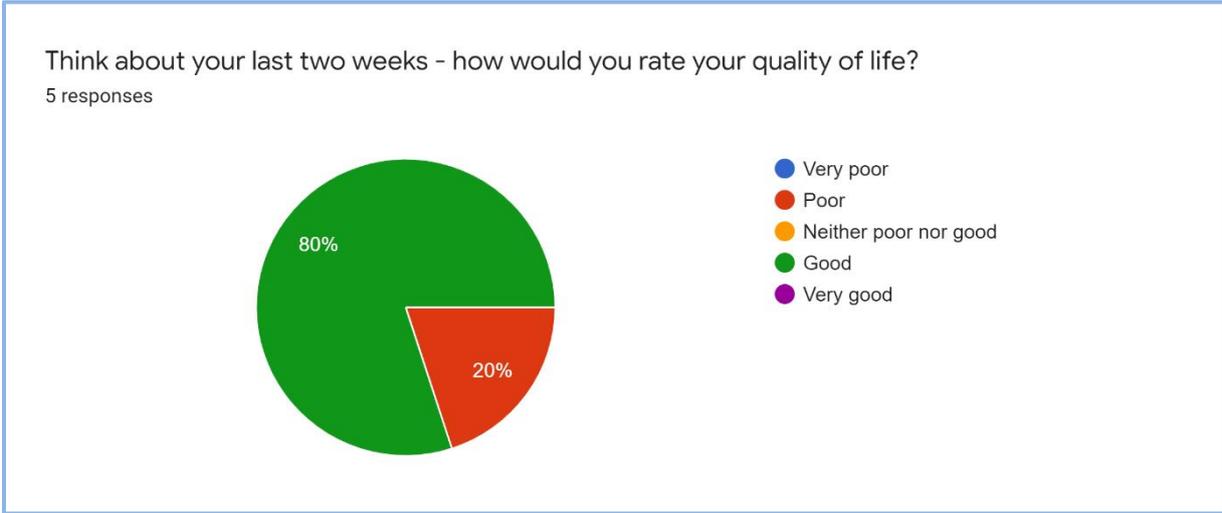
Figure 55 - Self-perceived quality of life of seniors (pre-test).

As we can see in this chart, the quality of life was rather high, with only one participant believing that there is room for improvements. The general score was 72%.
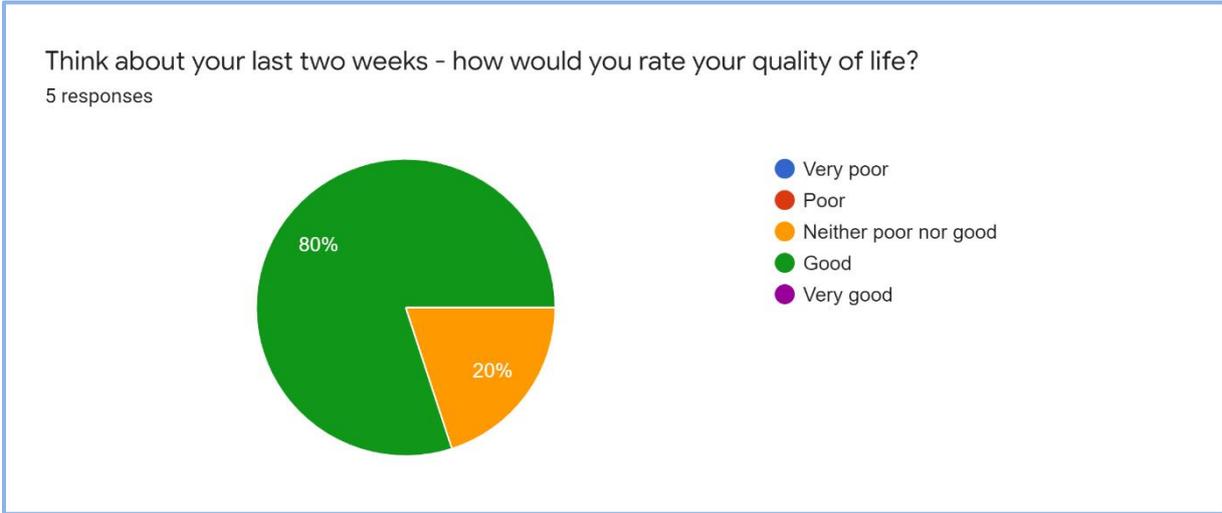
Figure 56 - Self-perceived quality of life of seniors (post-test).

The post-test results had not improved much. The same participant who believed their quality of life is rather poor changed their mind and gave a 3 out of 5 rating. The general score improved by 4% and was 76% at the moment. But, given the fact that the number of users is rather low, we cannot say this is a significant value.

Despite this, seniors gave higher ratings when we asked about specific things they experienced lately, such as 'How safe do you feel in your daily life?' or 'How healthy is your physical environment?'. At least one of the participants gave a higher rating at post-test than at the pre-test when asked about certain experiences. **If we follow the changes in rating for specific activities, the quality of life increased by at least 10%. Thus, the KPI referring to a general impact of the INCARE solution on quality of life has been met.**

Impact of the INCARE solution on technology acceptance

Managing and using technology can be a hard task for seniors, as the older generations are often not used to modern devices and they like to rely on their old ways. This is very visible in the following chart, showing the technology acceptance of seniors before they started using the INCARE platform and functionalities.
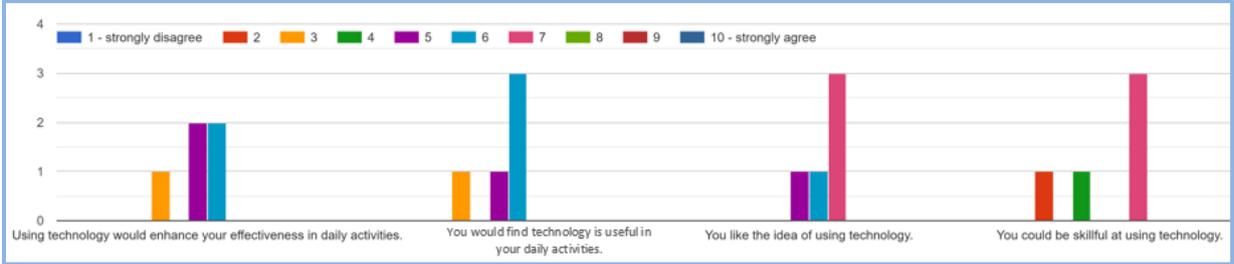
Figure 57 - Technology acceptance of seniors (pre-test).

The ratings are mostly low or moderate and the seniors lack self-confidence when it comes to managing technology. The general score regarding technology acceptance in the pre-test is 55%.
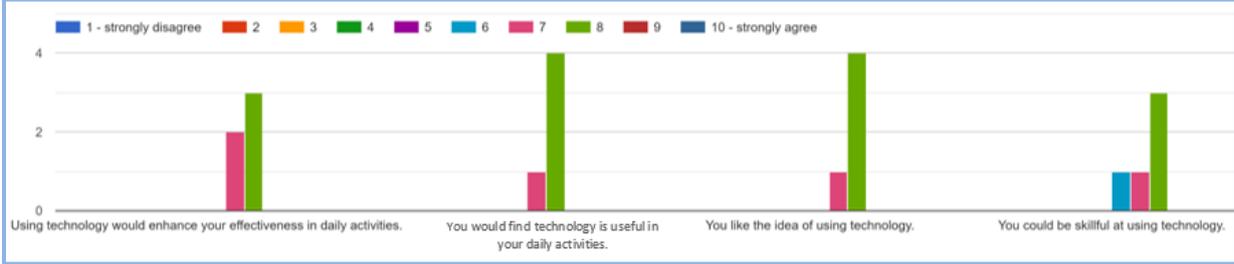
Figure 58 - Technology acceptance of seniors (post-test).

