

**AAL Project****Indoor and outdoor NITICSplus solution for dementia challenges****WP3: Pilots with primary and secondary users****D3.4: Report on extended pilots with the integrated platform****Contractual Date of Delivery to the AAL CMU:** M33**Actual Date of Delivery to the AAL CMU:** M33**Participant(s):** CITST<sup>2</sup>, IZRIIS<sup>4</sup>, ASLO<sup>5</sup>, DGW<sup>7</sup>, MSI<sup>9</sup>, EXYS<sup>1</sup>, BZN<sup>8</sup>**Author(s):** Oana Cramariuc<sup>2</sup>, Zsuzsanna Nagymáté<sup>9</sup>, Katarzyna Broczek<sup>7</sup>, Neja Samar Brenčič<sup>4</sup>, Jaouhar Ayadi<sup>1</sup>, Luca Gilardi<sup>1</sup>, Denes Perenyi<sup>8</sup>**Nature:** R (R-report)**Dissemination:** Public**Version:** 1v5**Total number of pages:** 51**Abstract:**

*The report describes activities carried out within Task 3.4 (Work Package 3).*

*The goal of this task was to optimize the platform and to validate it with primary and secondary users. Trials with the integrated platform were performed by the 4 end-user organizations in real life conditions. 65 primary users, 30 secondary users (26 informal and 4 formal) from Poland, Slovenia, Hungary and Romania. Out of these, 18 users were from the rural area. The configuration of the platform was adapted to each user's needs and capabilities. Dementia related aspects were followed during the pilots and considered against the IONIS platform functionalities.*

**Keyword list:** IONIS pilots, health monitoring, sleep monitoring, outdoor and indoor activity monitoring

## Executive Summary

The performed pilots have involved 65 primary users, 30 secondary users (26 informal and 4 formal) from Poland, Slovenia, Hungary and Romania. Out of these, 18 users were from the rural area. A large variety of setups was used in the pilots based on the identified users' needs and requirements. Several functionalities of the platform were identified as being relevant to the dementia patients and their caregivers, as summarized below.

The EMIFIT sleep sensor can aid in identifying worsening of some symptoms associated with dementia. For example, an end-user performing many bed-exits during the night might require differential diagnosis of disrupted sleep and bed exits, e.g. it might be due to behavioral symptoms such as agitation or wandering. Multiple bed exits during the night indicate also an increased fall risk and should prompt activities to reduce the risk of falling e.g. supportive devices (e.g. handrails, portable toilet). The Mi Band activity monitoring bracelet can indicate if the users stay active or if they are at risk of developing depression which is marked by increased lack of activity. The smartwatch has a huge potential for people with dementia in identifying wandering both indoors and outdoors. However, the current limitations in battery lifetime and the difficult usage by elderly people are restricting its usage. Maintaining a history of the users' health parameters can greatly aid in the timely identification of dementia comorbidities.

The satisfaction rate with the IONIS platform was rated to be above 70 %. The individual components of the platform were rated higher while the interface (portal) much lower. Thus, recommendations for improving the interface have to be first taken into account when bringing the IONIS products on the market.

In general, the elderly users living independently were able to use the devices on their own or with occasional help from their family members or friends. Digital literacy was identified in Hungary as being the main barrier in using the IONIS platform. However, one has to take into account that most of the users in Hungary were located in nursing homes and thus had a high level of dependence.

The optimization and tuning of the IONIS platform is also described in this deliverable. This was an ongoing process based on the feedback received by the technical partners from the end-user organizations.

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## Abbreviations

AAL	Active Assisted Living
IONIS	Indoor and outdoor NITICSplus solution for dementia challenges
PwD	Person with Dementia
WP	Work Package
MMSE	Mini Mental State Examination
BT	Bluetooth
BLE	Low energy Bluetooth
GW	Gateway
UWB	Ultra wideband
UI	User interface
VPS	Virtual Private Server

# 1 Introduction

This report describes the activities carried out within Task 3.4 (Work Package 3). The goal of this task was to optimize the IONIS platform and to validate it with primary and secondary users. Dementia specific aspects are carefully considered. Pilots with the integrated platform were performed by the 4 end-user organizations in real life conditions. The end-user organizations (CITST, IZRIIS, DGW, ASH) were mainly responsible for end-user involvement while technical partners were involved in technically supporting the pilots. Various scenarios have been developed prior to the start of the pilots. The end-user recruitment has followed the recommendations made during the midterm review of the project to involve users from both urban and rural areas. Consequently, the pilots have involved 65 primary users, 30 secondary users (26 informal and 4 formal) from Poland, Slovenia, Hungary and Romania. Out of these, 18 users were from the rural area

## 2 End-user recruitment and scenarios

### 2.1.1 Poland

Primary end-users were recruited in an outpatient geriatric clinic, where DGW employees work as consultants. End-users were carefully selected on the basis of: MMSE score (19-27), willingness to participate in the project and ability to walk independently. All the end-users signed an informed consent to participate in the pilot study. Personal data protection procedures according to the current law status were applied. The group of end-users in the pilots with IONIS platform consisted of 8 seniors including 5 females and 3 males. According to MMSE results, 5 end-users had mild cognitive impairment (MMSE score: 24-27) and three end-users had mild dementia (MMSE score 19-23). Special attention was paid to the suggestions formulated by AAL reviewers during the Mid-Term Review of the IONIS project (Jan.30,2019) to include significant number of end-users living in rural areas. Three of the end-users lived in rural areas, four in the municipality of Warsaw and one in the outskirts of the city. Almost all primary end-users (7 people) had a caregiver (usually a family member) referred to as a secondary end-user, available for an interview at the end of the pilot trial, and two participants had two caregivers. Thus, the number of secondary end-users exceeds slightly the number of primary end-users. Average age of end-users was 80 years, which reflects the profile of patients of the geriatric outpatient clinic. Advanced age might be considered an important strength of the study, since many older individuals do not have access to trials including research and development studies due to exclusion criteria. The pilots were started in mid-December 2019 and lasted approximately two weeks for each end-user with one exception described below.

The plan of pilots included 10 or more primary end-users according to the description of work of the project, but due to coronavirus SARS-CoV-2 (COVID-19) pandemic and known increased risk for older adults, the recruitment for pilot studies had to be stopped in the second week of March. Additional extension of the project by 3 months (accepted by AAL CMU and on the national level) did not allow for continuation of the project due to persistent unfavorable epidemiological situation. One of the end-users who entered the pilot trial at the beginning of March 2020, right before the lockdown due to coronavirus pandemic continued the pilot trial for four months until the end of the project on June 30, 2020.

Primary end-users								
No. of primary end-users	Masculine	Feminine	Average age	Urban location	Rural location	MMSE	Other health related issues	Socio-economic background
8	3	5	80 years	4	4	19-27	Chronic diseases: cardiovascular diseases, hypertension, asthma	Good socioeconomic status
Secondary end-users								
No. of secondary end-users	Masculine	Feminine	Average age	Urban location	Rural location	No. of informal	No. of formal	Education
8	4	4	No data	No data	No data	9	0	Majority: higher education

### 2.1.2 Slovenia

In Slovenia both end-user partners ASLO (Spominčica - Alzheimer Slovenia) and IZRIS (Institute IZRIS) were recruiting participants and carried out IONIS pilots together, involving their own users and addressing the public via digital and other communication channels. We have held the IONIS recruitment campaign among our members and users (users of different activities) on our website and in several public media. Potential candidates were contacted by phone/personally and an explanation of the project was given. Likewise, the candidates were informed about the impact and extent of his/her participation with reference to the voluntary nature of the participation. If the person agreed, he or she was handed out the written informed consent form, asked whether all information needed was provided. After the signing of informed consents inclusion criteria were checked. If the person meets the inclusion criteria he/she was invited to participate in IONIS pilot.

Primary end-users								
No. of primary end-users	Masculine	Feminine	Average age	Urban location	Rural location	MMSE	Other health related issues	Socio-economic background
16	9	9	74	11	5	23-27	CVD sight impairment	middle
Secondary end-users								
No. of secondary end-users	Masculine	Feminine	Average age	Urban location	Rural location	No. of informal	No. of formal	Education
14	7	7	70	9	5	14	0	primary, secondary school, higher education

### 2.1.3 Hungary

In MSI, the PILOT2 phase began on April 1, 2019 in several locations, as outlined below. The pilots took place in several forms, and were also multi-stage.

Locations:

1. MSI's St. Hedvig Elderly Home (18-25 primary users + 5 secondary users)
2. In the own flats/homes of "independent" users (3 primary users)

Testing forms and durations:

1. In St. Hedvig Home - measurements by caregivers (1 April 2019 to 31 December 2019)
2. In St Hedvig Home – some users' independent measurements (1 April 2019 to 31 December 2019)
3. In St Hedvig Home – independent measurements using 2 IONIS platforms with the hardware GW (5 November, 2019 to 10 March, 2020)
4. "Independent users" in their own flats/homes of "independent" users (1 April, 2019 to 31 March, 2020)

#### MSI's St. Hedvig Elderly Home

At the beginning of Phase 2 of the pilot, there were a total of 25 applicants in St. Hedvig Home, but in fact 24 people were involved at the time. The number of daily tests were varied: unfortunately, there were several deaths during this period and there were participants who moved to another home and several people left the pilot because for some reason they could not or did not want to continue. It was also common for the participant to be "on leave" to visit his/her family, and it was also common for absenteeism that some were at the doctor or in hospital at the time of the measurements.

On April 1, 2019, the first day of Phase 2 of pilot, there were 25 participants (living in St. Hedvig's Home) in the project. Gender distribution: 18 women and 7 men. There were several exchanges between participants



during the testing period, several withdrew for some reason, but new participants also joined, so there were 18 people on the last day of the caregiver-measured pilots (31 December, 2019), including 15 women and 3 men. A total of 11.224 health parameters were measured during this period in the St. Hedvig Home.

#### **“Independent” Primary users living in St. Hedvig Elderly Home**

7 end-users participated in the testing of the gateways, and 4 people tested the two gateways simultaneously. Two users belonged to one gateway. One tested the system with a blood pressure monitor, the other with a smartwatch and a personal scale. There was a change after two weeks of testing. A total of 16 two-week tests were performed on one gateway, for a total of 32 for the two gateways.

#### **“Independent” Primary users living at home**

In the second phase of the pilots, a total of 3 independent users participated in the project. At first, there were 2 males, one of whom was left out (14 July, 2019) of the project due to his deteriorating condition. Later a woman joined (25 September, 2019), so the PILOTs were completed by 2 people, a woman and a man. They remained in the program until March 31, 2020, the end of the independent pilots. They measured their health parameters in their own homes and tested the devices they received (smartwatch, sleep sensor, personal scale, etc.).

Both participants, who were tested until the completion of pilot, live in a family house in Miskolc town, with their spouse (one with her husband, the other with his wife). Their average age was 77, average MMSE score was 22.

Based on the data received, one of these end-users tested the devices almost every day, *i.e.* measured his health parameters, while the other, according to her own report, was less and less able to measure the agreed parameters as the project lasted due to deterioration. During this time the 3 independent users did 1.092 health measurements.

### **2.1.4 Romania**

The primary end-users recruited in Romania for the pilots were from among the participants in the first pilot phase. In addition, in order to address the midterm recommendations, we have also involved a couple (elderly – informal caregiver) who is living in the rural area. In addition, we also selected a couple of elderly husband and wife who are living more than half of the year in the rural area and the rest of the year in Bucharest. Their informal caregiver is located in Bucharest.

The users were contacted via phone and we explained the scope of the second pilots and the differences as opposed to the first pilots. The MMSE score was evaluated again for those users who were previously close to the lower limit threshold. This was done in order to exclude the users whose cognitive deterioration has advanced too much since their initial participation in IONIS. In addition, we have evaluated the MMSE score for the new users to ensure that they comply with the inclusion criteria.

13 elderly and 7 informal caregivers expressed their interest to participate in the trials. A face-to-face meeting was established with the participants. They were informed about the IONIS project, the development which took place since their first involvement in the project (if applicable) and the purpose of the pilots. The pilot devices were demonstrated to them. They were also informed about the data protection rules and that they would participate in pilots only with the IONIS user ID which will not be related with their identity in any way. It was explained to them, that they can exit the pilots without giving explanation at any time and that, in such a case, their data will be deleted unless otherwise agreed. They were also explained that after the end of the pilots the devices will be returned to CITST. Two contact phone numbers were provided such that they could reach the CITST personnel when needed. None of the participants was unable to decide for her/himself about participation in pilots. All participants signed an informed consent.

The initial pilot plans were unfortunately disrupted by the beginning of the COVID-19 pandemic. As a result, all users became unreachable during the 2 months lockdown. Also, after this period, during the alert state which was declared in Romania and which has been extended until the end of the IONIS project, elderly were afraid to interact with the CITST team members and, on our side, we were also cautious to approach them. Consequently, the extend of the pilots has varied a lot among users. For example, some users continued to test the platform during the lockdown because the devices remained with them. Some others, tested the platform for very short periods of time, e.g. 3 days.