As we can see in the chart above, the ratings have higher values in the post-test, after the seniors had a period of a couple of months when they permanently interacted with the INCARE platform. The general score regarding technology acceptance in the post-test is 76.5%, which shows a significant acceptance of technology as a result of testing the solution. **The increase of technology acceptance among seniors is by 21.5% and the KPI referring to a general impact of the INCARE solution on technology acceptance has been met.**

Impact of INCARE solution on health practices/routines

Health practices and routines were positively affected by the implementation of the INCARE solution in the seniors' homes. If the elderly users' interest for health monitoring, cognitive and memory improvement and physical activity were medium in pre-test, their importance increased in post-test. This can be seen in the following chart.
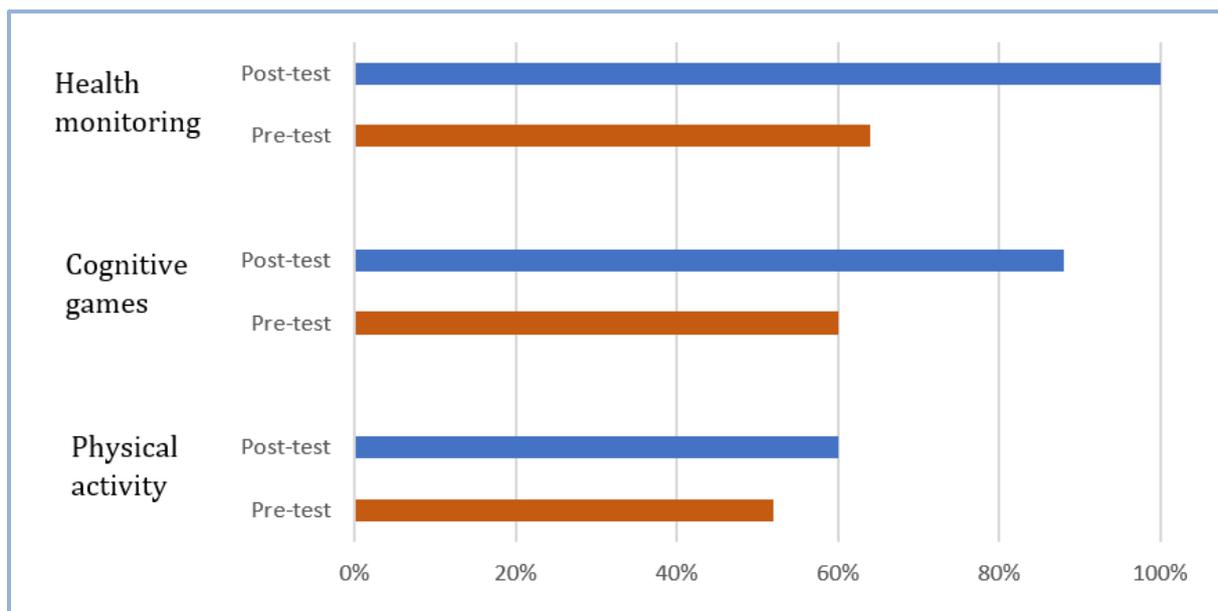
Figure 59 - Impact of INCARE solution on seniors' health practices/routines

The frequency of health monitoring in seniors increased from 66% to 100%, the elderly users realizing the importance of monitoring their health parameters for a healthy and happy life. **The frequency of cognitive exercises, here referring to games offered by the INCARE app, increased from 60% in pre-test to 88% in post-test.** Seniors enjoyed the games and requested more variety in the future.

An increase in frequency of physical activity was also observed among the seniors. It raised by 8%, from 52% in pre-test to 60% in post-test. Thus, we can say that the KPI which stated that there should be an increase in the frequency of physical activity as a result of the implementation of the INCARE platform has been met.

Reduction of burden of the caregiver and other caregiver benefits

The reduction of the burden of the caregiver is an important result expected out of the INCARE solution. The platform should be able to help the caregivers take care of their elderly relative and decrease the amount of time and resources they have to invest in order to take care of them.

At first sight, the caregivers' burden does not seem to decrease due to the implementation of the INCARE solution. The impact of caring on their lives seems to be similar in post-test to the one in pre-test. Despite this, the caregivers believed that the platform brought them benefits.
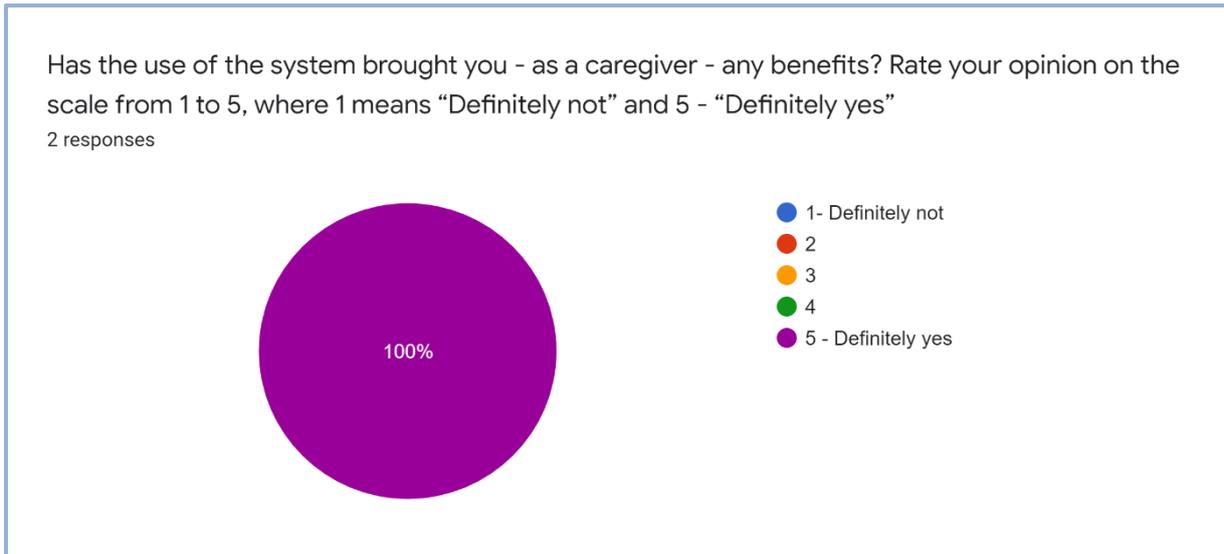
Figure 60 - Benefits bought by the INCARE solution to the caregivers.

They are mostly linked to a better sense of control over the seniors' health condition and less stress, but there are also some other benefits pointed out by the users, as it can be seen in the following chart.
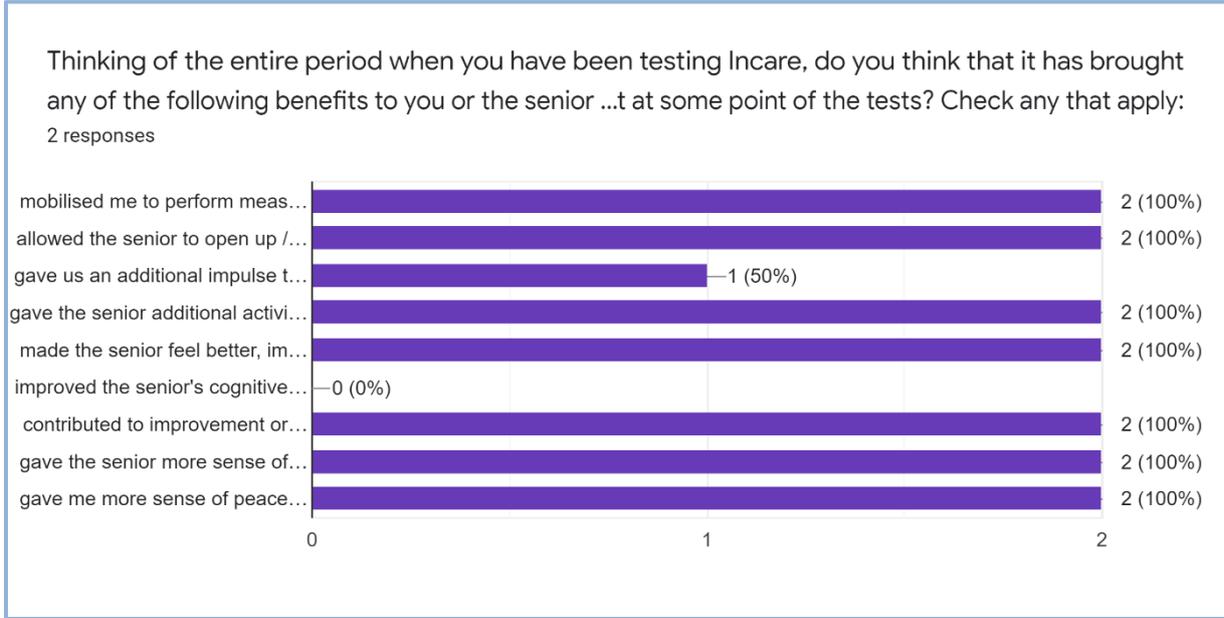
Figure 61 - Types of benefits brought by the INCARE solution to the caregivers.

Thus, the INCARE solution had the following advantages, according to the caregivers:

- mobilised the caregiver to perform measurements of the senior's health parameters more frequently;
- allowed the senior to open up;/feel more comfortable with new technologies;
- gave the senior additional activity, allowed to avoid boredom;
- made the senior feel better, improved his/her mood or psychological wellbeing;
- contributed to improvement or maintaining the senior's health;
- gave the senior more sense of peace and control over his/her health (ex. by being able to monitor and record health parameters, detect health-related hazards, control medication etc.).

Taking into consideration the benefits presented above, we can say that the INCARE solution reduced the burden of the caregivers, making us meet another KPI.

Evaluation of the robotic platform

By accessing the robotic movies through the INCARE app, a total of 7 participants – of which 5 were seniors, and 2 were caregivers – were requested to evaluate the movies depicting the functionalities of the 2 robots: Tiago, the service robot, and Pepper, the companion robot.

With regards to Tiago, the majority of participants considered that the service robot is a very interesting tool, yet somewhat limited and difficult to store. Considering the advantages of having constant supervision in case of an emergency, and a butler-like service at their disposal while maintaining their intimacy and daily routine, Tiago could be considered a great addition to any household. However, the key drawbacks are that it occupies a lot of space; it cannot be used for multiple-floor houses, or areas with thick carpets; and it is also not as fast or able as a human caregiver.

After reviewing the possibilities of Pepper, the participants concluded that, while adorable and informed, it still makes for a dull companion. Some useful features that were requested are: mobility over carpets or stairs, the ability to play games with the seniors, and an integrated radio, or the option of playing music.

3.4 Hungary

3.4.1 Sample description

130 elderly users participated in the test. 100 seniors were living in their homes and testing the solution at a day-care facility under the supervision of caregivers. 30 seniors were living in a nursing home where they also tested the solution.

Seniors

After the testing people were interested in continuing the measurements to see the eventual changes in the data. This justifies both the process and the web interface for informal and formal caregivers and for the elderly interested in checking themselves directly on the web. People have the opportunity to do so, however elderly people very rarely logged in to the system, while the formal caregivers by definition were interested, able and willing to log in and check data.

Individual testing was performed in different day-care centers for 100 elderly people, always with the supervision of formal caregivers. This solution was implemented in order to reduce the risks associated with the pandemics. These risks would have increased substantially if the seniors were to be tested in their homes. It would have involved moving the equipment between seniors in order to cover all 100 users.

The 30 seniors testing the solution in a nursing home have used the platform on a regular basis. Three sets were installed in the 3 locations of the same nursing home. These locations were in the same district. The internal health safety and environmental procedures of the institution were in line with the regulations, and the safety and health of the elderly, the caregivers and the end-user organization personnel could be taken care of.

Formal caregivers

A total of 5 professional caregivers participated in the tests. Two informal caregivers have also participated. The caregivers gained enough experience to provide valuable feedback on using and improving the system.

For example, caregivers in the first testing phase found the followings: the Blood Pressure Monitor worked fine and the data was also posted on the Internet interface with all but one that was later corrected. Pulse oximeter measurement were fine, however the results of the measurements were not visible on the web interface, or the measurement was broken several times on the web interface.

During Balance Scale measurements, data appeared only on the display of the device, neither on the Tablet nor on the web interface. The latter did not even appear as a listable tool.

Tablet NFC scans were fast, but it was difficult to switch from one user to another, application had to be exited and relaunched always have to step out and close the program to detect the next subject. Between measurements, idling, the tablet and app went asleep user had to relaunch the tablet and app.

Some hardware errors also occurred during testing, which was an enriching experience, how the error was detected, reported, escalated, fixed and operation went back to normal.

After fixing the errors the measurements were carried out correctly and became visible on the web interface. The web interface has also been corrected with the data measured by other devices and is already being uploaded to the interface.

Configuration was tested in 3 different sites, which was a good practical experiment for the professional caregivers, how to pack, unpack, restart the configuration and do successful measurements at another location.

Caregivers welcomed the functionality that all measurements are available through the web interface and they can comment them.

Commercially available measurement devices run out of power relatively quickly during regular use, which implies using heavy duty professional devices in case the frequency of the measurements goes beyond "home use" level.

Robotic platform evaluation

The aim of the robotic platform evaluation was to assess how elderly people would or would not accept non-human help, and 22 elderly persons aged between 65 and 75 were involved in and 7 caregivers were also involved in the evaluation. All participants listened to a short presentation on the role of robots and then watched educational videos about robots and some of them had the opportunity to meet Pepper robot in person.

3.4.2 Main results

User satisfaction – KPI

The user satisfaction KPI at the end of the INCARE solution test was set at no less than 7 out of 10 (70%) by the end of the pilots. Another target assumed was no more than $15 - 25$ % dropouts after half a year. Both of these conditions have been met.

The first question used to measure users' satisfaction was about whether users would recommend a product or service to others on a scale of 1 to 10. As the table shows below 14 out of 15 responses were aligned with the project's KPI, meaning that user satisfaction was not lower than 70%. Actually, the average score is 8,5, which is well above 7 amongst the seniors and half of them rated INCARE with 9 and 10 out of 10, which shows a very high satisfaction rate.

Caregivers had a similar view even if the responses are less spread out. However, it also means that they were more on the same page. In fact, 60% said that their satisfaction level in terms of recommending the product is 9 out of 10, which is a very high rate.