Primary end-users								
No. of primary end-users	Masculine	Feminine	Average age	Urban location	Rural location	MMSE	Other health related issues	Socio-economic background

13	5	7	78.6	10	3	25.2	cardiovascular, mobility, diabetes	above average income
Secondary end-users								
No. of secondary end-users	Masculine	Feminine	Average age	Urban location	Rural location	No. of informal	No. of formal	Education
7	3	5	53	6	1	7	0	university and high school education

## 2.1.5 Pilot scenarios

Several real-life (as recommended at midterm review) scenarios were proposed by the end-user organizations before the start of the pilots. These are presented in ANNEX 1. Here we outline a simplified scenario which was considered for the start of the pilots.

### Scenario

Step1: Various tasks (regular or occasional) are input into the IONIS calendar by the caregiver or the caretaker

Step2: The system is detecting that the user has started his day by having one or more of the following data from the sensors: movement sensor in the house, activity bracelet, sleep sensor.

Step3: The system reminds the elderly user every morning at xx o'clock to perform a certain task from the calendar (health monitoring,

Step3\_1: Step 2 is not implemented: the system reminds the elderly user every morning at xx o'clock to perform a certain task from the calendar (health monitoring,

Step4: The elderly user is pressing a button on the IONIS interface (portal) to acknowledge receiving the reminder.

Step4\_1: If the reminder is not acknowledged then the reminder is sent 2 more times, at a certain predefined time interval. If no acknowledgement is received then the system is notifying the caregiver by sending a message to the caregiver interface (portal).

Step4\_2: If the reminder is acknowledged then the system is waiting for the task to be performed, i.e. health measurements received by the IONIS server/GW. If the action is not performed then Step3\_1 is activated.

Step4\_3: If the task is performed and the values received by the IONIS system are within predefined limits then the elderly user and the caregiver can visualize the outcome on the interface (portal). Optional, the caregiver can opt to receive on the caregiver interface (portal) a message that the task has been completed and all is fine.

Step4\_4: If the task is performed and the values received by the IONIS system are abnormal then the caregiver is receiving on the caregiver interface (portal) a message that the task has been completed but the values are not within acceptable limits.

Step4\_5: If Step4\_4, the caregiver has a button to acknowledge receiving of the alert. If the button is not pressed then the message reappears at certain predefined intervals (shorter for critical events) until pressed.

## 3 Pilots in Poland

### 3.1 Introduction

The pilots were conducted by DGW in close cooperation with WUT – the technological IONIS consortium partner in Poland. The devices used for pilot trials in Poland included the following:

- Xiaomi Mi Band 3 - activity tracker;
- Kingwear smartwatch SWKW88;
- EMFIT QS Clinical Sleep sensor;

- UWB/BLE location tracking system (developed by WUT) for location of people and objects within home;
- Blood pressure meter with Bluetooth;
- IONIS Gateway provided by EXYS was used for the transfer of data to the IONIS platform. In case of EMFIT sleep sensor data were transmitted via the gateway to the EMFIT account provided with the device by the producer. Analysis of sleep was performed automatically by the application.
- Internet router provided by WUT.

## 3.2 Protocol

The protocol of the pilot studies included the following stages:

- Recruitment of end-users: assessment of the mental status with MMSE, assessment of functional status in terms of activities of daily living and mobility, explanation of the aims of the pilots and IONIS platform functionalities, asking about Internet access at home, preliminary user's consent.
- Home visit at pre-scheduled date, presentation of available devices for pilots with explanation, demonstrating charging of the smartwatch, time for questions and answers, explanation of personal data protection rules and protection of data obtained within the pilots, describing data transfer to the IONIS platform as well as access to IONIS portal for the purpose of checking the data by the caregivers (secondary end-users) and by the end-users themselves.
- Signing an informed consent and giving contact data of the investigator to the primary and secondary end-users.
- Installing the system: gateway, Internet connection with the gateway, sleep sensor, activity tracker and/or smartwatch, blood pressure meter. Sleep sensor and activity tracker were tested by all end-users, smartwatch by three end-users who accepted the device (explained in detail in the Section 3.4 – User experience and feedback), blood pressure meter by one user. Additionally, mapping of the apartment for indoor localization was performed for one end-user using methodology developed by the Hungarian partner, BZN.
- Installing the UWB/BLE location tracking system by the partner representing WUT. Explaining the role of tags to be worn by the user and attached to a chosen object (e.g. keys). This solution was tested in two end-users. Additionally, the UWB/BLE location tracking system was pre-tested in two users and special tests were performed in two older adults with moderate dementia living in a long-term institution to screen for wandering behavior.
- Presentation of IONIS portal to be used for checking the data transmitted from sensors, explanation of details of logging in to the IONIS portal, performing portal log in by the primary and secondary end-users.
- Presentation of the EMFIT sleep sensor account to be used for checking the data transmitted from the sensor, explanation of details of logging in, performing portal log in by the primary and secondary end-users.
- Checking the system integrity, Internet connection and transmission of data.
- Encouraging the secondary end-users to check the portal on regular basis. Encouraging the end-users to motivate other family members, if available, to check the IONIS portal. Time for questions and answers.
- Checking the IONIS portal daily by members of DGW.
- Contacting EXYS representatives by mail or Skype in case of observed difficulties, problems with data transmission etc.
- Contacting the end-user to resolve problems, e.g. in case of temporary Internet connection loss. Performing additional home visits, if necessary.
- Pilot studies lasted approximately two weeks, in case of transmission problems, the study period was extended. One user remained in pilots for four months as explained above under End-user recruitment.
- After finishing the pilot study, primary and secondary end-users were asked about their feedback and observations using a short-structured form with open questions. Questions were related to acceptance of devices, observed problems and willingness to use a similar system in the future as a

long-term support. Additionally, end-users were asked about an acceptable prize of the tested ICT solution.

Photographs below present setting-up of the system.



**Figure 1. EXYS Gateway and Internet router enable transmission of data to the IONIS platform.**



**Figure 2. EXYS Gateway connected to the end-user's Internet router.**





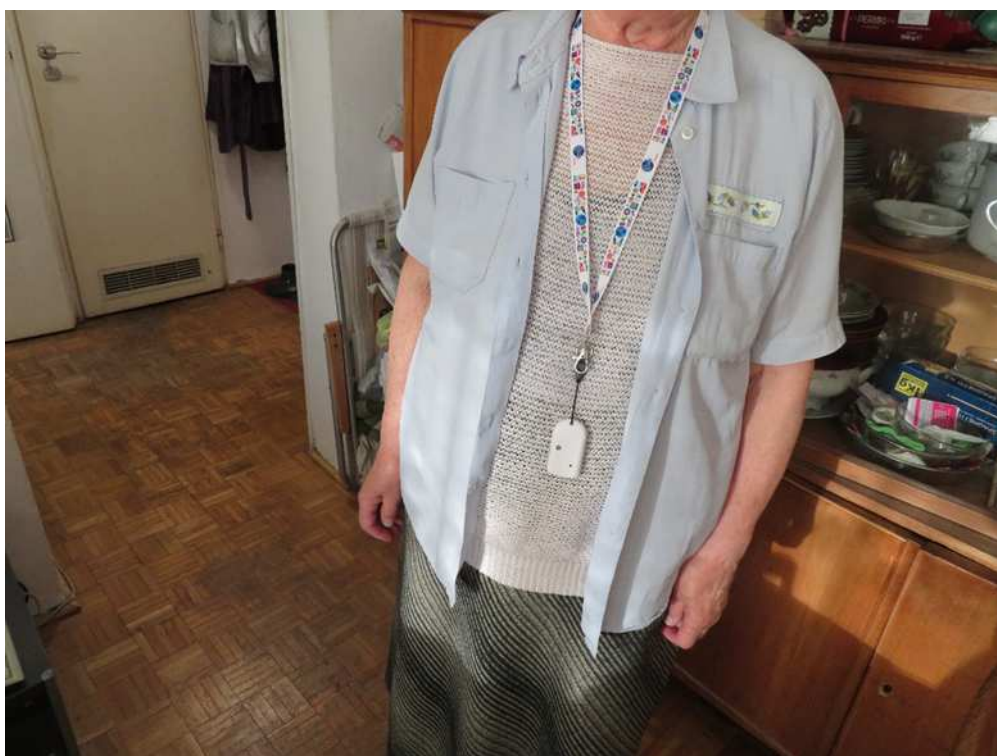
**Figure 3. End-user wearing Xiaomi Mi Band 3 activity tracker (right wrist) and smartwatch SWKW88 (left wrist).**



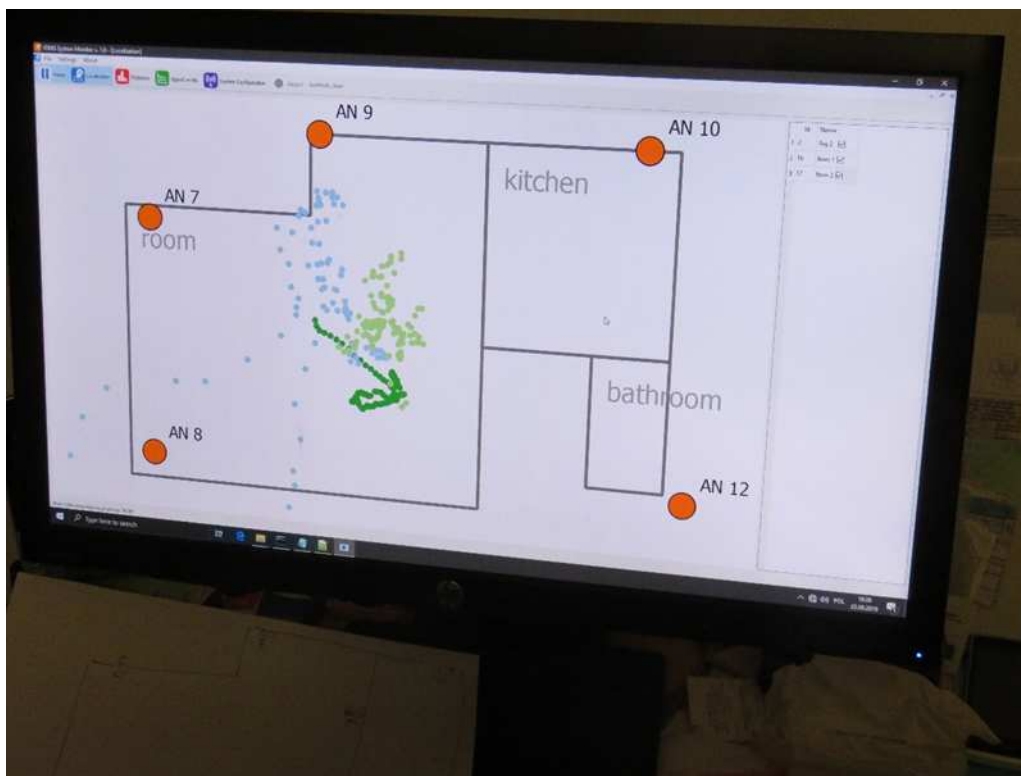
**Figure 4. Placement of EMFIT sleep sensor under a mattress.**



**Figure 5. Placement of UWB/BLE sensor (anchor) for location tracking system within home (developed by WUT).**



**Figure 6. An end-user wearing a tag for UWB/BLE location tracking (developed by WUT).**



**Figure 7. End-user interface (portal) for UWB/BLE location tracking system (developed by WUT). Five red circles indicate system anchors – sensors installed in the apartment of an end-user. Green small dots represent the trajectory of movement (a walking end-user wearing a tag).**

### 3.3 Deployment and platform configuration

Before the pilots, all the devices and sensors were checked in the laboratory conditions by the joined teams of WUT and DGW. The devices were subsequently connected to the IONIS platform in close cooperation between WUT and EXYS teams. The transmission of data was checked in laboratory conditions before starting the pilots with participation of end-users. Individual numbers were set-up to differentiate subsequent users and individual passwords were created by EXYS for logging into IONIS portal.

During the pilot trials with the end-users, several problems arose, previously not detected in laboratory tests of the system. They included, for example: sudden loss of data transfer due to temporary Internet access failure and loss of connection between the Internet router and the gateway; technical problems to log into IONIS portal due to technical configuration of computer devices (e.g. automatically installed firewalls); problems with transmitting blood pressure measurements to the platform (not all of the measurements were transmitted).

It was observed that in the end-users with no physiological arm swing during walking, Xiaomi Mi Band 3 significantly underscoring the number of steps. No arm swing during walking was due to very slow walking, paresis after stroke or walking with a walker (see photograph below). It was later proved in the laboratory conditions that the device counts the steps only when placed on the wrist and when the user has normal arm swing during walking. Interestingly, no information on this limitation of use was available in the Xiaomi Mi Band 3 user manual when the device was chosen and purchased for IONIS pilots. This is an example of an unpredictable result of the pilots that shows important limitation for application in older individuals with certain motor disabilities. This limitation may not be overcome by system adjustment or platform configuration, but has to be taken into consideration when tailoring IONIS solution to individual end-users.