On a scale from 1 to 10 how likely are you to recommend INCARE to a friend or a colleague? Rate your opinion on a scale from 1 to 10, where 1 means "Definitely not" and 10 - "Definitely yes"

15 responses
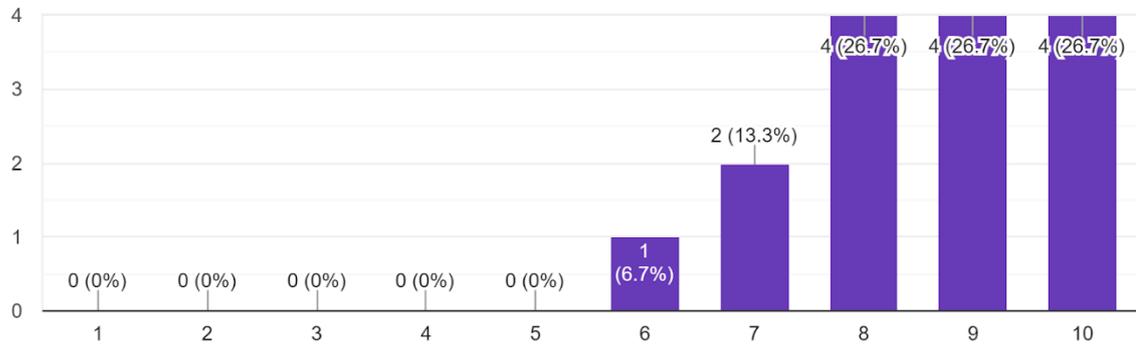
Figure 62 - Individual testing - seniors

On a scale from 1 to 10 how likely are you to recommend INCARE to another institution? Rate your opinion on a scale from 1 to 10, where 1 means "Definitely not" and 10 - "Definitely yes"

5 responses
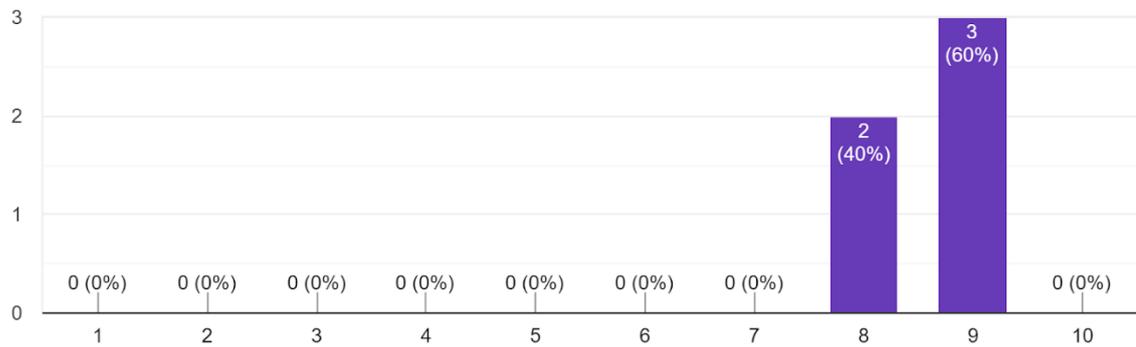
Figure 63 - Formal Caregivers

Taking into account all your experience, how satisfied or dissatisfied are you with the INCARE service? Rate your satisfaction on a scale from 1 to 10... not satisfied at all" and 10 - "I'm fully satisfied".
5 responses

- 1- I'm not satisfied at all
- 2
- 3
- 4
- 5
- 6
- 7
- 8

▲ 1/2 ▼
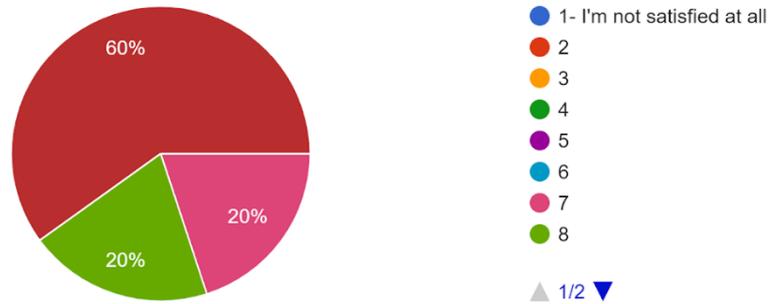
Figure 64 - Individual testing - caregivers

User satisfaction: usefulness of specific features

Evaluation of the health monitoring app – perspective of individual seniors

All features that allow monitoring health via dedicated medical devices were evaluated positively by the participants. For this question we used a scale from 1 to 5, where more than 80% of the seniors participating in the test declared that they found it useful.

Was the health monitoring module useful or not useful for you? Rate your opinion on the scale from 1 to 5, where 1 means "Definitely not useful" and 5 - "Definitely useful"
15 responses
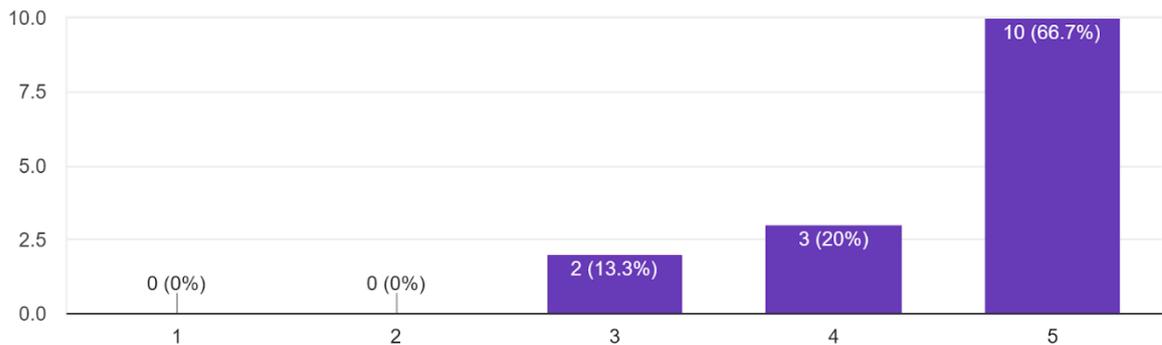
Figure 65 - Individual testing - seniors

Evaluation of the caregiver app – perspective of formal caregivers

In the second half of the test, caregivers were able to view the senior's results via the caregiver's panel accessible from the Internet browser. Caregivers from the beginning felt that this panel is a very useful one. After trying, using an rating of the system they showed a very positive response about it: Out of 5 no one have rated the usefulness of the system less than 4.

If applicable: Was the caregiver application useful for you? Rate your opinion on the scale from 1 to 5, where 1 means "Definitely not" and 5 - "Definitely yes"

5 responses

- 1 - Definitely not
- 2
- 3
- 4
- 5 - Definitely yes
- not applicable
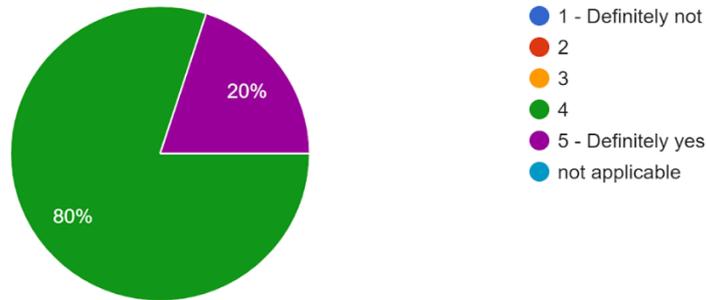
Figure 66 - Individual testing - caregivers

Evaluation of the games – perspective of individual seniors

Seniors participating in the test evaluated (on a 1 to 5 scale) each of the games available under the INCARE app. Again, the feedback shows that 12 out of 15 has given at least a 3 out of 5 and more than 50% a 4 or 5 out of 5. This clearly indicates that end-users enjoyed the games.