**Figure 8. A primary end-user walking with a walker.**

A primary end-user walking with a walker. Due to lack of arm swing associated with walking, Xiaomi Mi Band 3 does not measure steps correctly and in consequence, the result of daily activity is significantly underscored.

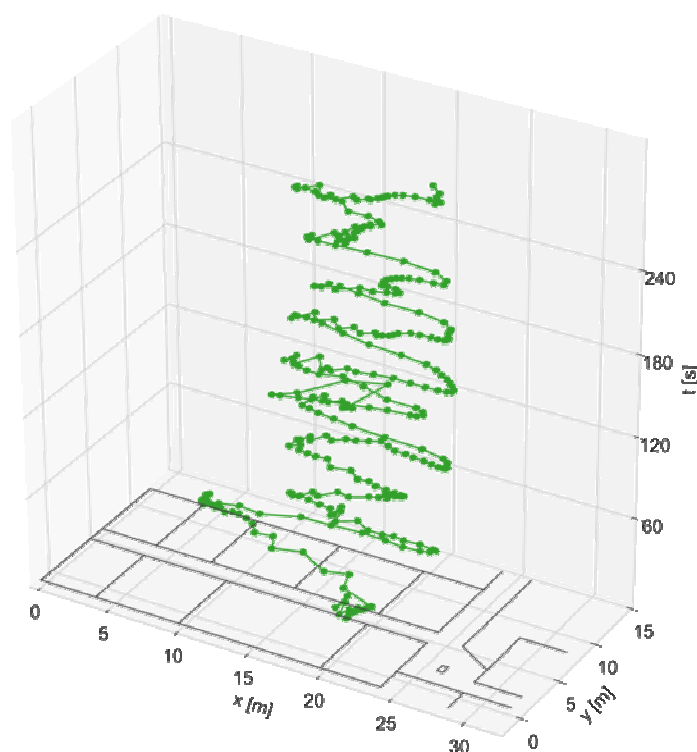
Additional problems arouse in connection with SWKW88. When the Internet mode was on, the device discharged its battery very quickly in approximately 4 hours. Moreover, if the device was discharged completely, the IONIS transmission mode was turned off and required new initialization.

Blood pressure meter with Bluetooth function performed and displayed measurements properly. However, the transmission of data was not complete, only some of the measurements were transmitted to the IONIS portal. The cause of this phenomenon was investigated by DGW in cooperation with WUT and EXYS and it was concluded that the phenomenon was due to the fact that blood pressure measurements were conducted immediately after the device was switched on, before the Bluetooth was activated. Steps towards solving this problem were taken, e.g. training the end-user to wait for one minute after turning the device on before taking the measurement.

Regular electronic mail exchange and Skype meetings with EXYS engineers allowed exchange of information and configuration of the platform and computers linked to the IONIS portal. Most issues were resolved within one or two sessions. Moreover, EXYS team provided on-line support on site at the end-users homes, if necessary. Technical partners tested solutions aiming at reducing SWKW88 battery discharge by turning off other applications using the energy of the smartwatch battery. This required good communication and performing additional trials with participation of technological and end-user partners of IONIS.

The results of the pilot testing were used for the further development of the platform and algorithms of data processing. For example, results of the UWB/BLE location tracking system were used to develop algorithms for detection of wandering – abnormal movement pattern seen in PwD. An example of the results of UWB/BLE system is shown below.





**Figure 9. Trajectory of movement of an end-user suspected of wandering behavior (UWB/BLE location tracking system developed by WUT).**

### 3.4 User experience and feedback

Acceptability of the solutions developed within IONIS project was one of the major issues to be addressed in the pilots by the end-user organizations including DGW. The overall acceptance of the system was good. End-users expressed their satisfaction related to the participation in the project focused on the needs of older adults. Most of them showed interest in novel technologies and ICT solutions. It was noticed, however, that the end-users perceived usefulness of proposed technological solutions, but in many cases did not relate the need to use ICTs to themselves. A common statement was “This is important aspect and solutions for older people are needed, BUT at the moment I don’t have a need of such a solution or using a device to monitor my status”. Such approach is seen very often in geriatric practice, e.g. older adults understand that falls are a big problem of the elderly population, but do not want to apply preventive measures to themselves, such as wearing appropriate shoes or installing handrails.

User experience and feedback will be described below for individual devices and the whole system including opinions of the primary and secondary end-users.

#### **Xiaomi Mi Band 3 - activity tracker**

All primary end-users accepted the device. They used the function of the wrist watch most often. Some of the users checked the number of steps regularly, approximately half of the users had difficulties with operating the device to show the number of steps performed during the day. Most of the end-users had problems with activating pulse measurement function which requires setting the device to the chosen function and holding a finger on the device for several seconds. End-users admitted that wearing the Mi Band 3 motivated them to be more active and walk more. From the geriatric point of view, this is a very interesting and important finding which proves that technology might have a positive impact on life-style.

Secondary end-users expressed positive opinions about the device and appreciated the possibility to monitor on-line the daily activity of their relatives. It proved that the function of Mi Band 3 as an activity tracker device goes beyond the direct function of step-counter, as it allowed indirect monitoring of daily activity. As shown on the photograph below, the end-user went out of the apartment and returned before noon, which is shown by the abrupt increase of the number of steps detected and transmitted by the system to the IONIS platform upon return home.



**Figure 10. The results of MiBand3 activity tracking device. Sudden increase of the number of steps indicates that the end-user went outdoors and returned at 11:00 a.m.**

The following example may illustrate the role of a simple activity measurement performed by Mi Band 3 as a safety measure for older adults. One of the primary end-users had a family member living abroad who checked the IONIS portal regularly every day. On one occasion when the number of detected steps was very low at midday, which was unusual for this primary end-user, the family member became worried and made a phone call to the primary end-user. The user proved to be in a usual condition and the reason for low count of steps was a temporary lack of Internet access.

#### **Kingwear smartwatch SWKW88**

Kingwear smartwatch is quite big and relatively heavy (as shown on the photo below), which arises questions about its suitability for older individuals.



**Figure 11. End-user putting on the SWKW88 smartwatch.**

SWKW88 was accepted by two out of three men participating in the pilots. None of the female participant accepted the device. They claimed it was too big, too heavy and did not suit their concept of a watch.

Two men who readily used SWKW88 were satisfied with its function as a watch and overall appearance, but had problems with the access to the results of the function of step counter. Even though the face of the clock is quite large, the function icons are small and assembled in a rotating circle which might be confusing even for people without any cognitive impairment. The smartwatch required daily charging. Charging of the device was somewhat complicated, because the charger provided by the producer required precise placing and fitting of the smartwatch. The photo below shows how the end-user is connecting the smartwatch to the charger. Moreover, when the Internet function was on, the SWKW88 battery lasted for only several hours

(approx. 4 hours). This previously unpredicted phenomenon required charging of the device several times a day and was troublesome for the end-users, especially taking into account their memory problems. Additionally, if the SWKW88 battery was discharged completely, the smartwatch was turned off automatically and it was necessary to manually restart IONIS application. This task was a nuisance for the users.

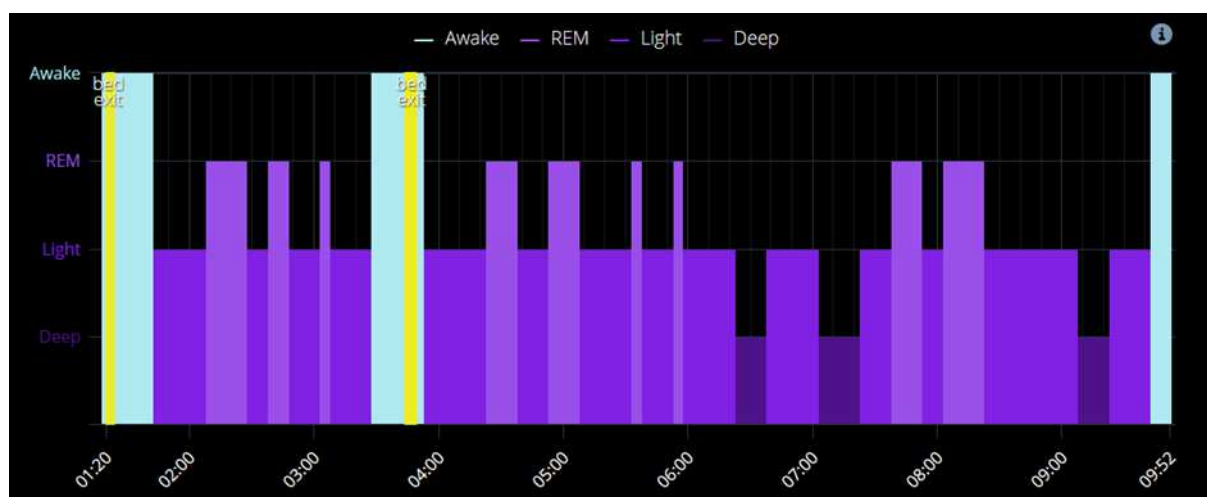
The secondary end-users expressed negative opinions about suitability of the smartwatch SWKW88 for older individuals.



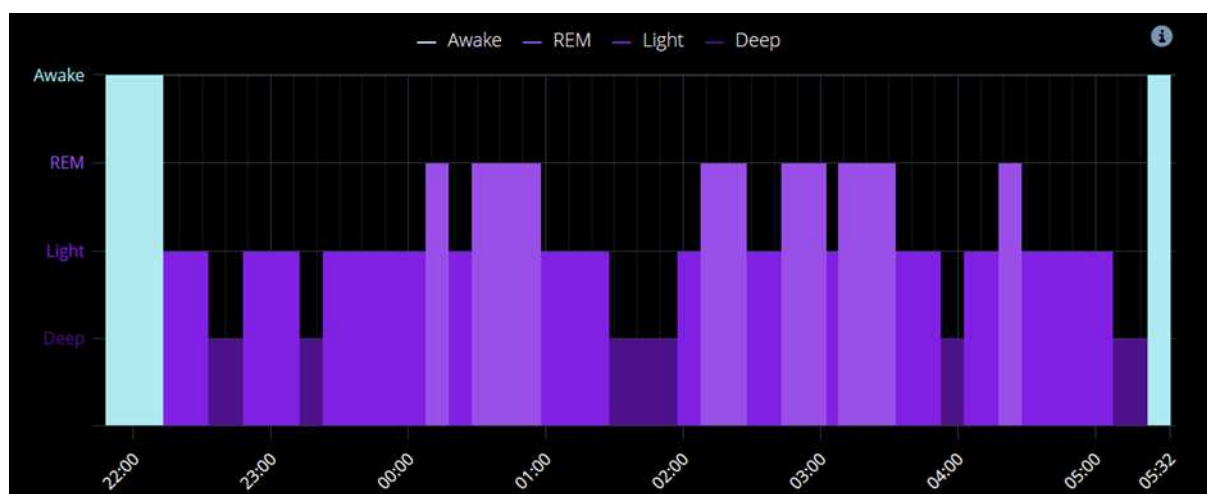
**Figure 12. An end-user learning how to charge the SWKW88 smartwatch.**

### EMFIT QS Clinical Sleep sensor

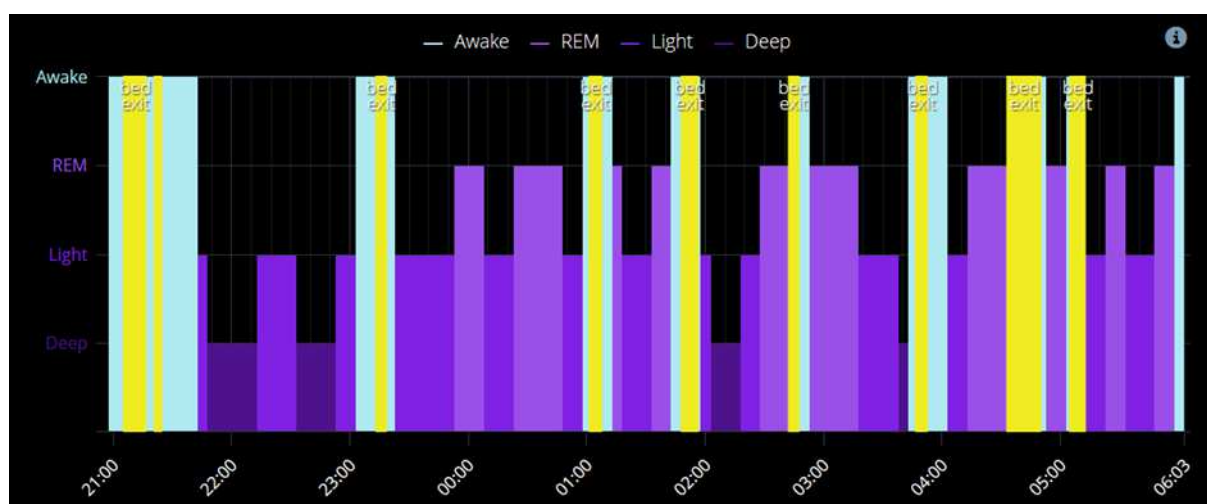
The sleep sensor was very well accepted by the primary and secondary users as a completely unobtrusive monitoring. It was found to be useful for monitoring of the presence in bed as well as bed exits at night. A change in the pattern of going to sleep and waking up in the morning could indicate change in health status of the primary end-user and prompt action by the secondary end-user. The sleep sensor was especially useful for users living alone – their family members could check their presence in bed during the night. In one case, the results of EMFIT sleep sensor prompted a decision of the caregiver to install a camera monitoring the apartment. The primary end-user had multiple night bed-exits to the toilet which significantly increased the risk of falling at night. Therefore, handrails were mounted and constant monitoring by a camera was introduced by the caregiver with acceptance of the user. The graphs below show examples of the results of EMFIT sleep sensor in three users.