IF YES] How satisfied or dissatisfied are you with the INCARE games? Rate your satisfaction on a scale from 1 to 5, where 1 means "I'm not satisfied at all" and 5 - "I'm fully satisfied".

15 responses

- 1- I'm not satisfied at all"
- 2
- 3
- 4
- 5 - I'm fully satisfied
- not applicable
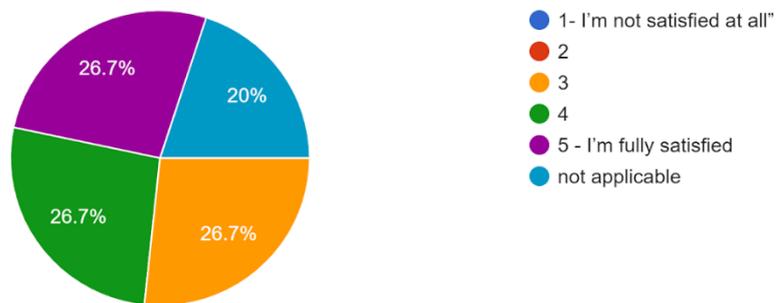
Figure 67 - Individual testing of games - seniors

[IF YES] Did you like or dislike the games? Rate your opinion for each game on the scale from 1 to 5, where 1 means "I didn't like it at all" and 5 "I liked it very much".
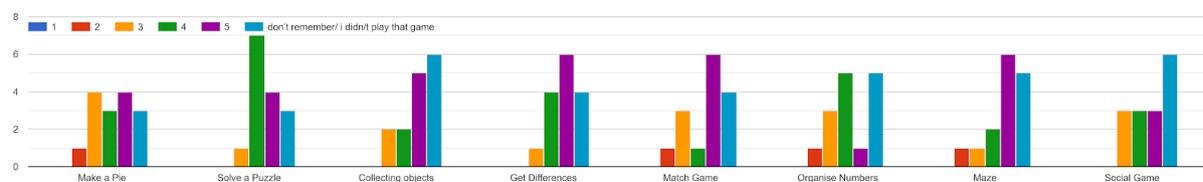
Figure 68 - Evaluation of each game

In terms of detailed feedback about each game: most popular games were the Match and the Collecting objects game with the Maze game being in third position. There was not any game that end-users would not enjoy at least a little bit and the majority of the games were not rated with less than 3. At the same time average score is 7,2.

Experiences and comments on cognitive games

Based on user feedback, the games were divided into two groups:

- Puzzle, brainteaser (Solve a Puzzle, Get Differences, Organise Numbers, Match Game)
- Funny, but more difficult for seniors (Make a Pie, Collecting Objects, Maze, Social Game)

Brainteaser games, such as looking for differences or solving a puzzle, were pretty much interesting for seniors. This, they say, stems from the fact that many people like to do crossword puzzles or watch quiz shows on TV, which are similar to these games. It's a way to spice up the monotony of their everyday life with a little excitement, a little thinking. In some cases, there was also a healthy rivalry between them, as the majority enjoyed these games, competing to see who could score more points. Brainteasers were found to be easier to use and navigate on tablets for senior users than in the case of games that belong in the so-called fun category.

These games could also be complemented by a multiplayer mode, where they could play against each other for a period of time.

In the group of fun games, it was the control that several elderly users found quite difficult. They don't typically use such tools in their everyday lives, so having to use more than one finger to control something is often more difficult and discourages them from playing, saying, "I can't do it anyway". Although many of them found it hard to control, it was still a lot of fun for them, because they got to see new things, experience new things, and have a good laugh. But this took quite some time, and after proper practice they started to enjoy the games. There were seniors for whom these games were more challenging and eventually more useful than the brain teasers.

From a usability and display points of view, control of the games in the case of fun games group would be reasonable to be refined and simplified. It would be useful and welcomed by users to list not only the best result, but also the top 3-5 results with username ranking. Another feedback from users was that the buttons they used to control the game often blurred the screen and obscured parts of the screen because they had their finger on them (e.g., Collecting objects). This could be positioned and reorganized differently.

Impact of the INCARE solution on quality of life

Impact of the INCARE solution on individual primary users' quality of life

Although half of the users said that the usage of the INCARE system has not improved their quality of life within two weeks, there are some promising results. Meaning that one third of the participants did feel that a change and rated their quality of life with either a 4 or a 5 out of 5. After talking to end-user who gave a lower score to this question, we also found out that they did enjoy the increased leisure time thanks to the games played within the system. They have also stated that most probably on a long run they would feel a change in their quality of life as well, especially in terms of their mental well-being and everyday mood.

Improvement was observed in the different dimensions of the quality of life, as it has been confirmed by the people participating in the study

- health, physical wellness - the system contributes to the wellness of the seniors by measuring and reporting their status for themselves and for the caregivers.
- mental - cognitive games, coping twitch technology, learning about themselves contribute
- emotional - overcoming fear, coping with their status, the support of the caregivers contributes to emotional wellness of the seniors
- social - the measurements, interaction with the system and the caregivers gives the feeling of being taken care of, belonging. In case there are centrally organised measurements, people have the opportunity to be together with people who have similar challenges.

Think about your last two weeks - how would you rate your quality of life?
15 responses

- Very poor
- Poor
- Neither poor nor good
- Good
- Very good
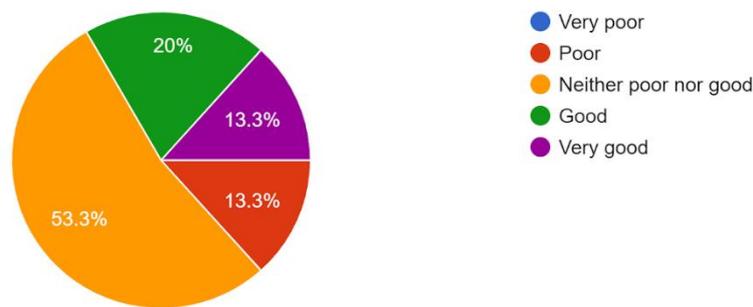
Figure 69 - Individual testing - seniors

Impact of the INCARE solution on technology acceptance

Impact of the INCARE solution on individual primary users' technology acceptance

In terms of technology acceptance, the graph clearly shows that right from the start, users were fairly positive about using and accepting technology. However, thanks to them trying out the INCARE platform, a platform that is something new to them, this rate could even improve a little bit.

Fear from technology - many times - comes from lack of interest or lack of abilities (knowledge, skills and opportunity).

Using the INCARE system regularly gave the opportunity to the people to gradually recognize their issues, status, and how to cope with them. Just by performing the test created interest, their questions could be replied to, and by watching other seniors influenced the attitude of the seniors. These repeated measurements supported incremental learning in smaller chunks, instead of coping with a complex system all at once. As computer literacy of the elderly is rather limited on the average, these small steps are really important for them to accept technology.

Impact of INCARE solution on health practices/routines

The tests included an assessment of the INCARE solution impact on some health-related activities, namely:

- Frequency of health monitoring routines,

- Level of physical activity,
- Frequency of engaging in brain exercises.