**Figure 13. Example of an end-user going to sleep late in the night and waking up late in the morning, with one bed exit during the night (yellow line). Change in the usual pattern might indicate health problems.**



**Figure 14. Example of an end-user living in a rural area who goes to sleep early in the evening and wakes-up early in the morning as a lifetime habit. Note differences in comparison with the previous graph.**



**Figure 15. Example of an end-user performing many bed-exits (yellow lines) during the night due to the need of going to the toilet (nocturia).**

Example of an end-user performing many bed-exits (yellow lines) during the night due to the need of going to the toilet (nocturia). In persons with dementia, such pattern might require differential diagnosis of disrupted sleep and bed exits, e.g. it might be due to behavioral symptoms such as agitation or wandering. Multiple bed exits during the night indicate also an increased fall risk and should prompt activities to reduce the risk of falling e.g. supportive devices (e.g. handrails, portable toilet).

EMFIT device is equipped with a light indicator of effective WiFi connection and transmission of data. It is very useful, especially if the signal strength is low. Below, is an example of lack of EMFIT signal transmission due to large distance between the device and the WiFi in the router.



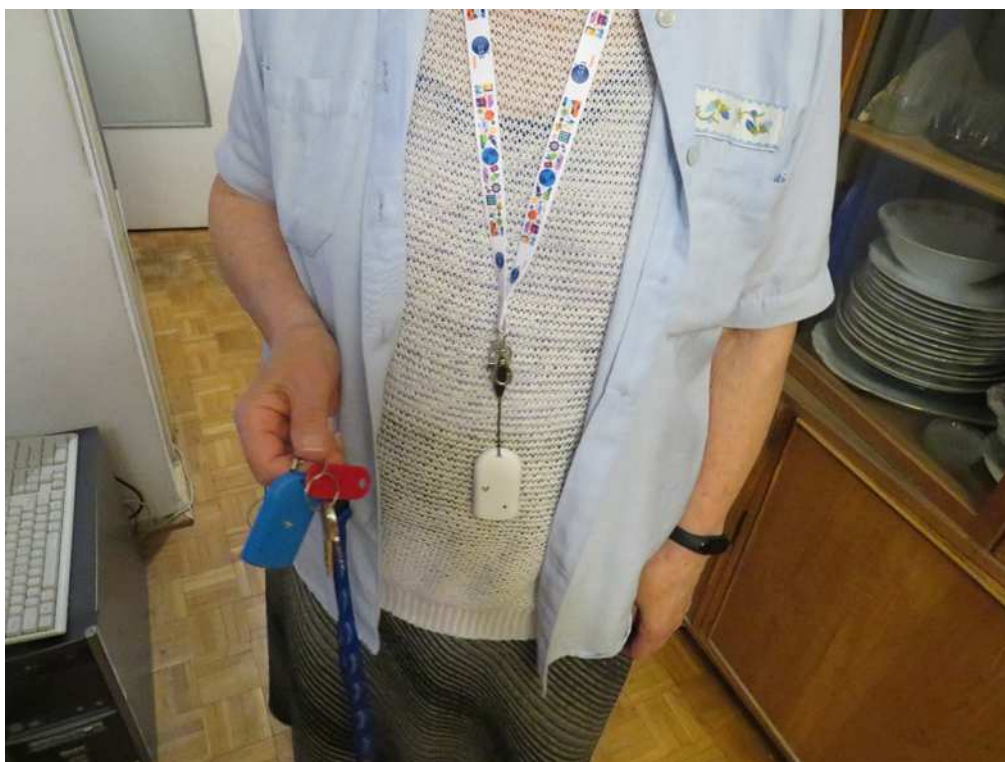


**Figure 16. Lack of WiFi connection of EMFIT sleep sensor indicated by a red light emitted by the device due to placement of Internet router in a distant room.**

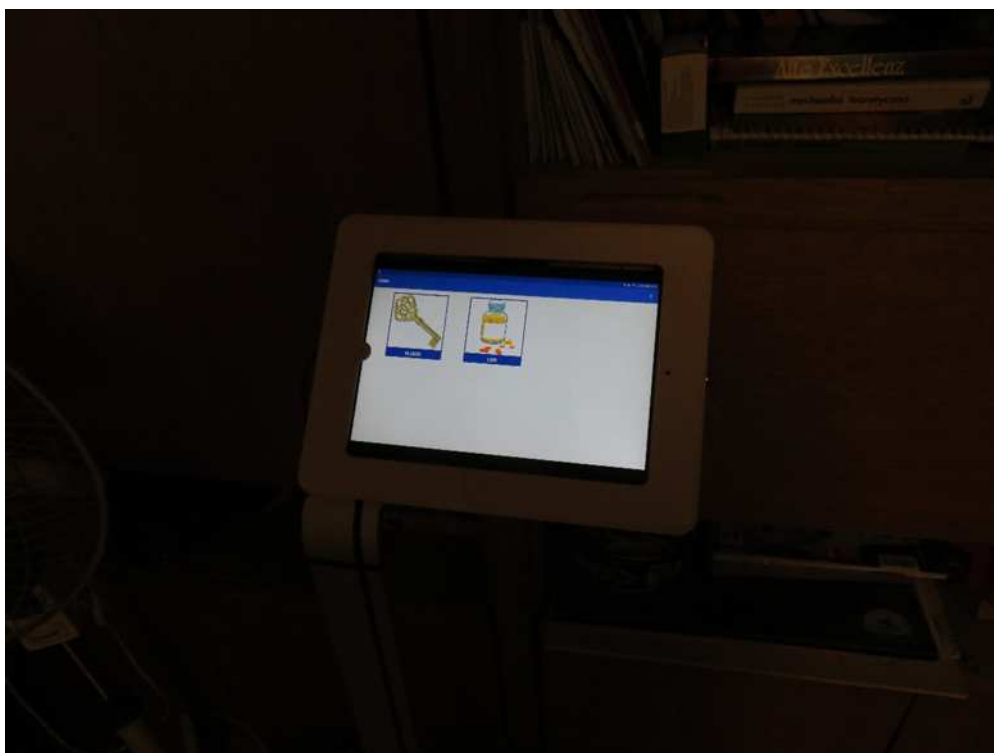
#### **UWB/BLE location tracking system (developed by WUT) for location of people and objects within home**

Primary end-users accepted the solution and the idea of wearing a tag enabling location in the apartment. The end-users did not complain about the placement of anchors in the apartment as the sensors were installed thoughtfully in places not readily visible, on the furniture or water pipes (shown on the photo in 3.2. - Protocol).

The primary end-users often forgot to wear the tags, which could be resolved in the future by placing the tags in the user's clothes instead of the lanyard form used in the pilots. At the start of the pilots, end-users expressed high interest in the function of finding objects and readily agreed to place tags on the objects e.g. keys, but during the pilots, they did not perform this function and claimed it was not suitable. The tablet for localization of object was placed on a comfortable and easily visible stand, but it did not prompt the users to use the "search for object" function. Photographs below illustrate the use of UWB/BLE location tracking system.



**Figure 17. UWB/BLE tags for location of the end-user (white rectangular box, lanyard form) and her keys (blue rectangular box attached to the key holder).**



**Figure 18. Tablet with installed object finding function of UWB/BLE location tracking system.**

### **Blood pressure meter with Bluetooth**

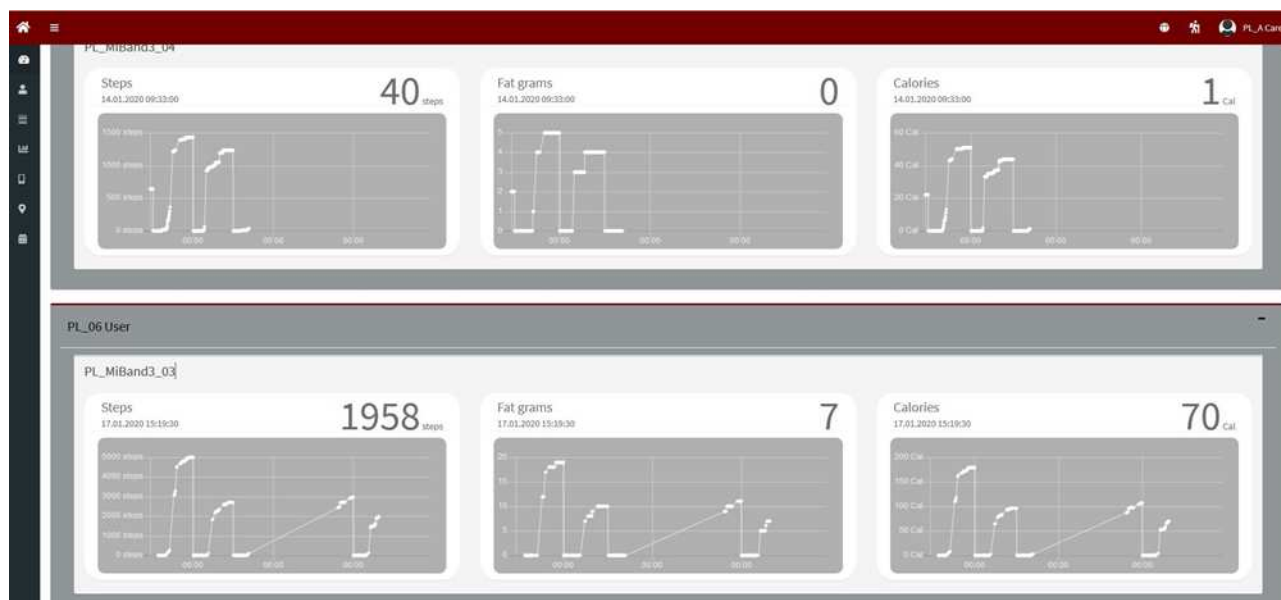
Primary and secondary users did not express any negative opinions about the blood pressure meter with Bluetooth, as it was very similar to a regular blood pressure meter.

### **IONIS portal**

Some of the primary end-users were willing and able to access the IONIS portal by themselves. They expressed the following comments about the dashboard: English language used in the user interface (portal) did not facilitate the use of the portal; opening of dashboard screen took a lot of time; the portal should be more intuitive to facilitate the choice of data files.

Secondary end-users checked the data in the IONIS portal with varying frequency. They expressed similar opinions and suggestions to those of primary end-users.

An example of the IONIS portal dashboard screen is presented below.



**Figure 19. Example of the IONIS interface (portal) dashboard screen.**

Example of the IONIS portal dashboard screen with results of two primary end-users wearing Mi Band 3 device. Lack of data in the upper figures was due to a temporary Internet connection failure confirmed on-site with the user.

### Additional user feedback

Several users expressed their perception of being “under observation” during the pilots. The statements were expressed in a joking manner, e.g. “Now, my daughter will know everything about me!” The DGW team did not notice any visible psychological discomfort during the trials. Primary end-users denied negative psychological impact of the pilots, when asked directly about it. On the contrary, most of them were proud to take part in research that might help seniors to lead safer and independent life. In general, it is important to address the issue of providing and maintaining the feeling of privacy and dignity of participants of any scientific research. Sensitivity to these aspects may guarantee that the human face of science will be always in the frontline of research.

## 4 Pilots in Slovenia

### 4.1 Introduction

In Slovenia the pilot 2nd phase began on August 9<sup>th</sup> 2019 and was completed on May 22<sup>nd</sup> 2020. The pilots were conducted with 30 end-users with the IONIS integrated platform. Piloting was performed together by both end-user partners, ASLO and IZRIIS. Piloting was performed with users with mild stage of dementia (MMSE score from 23 to 27) and their primary caregivers in their apartments / houses. Special attention was given to participants' area of living (urban (20 end-users) / rural environment (10 end-users)), their digital literacy (33% of primary end-users did not previously use computers or smartphones/tablets; all caregivers knew how to use personal computer to access and interact with IONIS platform and 73% were using their own mobile smart devices).