The results shown in the column charts show a significant improvement in terms of the above-mentioned categories. Thanks to INCARE end-users were much more conscious about monitoring their health and their engagement in doing brain exercises have also increased with a fair amount. This is an overall positive achievement of the INCARE project. Also, even if the rating on doing physical activity was not least that increased, it still showed improvement, which is again a big success as we all know that making seniors more active is one of the biggest challenges.

Seniors visit medical doctors primarily because of prescribing pharmaceuticals for chronic diseases. The healthcare system is overloaded, and many times there is a long waiting time, there is not enough time left for performing basic tests, e.g., blood pressure monitoring. Regular measurement performed through the INCARE system gives the opportunity to medical professional to focus their activities to those cases which are really need it. Both caregivers and seniors can say the effectiveness of the therapy indicated. INCARE is not a replacement, but a valuable extension to the healthcare system. Even if a lot of tests and measurements are in the central system of the health care authorities, insights provided by INCARE is of value to the seniors and caregivers, as reported by them, since it is more accessible, they can feel more control over the data and the process to stay active and healthy.

Reduction of burden of the caregiver and other caregiver benefits

In terms of measuring the burden of the caregivers we looked at the benefits of the INCARE stated by the caregivers. Results are very promising as all caregivers have seen an added value in using INCARE. The biggest advantage of it is that it allows caregivers to monitor seniors from a distance, meaning that they could become more mobile while working and as often as they wanted to. This has released stress and time pressure on the professionals. Caregivers have also stated that INCARE gives more sense of peace and control over their health by monitoring and recording their health data. As caregivers said this can also lead to end-users taking bigger responsibility and engagement, willingness to maintain or improve their health.

Benefits of using Incare

made the senior feel better, improved his/her mood or psychological wellbeing	73%
improved the senior's cognitive abilities, his/her mental health	73%
gave the senior additional activity, allowed to avoid boredom	80%
gave me more sense of peace and control over the senior's health (ex. by being able to monitor and record	80%
allowed the senior to open up / feel more comfortable with new technologies	87%
gave us an additional impulse to discuss health issues	87%
contributed to improvement or maintaining the senior's health	87%
gave the senior more sense of peace and control over his/her health (ex. by being able to monitor and record	87%
mobilised me to perform measurements of the senior's health parameters more frequently	93%

Figure 70 - Benefits of using INCARE - formal caregiver

When we asked caregivers to express the benefits of using INCARE with their own words, they have given very similar results like the ones described above. However, the clear importance and advantage of collecting and monitoring data and especially the real-time support that can be provided thanks to the system were the one that stood out the most.

What could be the benefits of having such system in the institution like yours?

5 responses

The availability of lots and reliable data provides safety.

We can easily monitor the status of users, the system alerts us if there is a discrepancy, and the majority of users enjoy the games. The demonstration of the robots has also attracted interest.

Users' health and other data are automatically stored and are always available to professionals. This means greater user safety.

In addition to the health and communication benefits, elderly users can also be significantly motivated by its usage.

Significant and real-time support for carers and family members.

Figure 71 - What could be the benefits of having such a system in an institution like yours? Caregivers, n =5

Evaluation of the robotic platform

According to statistics from the Hungarian Central Statistical Office, in Hungary, the ratio of women to men in the population over sixty-five is 60%-40%. Unfortunately, the ratio is much worse among people

over sixty who are active and visit senior citizens' clubs, and the proportion of men is significantly lower. Therefore, our evaluation results are not representative in terms of gender. In our survey, there were nine female and one male respondents, giving a sex ratio of 90%-10% female to male. Data was collected using a questionnaire prepared by the INCARE consortium partners.

It focused on the knowledge, acceptance and possible use of robots and the acceptance of care assistance. In addition to watching the videos, 10 of the 22 elderly users had the opportunity to meet Pepper robot in person.

The main criterion for evaluating the robotic platform used was the acceptance level of the proposed solution. The anticipated value of this indicator in the project was set at 70-75%. This means that for the criterion to be met, 70-75% of the respondents evaluating the robotic platform should declare they would accept using such a solution in their daily life (now or in the near future). This is why at the end of the interview (after a detailed discussion of what the robot looks like with its specific features) participants were asked the following question:

> *If you needed extra support in different life situations that you saw on the video, would you be willing to use the INCARE robotic solution?*

Respondents were asked to answer on a 1 to 5 scale, where 1 meant "I would definitely not want to use that solution", and 5 meant "I would definitely like to use such a solution". Participants justified their choice.

We asked the following respondents about their acceptance of the presented robotic solution:

- seniors and caregivers (family members) testing INCARE in their place of residence
- representatives of daily care facilities testing the INCARE app in the institution

More than 80% of the elderly users and the majority of the caregiver participants are willing to use the robotic platform in certain, specific life situations. (hence if they had none or limited support from the caregiver, and if the senior's health were poor). **The acceptance target of 70-75% chosen for the study (KPI) was therefore reached.**

Tiago

TIAGo is a commercially available robot from Pal Robotics, suitable for research in areas such as Ambient Assisted Living, healthcare and light industry. TIAGo can be easily configured and developed to meet a wide range of research needs.

Acceptance of the robotic platform

Tiago

TIAGo is a commercially available robot from Pal Robotics, suitable for research in areas such as Ambient Assisted Living, healthcare and light industry. TIAGo can be easily configured and developed to meet a wide range of research needs.

Figure 72 - Tiago robot

Pepper

The Pepper robot is a product of SoftBank Robotics. It is a humanoid robot, 120cm tall. Designed primarily for communication, it can recognize human faces and emotions. Also, due to its humanoid nature, it can perform simple tasks with its hands. In our experiment, we demonstrated the robot's capabilities by handing a glass to an elderly person, performing simple communication tasks and entertainment.

Figure 73 - Personal meeting with Pepper the robot (1)

Figure 74 - Personal meeting with Pepper the robot (2)

Figure 75 - Personal meeting with Pepper the robot (3)

Figure 76 - Personal meeting with Pepper the robot (4)

Before the information and videos were shown, respondents were asked the following question: "Apart from the appearance of these robots, if you needed additional support in various life situations, would you be willing to use the robotic solution?" Then we asked them the same question after they had already received information and watched the videos or met Pepper.

The initial answers were then compared with the second answers. Due to the small sample size, the results cannot be considered representative, however, we have taken into account the results of our previous survey with a larger sample size (2020) as well, the results of which were published in the 15 December 2020 issue of the journal "Nővér".

After the presentation, the videos and the personal interaction, there was a relative increase in confidence in handling robots, and the initial relative caution was replaced by a confidence that the robots would not go wrong. It was confirmed that the aversion is not deep-rooted but based primarily on a lack of detailed and reliable knowledge. It was shown that after a short introduction and demonstration, a significant part of the prejudices could be reduced and acceptance and confidence could be greatly increased.

FOR SENIOR: As you can see, the Incare application can run on various types of robots. Apart from the appearance of these robots, if you needed additi...I would definitely be willing to use this solution".
21 válasz
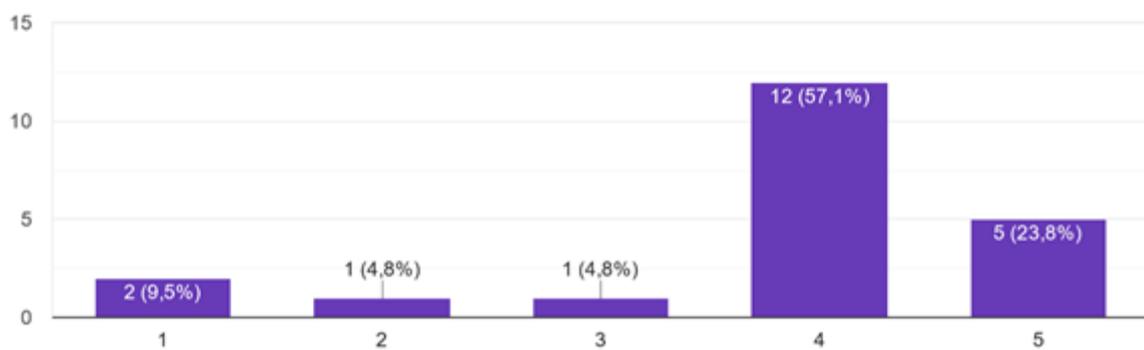
Figure 77 - Acceptance of robots by seniors in Hungary
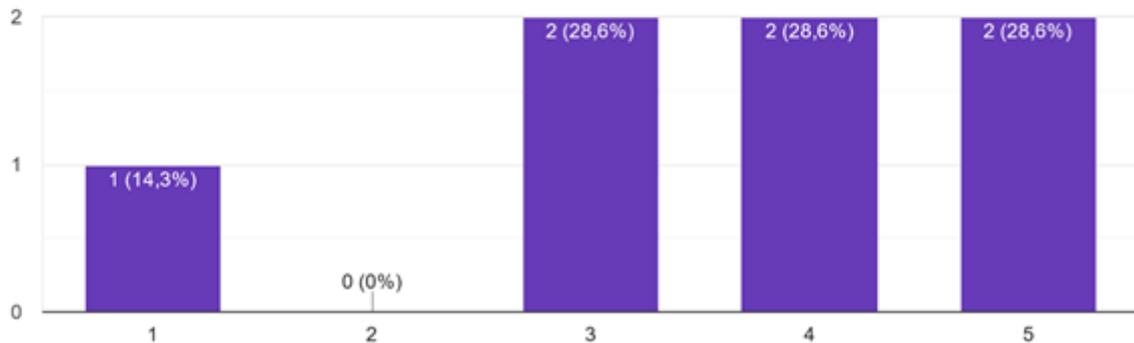
Figure 78 - Acceptance of robots by caregivers in Hungary

Evaluation of the usefulness of the presented features of the robot

For the evaluation, we needed two robots with fundamentally different designs and functionalities, so that the difference between the robot types would be clear to the respondents and we could observe the acceptance of robots with a different design. Moreover, there is a significant price difference between the two designs, so it is likely that cost will also influence their acceptance and willingness to use them.

Tiago

Tiago is robust, slow-moving, its voice also sounded rather alien to elderly users. Some felt that it was too large and gave a rather alien impression to users, who said that although it could be useful, they would not want to be left alone in a room with it; and did not really trust it.

Pepper

Overall, Pepper was the more popular, mainly due to his smaller size and human, "boyish" voice. As a result, he is more accepted, e.g., as a conversationalist, but his disadvantage is that he is not really suitable for real, physical assistance, e.g., delivering food, drinks, medicines, serving. Less humanoid robots are better suited for the latter tasks, with a larger display, which is an advantage for elderly users.

Conclusions: fear and rejection by older people is largely based on prejudice. With a short introduction and a basic understanding of robots, older people's rejection of robots can be turned into acceptance and their curiosity about robots and robotic care can be awakened.

Recommendations for the robotic platform

- concerns and fears about robotic care among older people are mainly based on preconceptions, and brief information and demonstrations have succeeded in achieving substantial improvements in acceptance and raising levels of trust at almost all levels; with a short presentation and a basic understanding of robots, older people's rejection of robots can be turned into acceptance and their curiosity can be awakened towards robots and robotized care

- non-humanoid robots (e.g. delivery robots) seem to be preferable for practical assistance in elderly care, taking into account functionality aspects
- education and trainings should be done as early as possible, at the beginning of retirement or even before, when people are more receptive
- when designing and planning robots to be introduced into elderly care, it is important to take into account the needs and ideas of elderly people so that the robots are easily acceptable to them and can be easily integrated into their daily lives
- post-training overconfidence in handling robots and overestimation of one's own handling skills is a real situation, and further research is needed to explore and understand the causes in these areas

3.4.3 Recommendations for optimization the INCARE solution:

- improving the user experience, (e.g., ease of use, logging in, changing user smoothly)
- enriching functionality (e.g., search and listing features, warning thresholds, process recommendation in case of deviations from normal data, etc.)
- integration (e.g., with devices from other manufacturers, extending battery life)
- connection to the central health database operated by the government health authorities
- the integration of a larger number of more complex (less child-friendly) and familiar types of games (e.g., crosswords)
- use of a larger screen for easier navigation and better readability
- robots should be service robots rather than human robots and should be smaller in size
- more detailed instructions on how to use the application, but these should be accompanied by training and regular face-to-face trainings
- faster bug fixing, troubleshooting and stable operation of the application and the platform

3.5 Leading market position

In order to address the leading market position KPI based on the results of the pilots we have engaged in analyzing the data acquired during the pilots and to estimate the saving in costs which the INCARE platform could provide for its users. Further insight into the market position, based on market research and not on pilot data, is offered in the Business Plan deliverable.

Hypertension is the leading cause of a stroke, being associated with more than 64% of cases worldwide as well as the most important factor that can be changed in order to reduce the risk of occurrence[10]. Along ischemic heart disease, strokes represent the most common causes of death[11] and the third cause of disease burden (19% of all cases) worldwide.[12] Ramon Luengo-Fernandez and his collaborators (2017)[13] found that, in 32 European countries, the cost of medical care for the 9 million stroke patients was 27 billion EUR, together with the social care costs of 5 billion EUR. Considering this, the economic

[10] Wajngarten M, Silva GS. Hypertension and Stroke: Update on Treatment. Eur Cardiol. 2019;14(2):111-115. Published 2019 Jul 11. doi:10.15420/ecr.2019.11.1

[11] Lozano R., et al., Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet. 2012 Dec 15;380(9859):2095-128. doi: 10.1016/S0140-6736(12)61728-0. Erratum in: Lancet. 2013 Feb 23;381(9867):628.

[12] Murray CJ, et al., Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet. 2012 Dec 15;380(9859):2197-223. doi: 10.1016/S0140-6736(12)61689-4. Erratum in: Lancet. 2013 Feb 23;381(9867):628.

[13] Luengo-Fernandez R, Violato M, Candio P, Leal J. Economic burden of stroke across Europe: A population-based cost analysis. European Stroke Journal. 2020;5(1):17-25. doi:10.1177/2396987319883160

impact can be estimated as 1.7% of the total health expenditure; however, focusing on individual patients and their respective caregivers, the medical and social costs amount to 3,483 EUR per year.

In addition to the above, we have to consider the risk associated with hypertension. According to Zbigniew Gaciong and his collaborators (2013)[14], an increase in blood pressure over the value of 115/75 mm Hg will also increase the risk of stroke. Hypertension increases the risk of ischemic stroke by 28% and hemorrhagic stroke by 38% for each 10 mm Hg rise. Thus, values above 150/99 mm Hg are increasing the risk of stroke by more than 100%.