We have planned to include the end-users in the pilots on average for 4 weeks. Two end-users were continuously included in IONIS pilots for the whole period, in the first phase of individual modules piloting and in the second phase. Other end-users were included in IONIS PILOT 2nd phase for different time periods (from 14 days after the COVID-19 lockdown to 2 months during COVID-19 lockdown). During COVID-19 lockdown pilots were performed on a limited scale as physical interaction with end-users was not

possible. Some of the already installed sets remained operational, some were disconnected by end-users and we were not able to install IONIS at new end-users' residences.

Locations where the pilots were performed were:

1. Urban area
  - a. Ljubljana - testing lab at ASLO and IZRIIS - end-users and family members for testing the different devices and functionalities
  - b. Kranj - individual home / family flat or flat
  - c. Koper - individual home / family flat
  - d. Ljubljana - individual homes / family house or flat
  - e. Maribor - individual home / family flat
2. Rural area
  - a. Bohinjska Bistrica - individual homes / family house
  - b. Kurešček - individual homes / family house
  - c. Prapetno - individual homes / family house
  - d. Velika Nedelja - individual homes / family house
  - e. Zatočmin - individual homes / family house

## 4.2 Protocol

In the first step of the IONIS 2<sup>nd</sup> phase pilot, end-users were presented with different devices, functionalities and IONIS platform services. End-users had the opportunity to interact and test the IONIS solution in ASLO and IZRIIS lab testing. If the participants were not able to visit the lab, we have made detailed presentation at their home before installation. Participants were able to freely use the devices and have had enough time to explore the IONIS solution. Together we performed concrete tasks, like charging the devices, using the devices, entering their information, including new inputs (a new event or a medical appointment in the calendar). Afterwards, we have asked them if they understand it and if they know how to use it, they were also invited to perform the tasks by themselves and ask for assistance.



**Figure 20. User testing the IONIS devices.**

Based on the end-user requirements we have designed the following IONIS piloting equipment sets:

- Sleep quality sensor, smart bracelet with room level localization, activity recognition and heart rate measurement, domotic sensors (open/closed doors, opened/closed windows, smart light switches), mobile phone, IONIS integrated platform with calendar, scenarios and notifications, SPO gateway – two end-users were continuously involved in piloting since August 9<sup>th</sup> 2019, developed and integrated functionalities were added on an ongoing basis; it was possible to test the operation over a longer period of time;
- Sleep quality sensor, smart bracelet with room level localization, activity recognition and heart rate measurement, mobile phone / tablet computer, IONIS integrated platform with calendar,



- scenarios and notifications, SPO gateway; 18 end-users were included in the pilot from three weeks to two months;
- Sleep quality sensor, smart bracelet with room level localization, activity recognition and heart rate measurement, smart weight scale, tablet computer, IONIS integrated platform with calendar, scenarios and notifications, EXYS gateway; 6 end-users were included in the pilot from three weeks to two months;
  - Smart watch with room level localization, outdoor localization, activity recognition and heart rate measurement, sleep quality sensor, smart blood pressure measurement device, tablet computer, IONIS integrated platform with calendar, scenarios and notifications, SPO gateway; 4 end-users were included in the pilot from three weeks to two months.

After the end of each pilot with end-users we have performed a usability survey where we have measured the end-users' satisfaction with individual functionalities and with the IONIS integrated platform. The satisfaction was measured on a Likert scale from 1-Very unsatisfied to 5-Very satisfied. We have also discussed their experience with IONIS solution.

### 4.3 Deployment and platform configuration

On the agreed date we have visited the person's home/apartment, installed the devices, provided with the necessary credentials to access the account on the IONIS platform. We have demonstrated to the participants how to use the devices, how to use the IONIS platform. Primary and secondary end-user were invited to test the equipment, perform certain tasks with the devices and IONIS platform and consult with the technicians on-site. For any questions or troubleshooting, participants could contact our technicians. Occurred problems were regularly reported to the IONIS technical partner responsible for device integration or IONIS integrated platform. During the testing phase one of the staff monitored the reports from the end-users and collected their complaints or suggestions and reported to the technical team. An example of communication report:

*Today, I have tested the IONIS web platform. The smartwatch KW88 connects to the website without any difficulties. The problem appears with a blood pressure meter (AND A&D Medical UA-651BLE). I have measured my blood pressure for about 10 times. Website records only 3 times. It was recorded at 10.22 am, 10.27 am, 10.29 am.*

*I have also tested the calendar and the reminder. I can add the reminder. But I didn't receive a notification or show it on the dashboard.*

End-users involved in the IONIS 2<sup>nd</sup> phase pilots have tested the scenario presented in section 2.2.5. In this scenario various tasks were inserted into the IONIS calendar by the caregiver or the primary end-user. At the beginning we have trained with end-users the use of platform. The tasks could be regular or occasional, health related or related to social and meaningful activities. The IONIS system collected the data about primary end-user activities (wake up, moving around the apartment). The system notified the user to perform a certain task: health related (measurement) or other calendar activity. The user acknowledged receiving the reminder by pressing a button on the IONIS interface (portal). The IONIS system also detected automatically if a health measurement was performed by the integrated device. The end-users accessed the IONIS platform to access their data about measurements, activity tracking, and sleep quality analysis.

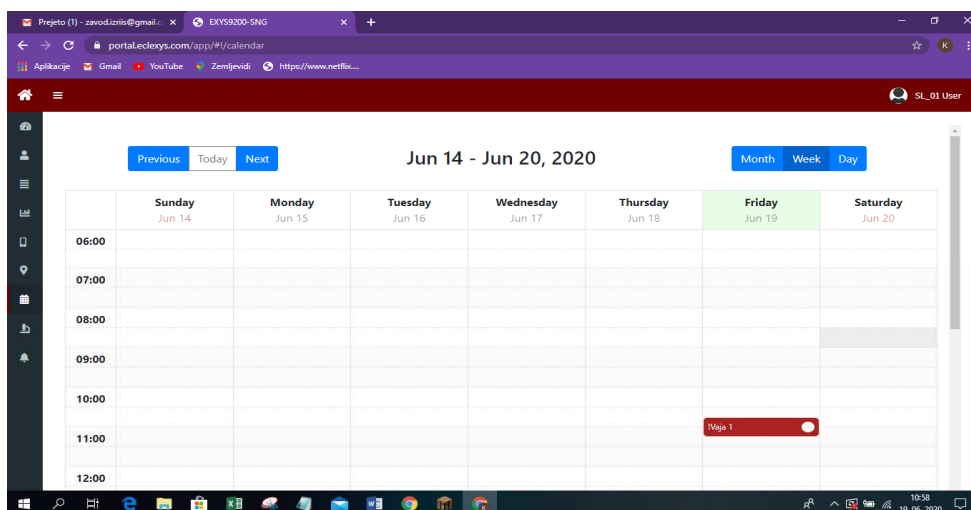


Figure 21. Example of calendar reminders.



Figure 22. Example of blood pressure measurements.

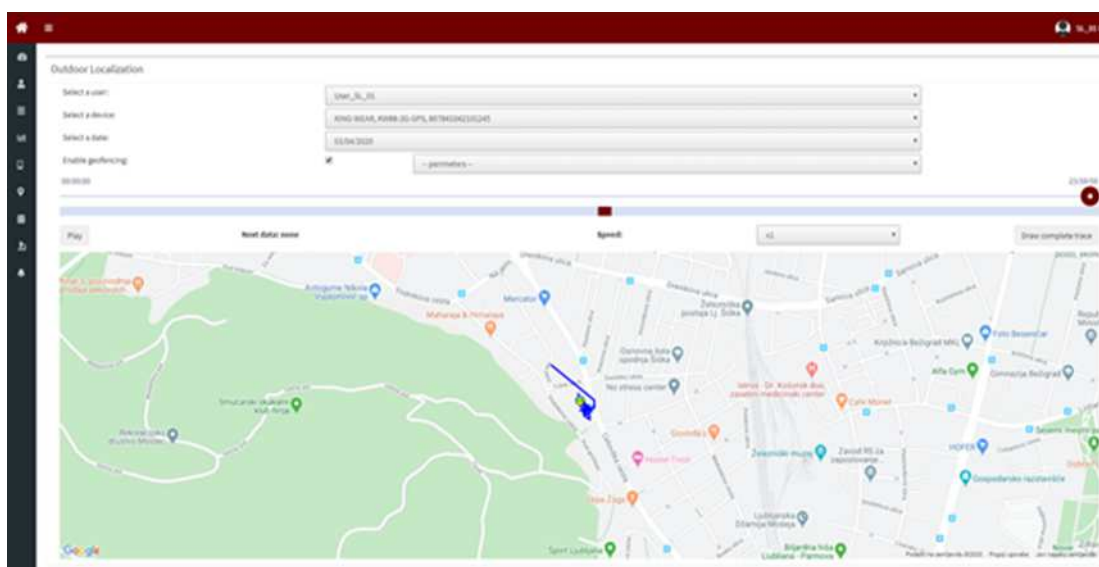


Figure 23. Example of outdoor localization.

## 4.4 User experience and feedback

The overall experience of end-users with the IONIS solution was positive. Although they have experienced some problems with accessing the IONIS web interface (portal) and/or the use of the devices, none of the users exited the pilots. The main problem appeared to be related with their digital literacy. Moreover, we have detected an increase in the primary and secondary end-users' confidence and competences with digital solutions (web interface, smart phone, tablet computer). During the whole duration of the pilot our staff was available to support them with the use of the IONIS solution. The main encountered problems were:

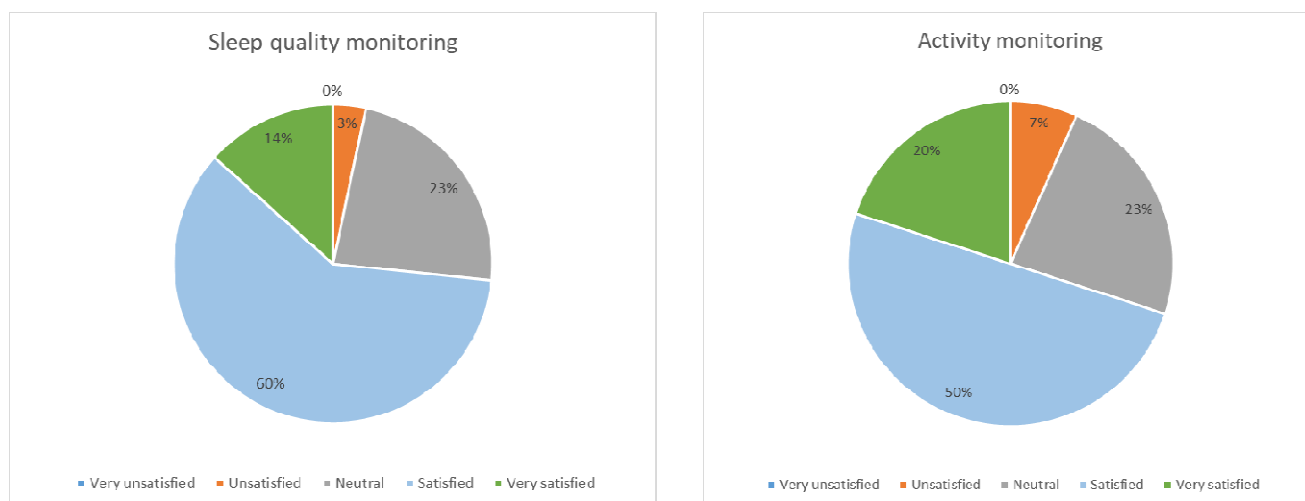
- IONIS web platform was in English language only; we have provided them with translations and instructions in Slovenian language;
- battery time of the smartwatch was very short and they had difficulties in charging it, afterwards they have forgotten to put it on; some of the caregivers paid special attention in checking the smartwatch status;
- the charging procedure for the Xiaomi smart band was very demanding, fortunately the average battery life was 9 days;
- they have experienced slow connection times and low responsiveness of the IONIS web platform.