Consequently, having established the above threshold, we considered the statistics in the pilot date. We found that over 227 of the measures had either the diastolic value over 150 or the systolic pressure above 90 mm Hg, with 32 measurements exceeding both limits (from 21 users). Thus, 21 users could save 3,483 EUR per year. At the same time, the costs per year for the INCARE platform comprising the INCARE app (30 EUR), 1 blood pressure meter (60 EUR), communication with caregivers (5 EUR/month) would amount to 150 EUR for the first year and 60 EUR for every following year. Compared to the 3,483 EUR per year and intricate physical and psychological damage caused by a possible stroke. **We can conclude that this aspect alone is supporting the fact the INCARE solution is determining a 10% decrease in costs for end-users care over prolonged time.**

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[14] Gaciong Z, Siński M, Lewandowski J. Blood pressure control and primary prevention of stroke: summary of the recent clinical trial data and meta-analyses. Curr Hypertens Rep. 2013;15(6):559-574. doi:10.1007/s11906-013-0401-0

4. Conclusions

This report aims to present key findings from the study, in an order based on the KPIs assigned for the project in advance or during the fieldwork. The report also provides a summary evaluation of specific system components, as well as the perceived benefits resulting from testing the solution, and observations and recommendations that emerged during the trial stage.

Table 2 – KPI reached by the consortium partners at the end of the pilots.

KPI description	KPI target	POLAND	ROMANIA	HUNGARY	SLOVENIA
user satisfaction	user satisfaction is not lower than 7 out of 10 (70%) by the end of the pilots. No more than 15 – 25 % dropouts after half a year.	User satisfaction: above 7 out of 10 seniors:8 informal caregivers: 7.8; formal caregivers: 8. Dropouts: 0%	User satisfaction was above 7 out of 10, with seniors giving an average score of 9, and informal caregivers giving an average score of 8.5. Our dropout rate was 0.	Reached 7 out of 10: average of seniors was 8,5, caregivers 9,3	The average score given by the seniors was 9 and the average score given by the caregivers was also 9. This is over the user satisfaction score required (7 out of 10). The dropout rate was 0.
caregiver burden	reduction of the burden of the caregiver	no significant change in the level of caregiver burden however the system brought significant benefits to the caregivers - (80%) declared that using INCARE's solution increased their sense of peace and control over the senior's health.	There was no statistical change in the level of caregiver burden, but the solution brought several benefits, according to caregivers: improved the senior's health, saved time and reduced the stress levels of caregivers.	For the caregivers: reduction of time needed to measure one elderly, predictability of measurements, early warning of possible risks, higher level of acceptance by the elderly and of the caregiver, elderly want to continue with the measurement. 80% of the tested population recommending INCARE	The INCARE solution reduced the burden of the caregivers and brought them several benefits: better sense of control over the seniors' health condition, less stress, more free time.
acceptance of robotic platforms	70-75% acceptance rate	acceptance rate: 70% - seniors; 74% - caregivers	The acceptance rate was approximately 85% (seniors and caregivers).	acceptance rate: 80% for seniors and 85,8% for caregivers	Seniors and caregivers found the robotic platform useful ever since the pre-test.
frequency of physical activity	daily - either indoor (INCARE platform) or outdoor (e.g., walking)	3% increase regarding seniors' physical activity	The frequency of physical activity among seniors increased from	Increases mindfulness about health and physical activity	An increase in frequency of physical activity was observed among the seniors.

		frequency (from 70% to 73%)	52% (pre-test) to 72% (post-test).		It raised by 8%, from 52% in pre-test to 60% in post-test.
adherence to medication and medical appointments	90% due to INCARE reminder module	not applicable	Cannot evaluate.	not applicable	Not applicable.
non-appropriate emergency calls	1% (falls, home alerts, health alerts)	not applicable	Not applicable.	not applicable	Not applicable.
competitive market position	10% decrease in costs for end-users care over prolonged time	yes (see section 4.5)	yes (see section 4.5).	yes (see section 4.5)	yes (see section 4.5)
level of interest in purchasing the solution once it becomes commercially available	10% of the pilot users interested in purchasing the solution once it becomes commercially available.	67% individual seniors and 80% informal caregivers are interested in purchasing the solution	70% of seniors and 75% of caregivers are interested in purchasing the solution.	67% individual seniors and 50% informal caregivers are interested in purchasing the solution	100% of seniors and 100% of informal caregivers are interested in purchasing the solution.
level of interest to continue using the solution after the end of the project	5% of the pilot users interested to continue using the solution after the end of the project and willing to provide further feedback	87% individual seniors and 87% informal caregivers are willing to continue testing the solution after the end of the project (rating 4 and 5 on a scale from 1 to 5).	There are at least 70% of seniors and 75% of caregivers who are interested in further using the solution and providing feedback.	77% individual seniors and 80% informal caregivers are willing to continue testing the solution after the end of the project (rating 4 and 5 on a scale from 1 to 5).	100% of seniors and 100% of informal caregivers are willing to continue using the solution after the testing process finishes.
general impact of the INCARE solution on health practices/routines (frequency of engaging in brain exercises, health monitoring)	increased frequency of engaging in brain exercises, health monitoring	20% increase regarding seniors' monitoring health frequency (from 73%-93%), 20 pp increase regarding seniors' engagement in brain exercise activity (from 62% to 82%)	There was a general increase of 17% in health practices (16% for monitoring their own health; 20% for physical activity; 16% for playing cognitive games).	up to 10x more regular BPM, ECG etc. recorded, and visible to the medical caregiver, in addition to the medical examinations increase patient care and gives early warning for escalations to the health care system.	The frequency of health monitoring in seniors increased from 66% to 100%. The frequency of cognitive exercises increased from 60% in pre-test to 88% in post-test. The frequency of physical activity increased from 52% in pre-test to 60% in post-test.
general impact of the INCARE	an increase in declared quality of	no significant difference in the general quality of	The general increase in the level of quality of	17% of the BPM measurements were beyond	The quality of life of seniors increased by at least 10%.

solution on quality of life	life (between pre-test and post-test)	life (the average score in post-test was 71%, compared to 70% in pre-test), however 53% surveyed seniors in the post-test exhibited significant improvement regarding the quality of life.	life due to the INCARE solution was from 76% (pre-test) to 86% (post-test).	normal blood pressure values, which represents a major risk for e.g., stroke, myocardial infarction, etc. These risks were recognised early and patients were forwarded to further examination and treatment by medical professionals.	
general impact of the INCARE solution on technology acceptance	an increase in declared technology acceptance (between pre-test and post-test)	no significant increase in the overall technology acceptance (the average score in post-test was app. 78%, compared to 76% in pre-test), however in post-test 43% participants declared a higher level of technology acceptance than in the pre-test.	There was an increase of technology acceptance among seniors of 15% (from 71% in pre-test to 86% in post-test).	55% of the seniors participating in the study got used to the usage of the solution, both themselves and the professional caregivers developed a certain routine/habit of using the system, they overcame fear, suspicion over technology. Further studies are needed to determine exact percentage values.	The increase of technology acceptance among seniors was by 21.5% (55% in the pre-test and 76.5% in the post-test).

5. Document history

Date	Changes	Version	Author
M31	ToC initiated	1	STOCZNIA
M33	Polish setup described	2	STOCZNIA
M36	Description of the Romanian pilots	3	CITST
M37	Hungarian and Slovenian pilots added	4	BZN, IZRIIS
M38-39	Pilot results, KPI calculations	5-8	STOCZNIA, CITST, BZN, IZRIIS
M39	revision CITST and submission	9	CITST