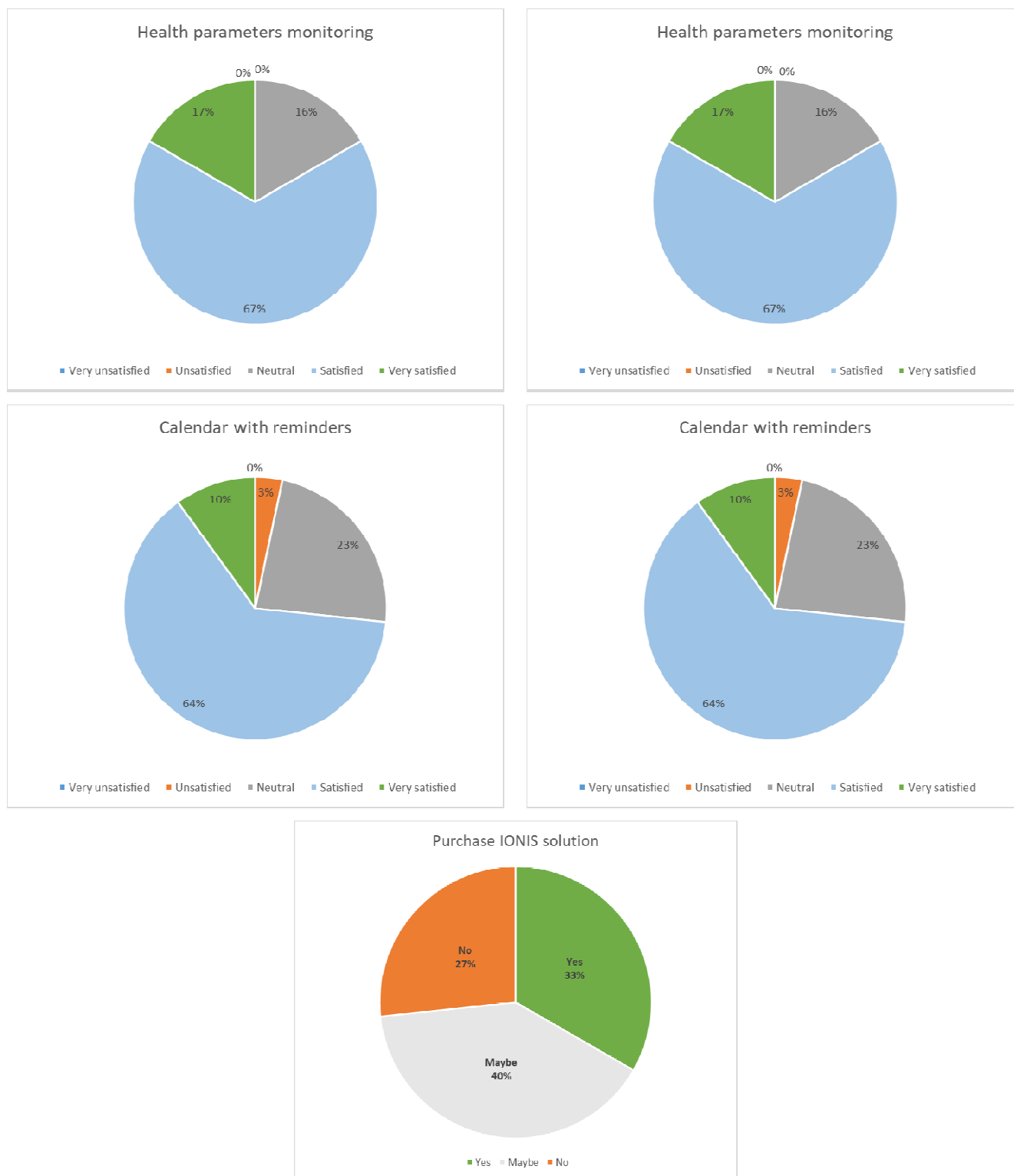
We would recommend to have digital literacy workshops for end-users, prior the pilots: In this way their competences with the use of smart devices and web interfaces would increase.

The main advantage of the IONIS solution from the perspective of primary and secondary end-users was the unobtrusive nature of integration. The system needed none to minimal user intervention, it "was working in the background and giving me support in performing my everyday activities...", "I was not terrified any more to forget if I have already taken my pills" and "I was reassured that if I would get lost finding my way back home from the cafe, my son will be able to find me and bring me safely back home...fortunately this never happened...". Based on their experience IONIS was addressing the right dementia related problems affecting their activities of daily living.

Majority of the involved end-users were not confident to be able to use a smart solution, especially considering dementia related problems they were experiencing. During the pilots they emphasized that IONIS was tailored to their needs as it didn't require their interaction to operate properly. Moreover, the IONIS platform components were designed so as not to reduce their level of independence, for example the reminders for tasks / appointments could be set to trigger only if the event did not happen. In this way they have kept their independence and were supported with IONIS in case an undesired event occurred. Users reported they have experienced also improvement quality of life perception as they had to organize and structure their day (calendar, scenario and notifications), were motivated to be more physically active (activity monitoring) and were able to have more social relations. The later was direct effect of IONIS providing for increased security at home and caregivers were able to leave home more often. It was also indirect effect of IONIS, they have had more visits of their friends and relatives to see the "intelligent system".

We have measured also the end-users' satisfaction with the IONIS individual functionalities, IONIS integrated platform and their willingness to become IONIS customers. The results are shown in the figures below.





**Figure 24. User experience analysis.**

The satisfaction rate with individual components was from 70% satisfied users with IONIS platform to 83% satisfied users with health parameters tracking. The overall satisfaction with IONIS solution was 70%. When we asked them if they would be willing to buy IONIS, 33% said, they would buy it, 40% could not decide (they were mainly concerned about the price / monthly fee) and 27% of the users involved in pilots would not buy an intelligent assistive service like IONIS.

## 5 Pilots in Hungary

### 5.1 St. Hedvig Home pilots

In the beginning of the pilots, the measurements were performed and supervised by four nurses and a senior nurse. In the meantime, however, one nurse withdrew from the program.

At the St. Hedvig Home, the health measurements were performed on a daily basis — including weekdays and weekends — for all pilot participants (with the exception of those who were measuring independently in the home using the GWs). These were done with caregiver supervision and caregiver assistance. Although there were some end-users who were able to measure e.g. their blood pressure and body weight in the presence of the caregiver, no elderly was able to use the glucometer for measuring their blood glucose not the balance measurement device. These were only done by the caregivers.

All participants' blood pressure, body weight, and balance were measured on a daily basis. Three participants had blood glucose measurements every day, and the others had blood glucose measurements as needed or when they wanted. ECGs were also performed on three people per day, but also on others, or even several times as needed.

2019. okt. 21 - okt. 27-ig	Hétfő (okt. 21.)	Kedd (okt. 22.)	Szerda (okt. 23.)	Csütörtök (okt. 24.)	Péntek (okt. 25.)	Szombat (okt. 26.)	Vasárnap (okt. 27.)		
<b>Összesen 198 (21) napi mérés végeztek a szomszédok:</b>	7	7	7	7	7	7	7	beírt	
V - vérnyomásmérés (fő)	3	1	1	1	2	1	1		
TT - testtömeg mérés (fő)	2	1	1	1	2	1	2		
A - alvászminőség-mérés	1	1	1	1	1	1	1	beírt	
okosóra -	2	2	2	2	2	2	2		
C - vércukorszint mérés - 1 touch select!!!									
<b>Napi mérésből kimaradt (fő):</b>	0	0	0	0	0	0	0	beírt	
<b>Mérésben résztvevők száma:</b>	2	2	2	2	2	2	2	beírt	
<b>Külsős mérések száma:</b>	8	5	5	5	7	5	6	41	kiszámolja
<b>Összesen 198 (21) napi mérés végeztek a szomszédok:</b>	18	18	18	18	18	18	18	beírt!!!!	
V - vérnyomásmérés (fő)	18	15	15	18	14	14	15		
C - vércukorszint mérés (fő)	2	2	2	2	2	2	2		
TT - testtömeg mérés (fő)	18	15	15	18	14	14	15		
ES - egyensúly mérés (fő)	18	15	15	18	14	14	15		
<b>Mérésben résztvevők száma:</b>	18	15	15	18	18	18	18	beírt	
<b>Szt. Hedvig-ben a mérések száma:</b>	92	77	77	92	76	76	80	570	kiszámolja
Sz - szabadságon van (fő)						1			
B - betegség miatt nem tudott részt venni (fő)		1				3			
K - Kórházban van (fő)									
N - Nem volt kedve ma mérésre jönni		2	3		3		3	beírt	
NT - Nem tudta használni az eszközt (elfelejtette)									
V - városba ment (délután jön vissza)									
A - Ambulancián járt vizsgálaton					1				
L-Leadta a TEG-t. Kilépett a projectből.									
M - meghalt									
<b>Napi mérésből kimaradt (Szt Hedvig):</b>	0	3	3	0	4	4	3		kiszámolja
<b>PILOT-ba bevontak össz. száma (fő):</b>	20	20	20	20	20	20	20		kiszámolja
<b>Napi mérésből kimaradt (össz.fő):</b>	0	3	3	0	4	4	3		kiszámolja
<b>Össz mérések száma:</b>	100	82	82	97	83	81	86	611	kiszámolja

Figure 25. An example of a weekly measurement quantity (21-27 October, 2019).

There were participants who were given a smartwatch for testing, with the help of which the heart rate, the amount of movement (number of steps), the outdoor and indoor location of its wearer could be traced. The caregivers received a report on the charge level of the smartwatches and it was their job to charge the watches. A sample of the daily data stored can be found in the form of a table (below)

UserID	Projekt	User	Vérnyomás	Vércukor	Testhőmérséklet	Mérlegelés (BalanceScale)	SmartWatch	BalanceScaleSwingPoints	A&DScale	BM95	PreBM95Data	Összesítő
11	AAL IONIS	Beteg 1	240	0	0	0	0	0	9	0	0	249
12	AAL IONIS	Beteg 2	582	0	0	0	0	0	314	3	3	902
9	AAL IONIS	Beteg 3	228	2	0	0	0	0	5	0	0	235
81	AAL IONIS	Beteg 101	0	0	0	0	0	0	0	0	0	0
68	AAL IONIS	Beteg 102	213	2	104	46	0	46	33	9	9	462
75	AAL IONIS	Beteg 103	212	17	139	47	0	47	40	11	11	524
54	AAL IONIS	Beteg 104	238	14	148	51	0	51	50	5	5	562
67	AAL IONIS	Beteg 105	99	9	5	0	0	0	0	0	0	113
70	AAL IONIS	Beteg 106	184	10	63	11	0	11	37	2	2	320
57	AAL IONIS	Beteg 107	357	20	212	83	0	83	58	4	4	821
91	AAL IONIS	Beteg 108	2	0	0	0	0	0	0	0	0	2
50	AAL IONIS	Beteg 109	210	11	96	16	0	16	50	6	6	411
71	AAL IONIS	Beteg 110	291	26	157	49	0	49	52	14	14	652
58	AAL IONIS	Beteg 111	204	2	99	10	0	10	51	0	0	376
62	AAL IONIS	Beteg 112	213	15	104	55	0	55	37	11	11	501
63	AAL IONIS	Beteg 113	258	10	135	53	0	53	47	4	4	564
51	AAL IONIS	Beteg 114	276	9	156	70	0	70	55	6	6	648
77	AAL IONIS	Beteg 115	269	65	152	64	0	64	44	9	9	676
74	AAL IONIS	Beteg 116	154	7	78	8	0	8	41	8	8	312
69	AAL IONIS	Beteg 117	287	10	165	67	0	67	45	30	30	701
72	AAL IONIS	Beteg 118	159	7	51	8	0	8	20	4	4	261
78	AAL IONIS	Beteg 119	217	17	77	0	0	0	45	1	1	358
64	AAL IONIS	Beteg 120	242	15	140	59	0	59	49	4	4	572
65	AAL IONIS	Beteg 121	192	8	86	11	0	11	43	2	2	355
60	AAL IONIS	Beteg 122	30	0	0	0	0	0	0	0	0	30
76	AAL IONIS	Beteg 123	93	2	5	0	0	0	0	0	0	100
56	AAL IONIS	Beteg 124	216	9	104	38	0	38	33	9	9	456
52	AAL IONIS	Beteg 125	280	13	157	50	0	50	54	6	6	616
49	AAL IONIS	Beteg 126	253	15	180	71	0	71	114	10	10	724
61	AAL IONIS	Beteg 127	139	17	109	25	0	25	46	11	11	383
53	AAL IONIS	Beteg 128	166	13	149	65	0	65	48	14	14	534
66	AAL IONIS	Beteg 129	71	5	58	49	0	49	0	7	7	246
73	AAL IONIS	Beteg 130	25	3	23	8	0	8	0	3	3	73

Figure 26. A sample of the daily data stored can be found in the form of a table.

and also in the form of a graph of it, for example, if a given participant wants to present it to his/her doctor (below).

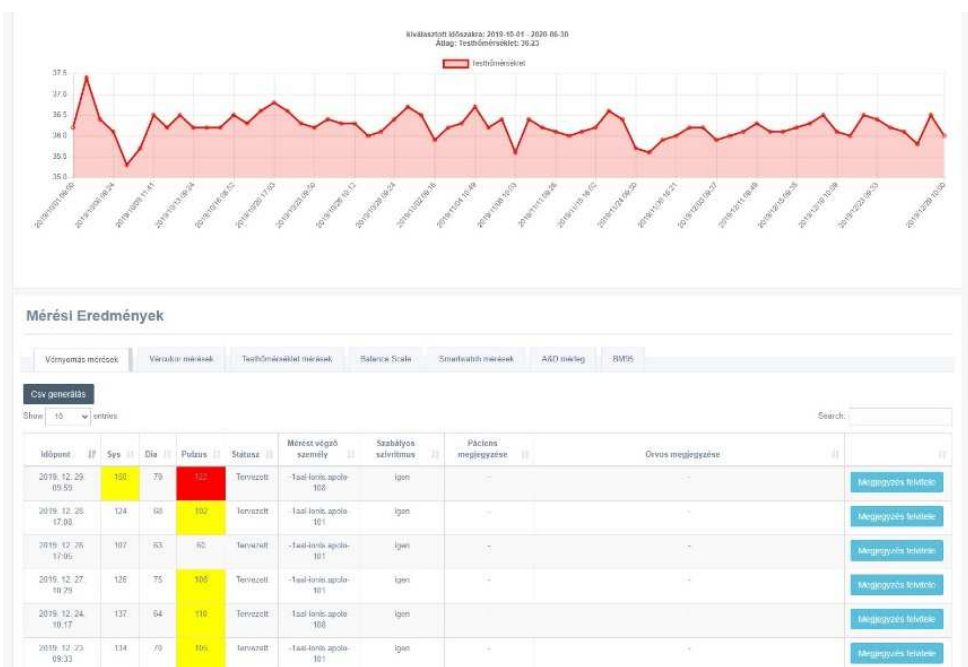


Figure 27. A sample of the daily data stored presented in graphical form.

There was also an end-user in the St. Hedvig Home who tested the sleep quality sensor placed under the bed mattress.

## 5.2 Pilots with “independent users”

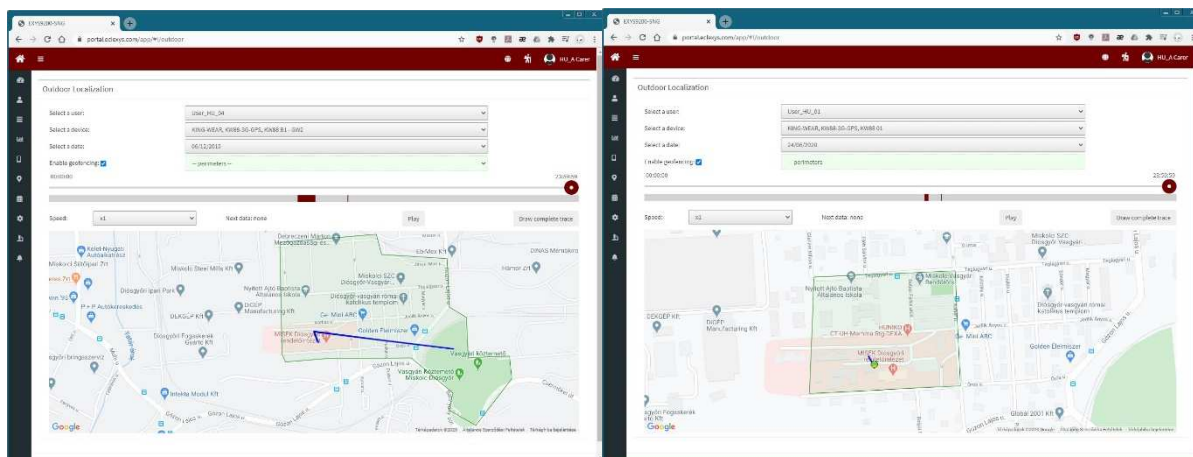
Participants who were able to master all elements of the self-measurement process (turning on a cell phone, logging into the system, using their own NFC member tag, attaching a blood pressure monitor, etc.) participated in the pilots also almost independently, i.e. they performed the measurements by themselves but under the supervision of the caregiver on duty.

### 5.2.1 Pilots in St. Hedvig Home

To test the integrated system, we received 2 IONIS Gateway devices from the Swiss consortium leader. End-users who were able to and undertake self-measurement rotated in two-week shifts using the GW and associated devices. This pilot started on November 4, 2019. In the integrated system, we tested the

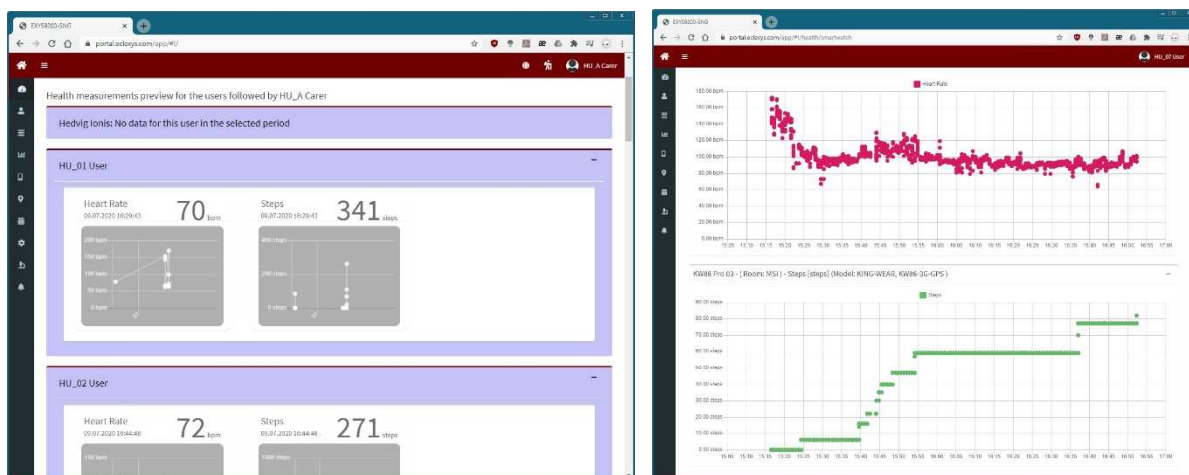


personalized calendar function, outdoor and indoor localization and various warnings and alarms issued by the platform.



**Figure 28. Outdoor geofencing**

7 end-users participated in the testing of the gateways, and 4 people tested the two gateways simultaneously. One tested the system with a blood pressure monitor, the other with a smartwatch and a personal scale. There was a change after two weeks of testing. A total of 16 two-week tests were performed with each GW. Thus, measurements were performed for a total of 32 periods of two weeks. The data sent through the gateway arrived at the IONIS server.



**Figure 29. Recorded data from independent users.**

### 5.2.2 Pilots in the user's own home

Independent participants tested the system in their own homes. They measured their blood pressure, body weight, one user also tested an EMFIT sleep sensor, and occasionally measured blood sugar levels. The graphs below are based on data from the daily measurements of one independent end-user.



One of the aims of the pilots was also the optimization and tuning of the IONIS platform based on the feedback obtained from the end-users.

The most common problems reported during the pilots were:

- The two GWs have become very hot
- In several cases, the acquired data did not reach the IONIS server
- GWs stopped a few times and needed to be restarted
- Mobile internet sticks connected to the gateway could not connect to the network every time it was started, so it was necessary to restart the GWs..
- In some cases, erroneous data appeared.





f. Navigating and using the IONIS interface (portal) required too much IT knowledge, which excluded the participants from use, but even exceeded the digital literacy of the caregivers. Moreover, since the info was in English.

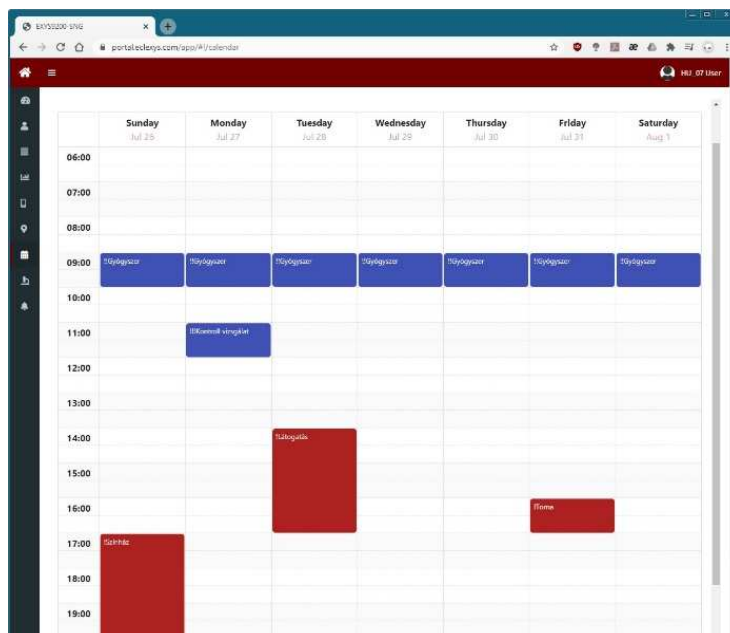


Figure 32. Calendar events.

### 5.3.1 The IONIS integrated devices

#### a. Withings Sleep Tracking Mat - sleep sensor

The most common problems were:

- The data was received on a separate server - the server provided by Withings Sleep Tracking Mat.
- Where the internet was weak, a separate GSM WIFI router had to be used
- For those who stayed in bed a lot during the day, the sleep analysis program could not interpret sleep cycles.

#### b. KingWear 88 type smartwatch

KingWear 88 smartwatch was used for assistance, outdoor and indoor localization, activity measurements (number of steps), heart rate measurement, and geofencing.

The most common problems were:

- Where the signal strength of the GSM service provider was weak, it was constantly searching for a network, causing some devices to become disturbingly warm and discharged extremely quickly.
- It was necessary to charge them daily, and in some cases several times a day.
- It was difficult to connect the charger, so BZN staff created a special 3 D printed adapter to make it easier for the elderly to charge.

All the errors found, detected and identified were recorded and reported during the consortium Skype meetings to help the developer to create a well-working, perfect integrated system in the project.

## 5.4 User experience

Several residents of the St Hedvig Home claimed that they felt more secure as their health parameters were measured every day during the IONIS pilots. It turned out that the pilot was a new kind of program for them in the boring daily routine. Thus, they could talk about it with others, they had to learn new things, so they had to move more because they had to get out of their rooms. It was also a positive benefit of the daily measurements that, if necessary, the previous results of a given resident could be easily passed on to the doctor. For example, there was a primary user who developed atrial fibrillation when the ECG was made, and one of these was accidentally recorded because we were making a short video about the project just

then. This video was presented at the Warsaw meeting. While watching the video, a doctor attending the meeting immediately discovered that there was a case of atrial fibrillation.

Regarding smart watches and indoor localization, there was no incident in the St. Hedvig Home that required intervention. Fortunately, during the trial period there was no wandering either. Users found that there was something interesting and new about the smartwatch which they had never encountered before. There were also participants who weren't very happy being tracked through the smartwatch whenever and wherever they were going. It was also an interesting experience that when one of the participants got a smart watch for testing, he was told what he got and why he got for and he was told also to take care of the watch because it is quite an expensive thing. A few days later we saw the smartwatch not sending data so we went out to the Home to check what happened. We saw that the participant was not wearing the watch. We asked him what happened, where is the smart watch? He replied, "Because it's very valuable, I put it in the Home's safe".

Unfortunately, none of the primary users of MSI were able to check or use the interface (portal) because of a lack of digital literacy. The interface (portal) was completely incomprehensible to the primary users of the St. Hedvig Home, so they could not use any of its functions on their own.

## 5.5 Conclusion in relation to users

Based on the experiences and feedback of the users, one of the biggest problems in almost all cases was that all but one of the primary users in the pilots had no digital literacy at all. This, not only made it difficult to use the integrated system and in some cases prevented users from using it. Unfortunately, this was also true for secondary users participating in the pilots. In addition, since none of the participants spoke English, these two problems were just enough to prevent users from trying to use the IONIS interface on their own.

## 6 Pilots in Romania

### 6.1 Introduction

In Romania the 2nd phase of the IONIS pilots began in August 2019 and was completed in May 2020. This period included a 3.5 months break because of the COVID-19 pandemics. The devices used for pilots in Romania included the following:

- Xiaomi Mi Band 3 - activity tracker;
- EMFIT QS Sleep sensor;
- A&D Precision Health Scale (UC-352BLE)
- A&D Blood Pressure Monitor (UA-651BLE)
- Z-Wave Fibaro Motion Sensor (FGMS-001)
- King Wear K88 Heart Rate Smartwatch
- IONIS GW with and without Z-wave connectivity.

### 6.2 Protocol

The protocol of the pilot studies included the following stages:

- Recruitment of end-users as described in section 2.1.4.
- Home visit at pre-scheduled date to identify the users' needs and wishes regarding the functionalities of the IONIS platform. We presented to the users the available functionalities and associated devices. We explained the usage of each device and also presented alternative devices for the same functionality (e.g. smartwatch and Mi Band can both record the number of steps). We also presented the IONIS interface, the own interfaces of the EMFIT and Mi Band devices. Translation of the interfaces was provided upon request.
- Once the setup for the pilot was selected, the user practiced under our supervision the usage of the devices and interface.
- Signing an informed consent and giving contact data of the CITST members to the primary and secondary end-users.
- Installing the system included also the installation of the GW and an access point which was used in case that the internet connection was poor or absent. The placement of the movement sensor (if selected) was discussed with the users. Additionally, mapping of the apartment for indoor localization was performed for one end-user using (see section 6.3).

- Once all sensors and devices were in place, we checked together with the user that the acquired data was reaching the IONIS server and was visible on the IONIS interface. We established a schedule for checking the IONIS interface for both the elderly and their informal caregivers
- Questions from the end-users were answered during the whole preparation session.
- Checking the IONIS portal daily by the members of CITST's team. These were also acting as informal caregivers for those users who participating without one.
- Home visits were payed once a week and whenever requested by the users because of a problem related to the usage of the platform or interruption of service (e.g. no internet connection, broken connection with the GW, etc.)
- After finishing the pilot study, primary and secondary end-users were: presented with options for after the pilots; asked about their feedback and observations using a structured form with closed and open questions. Questions were related to acceptance of devices, observed problems and willingness to use a similar system in the future as a long-term support.

### 6.3 Deployment and platform configuration

Participant were provided with the necessary credentials to access the account on the IONIS platform. The installation of the platform has involved, besides training of the users, also the actions described in this section.

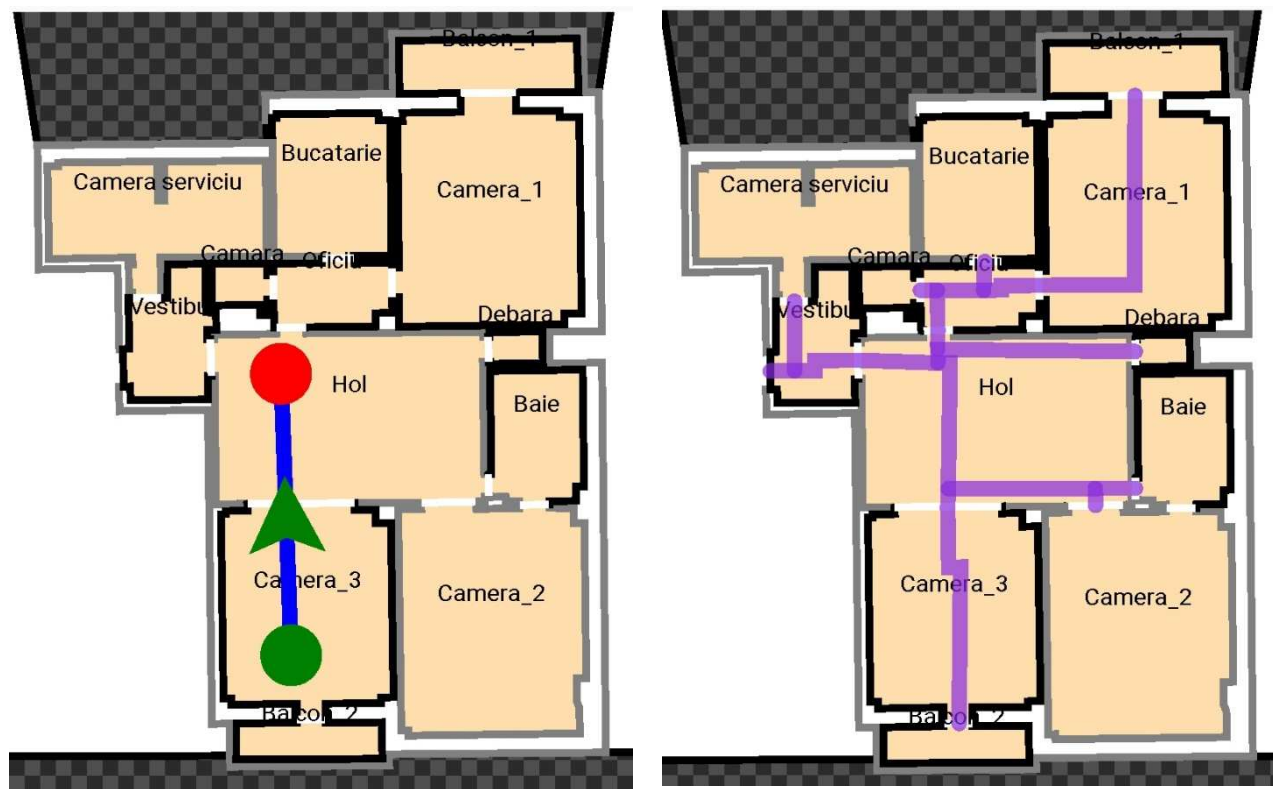
1) Installation of the GW was requiring the existence of a local WiFi network to which to connect the GW. When such a network absent, we had to also install an access point with mobile data connection. Also, depending on the selected setup for the platform, we deployed the GW with or without Z-wave connectivity. In particular, if the movement sensor was selected, then Z-wave connectivity was required.

2) Installation of the EMFIT sleep sensor also required local WiFi connectivity. In addition to some users missing WiFi connectivity, we also encountered two unexpected installation issues:

- the bed had only one mattress of the type which has a wooden frame and legs. So, there was no place to install the sensor;
- the user was sleeping on an extendable sofa bed which again was rendering the installation of the sensor impossible.

3) Charging of the Mi Band device proved to be so difficult that we decided to always deploy it fully charged and then charge it ourselves after approximately 1 week of usage.

4) The apartment of the user which was intended for indoor localization measurements had to be mapped using an application developed by the BZN partner and installed on an Android tablet. For this purpose, we had to provide BZN with a scale map of the apartment and with the measurements of the WiFi signal strengths. Fortunately, most of the Romanian users have a map of the apartment done to the scale because it is required for the national evidence and whenever somebody is selling/purchasing an apartment/house. The



**Figure 33. Interface of the application used for mapping an apartment such as to perform indoor localization with the smartwatch.**

5) Usage of the health monitoring devices was tested such as to establish the places in the home of the user where the devices were able to connect via Bluetooth to the IONIS GW. Because of the short range connectivity, the users were instructed to perform de measurements as close as possible to the GW. For example, in the user's apartment shown in Figure 33, the GW was placed in the room "Camera 3". Thus, the measurements (blood pressure & heart rate, weight) had to be performed in the same room or in the "Hol" room. Other places were out of reach for the data transmission.

## 6.4 User experience and feedback

The aim of the pilots was to establish the acceptability and usefulness of the solutions developed within the IONIS project among the intended end-users (people with MCI and mild dementia, informal caregivers) and to tune the platform based on the users' feedback. Based on the feedback received during the pilots and the answers of the users to the questions posed in the end of the pilots, we can conclude that the overall acceptance of the system was good. End-users expressed their satisfaction related to the participation in the project and showed interest in novel technologies and ICT solutions. However, when asked if they would like to purchase the future IONIS product, users were reluctant in committing to it. Nevertheless, several users expressed their interest in continuing to use some of the IONIS features (e.g. health monitoring, sleep monitoring and activity bracelets).

Users' experience and feedback will be described below for individual devices and the whole system including opinions of the primary and secondary end-users.

### 6.4.1 Xiaomi Mi Band 3 - activity tracker

As already outlined in D3.3, the users' acceptability for the Xiaomi tracker was high because the device is comfortable to wear (small, soft bracelet) and has a long battery life. Issues reported during the trials were the poor visibility of the screen when outdoors, difficult charging procedure, not water proof, no continuous heart rate information.

A 7000 steps goal per day was set for each user. The general attitude was very positive. Users reported to be feeling motivated in being more active. Three users suffered from diabetes and their MCI was partially related to the changes in the blood vessels induced by their long-term diabetes. Thus, for these users, keeping an active live and achieving their 7000 steps goal was important also from dementia management point of view. Same was the situation with the users suffering from cardiovascular and had a diagnosis of

vascular dementia. The rest of the users, understood that keeping an active life represents a proactive measure for maintaining their physical health and implicitly their mental health.

On the caregiver's side, they were able to check the activity of the primary users on the IONIS interface (portal). The fact that the elderly were keeping active was an indication of good physical and mental health. For example, prolonged inactivity can be a sign of depression which is often linked to dementia.



### 6.4.2 EMFIT QS Sleep sensor

The EMFIT sleep sensors which are installed under the user's mattress were used during the Romanian pilots. The installation has sometimes posed unexpected problems like for example missing plugs close to the bed, inadequate bed structure (see Figure below) or a sofa bed used both as a sofa during the day and as a bed at night. The first two cases were solvable with either an electric cord extender or by placing the sensor directly under the bedsheet (the users did not complain about the sensor bothering him during the night). However, we did not find a solution for the third case because. One considered possibility was for the user to install himself the sensor under the bedsheets before going to sleep. However, this turned out not to be acceptable and we dropped the usage of the sleep sensor. The interface as well as other problems encountered during the usage of the sensor were also reported in D3.3.



**Figure 34. A bed without a classical mattress (left) and a sofa bed (right).**

The sleep sensor was very well accepted by the primary and secondary users. Primary users did not complain about the sensor bothering them during sleep. They said that they do not feel it at all. One primary user has tested the sensor for 3 months because the sensor remained installed during the lockdown period. His caregiver was able to monitor bed exists and time spent in days, both of which are relevant in the case of people suffering from dementia. Also, a change in the pattern of going to sleep and waking up in the morning



could indicate a change in health status of the primary end-user and prompt action by the secondary end-user.

### 6.4.3 Health monitoring devices

The health monitoring devices used during the Romanian pilots were the A&D Precision Health Scale (UC-352BLE) and the A&D Blood Pressure Monitor (UA-651BLE). The latter is particularly relevant for vascular dementia. Also, the weight scale can indicate if there is sudden weight gain which might be caused by heart failure, a condition often associated with dementia.

There were no complaints regarding the usage of these device since they do not differ from the devices which the users normally own. The only complain was about the fact that the devices had to be placed close to the installed GW. In some cases, this was making the users uncomfortable because some were used to measure their blood pressure in a certain way and place.

Both primary and secondary users were interested in following on the IONIS interface (portal) the history of their measurements. Especially for hypertensive users, their caregivers were very content with this feature because high blood pressure increases the risk of stroke which can lead to vascular dementia. However, the users considered that the plots can be configured to be more adequate for older people (e.g. larger dots, better choice of colors).

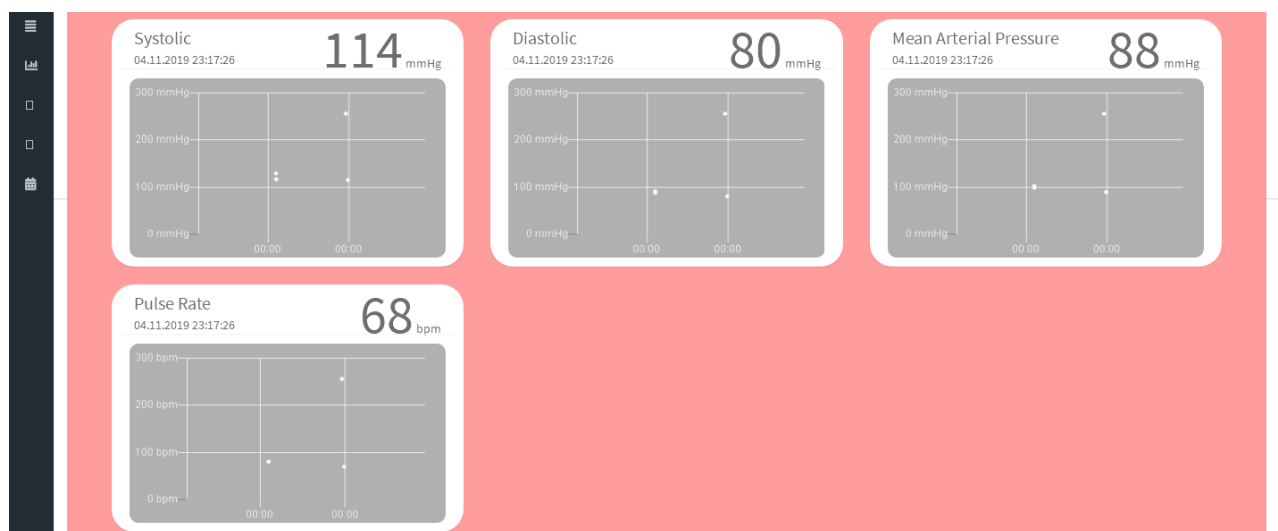


Figure 35. Health monitoring data on the IONIS interface (portal).

### 6.4.4 Z-Wave Fibaro Motion Sensor

The Fibaro motion sensor was used to implement the scenario in section 2.1.5, i.e. to indicate that the user has started her/his daily activity. The placement of the motion sensor was discussed with each user during the pilot preparation phase. There were no complains about the usage of the motion sensor since this is a completely non-intrusive sensor.

### 6.4.5 King Wear K88 Heart Rate Smartwatch

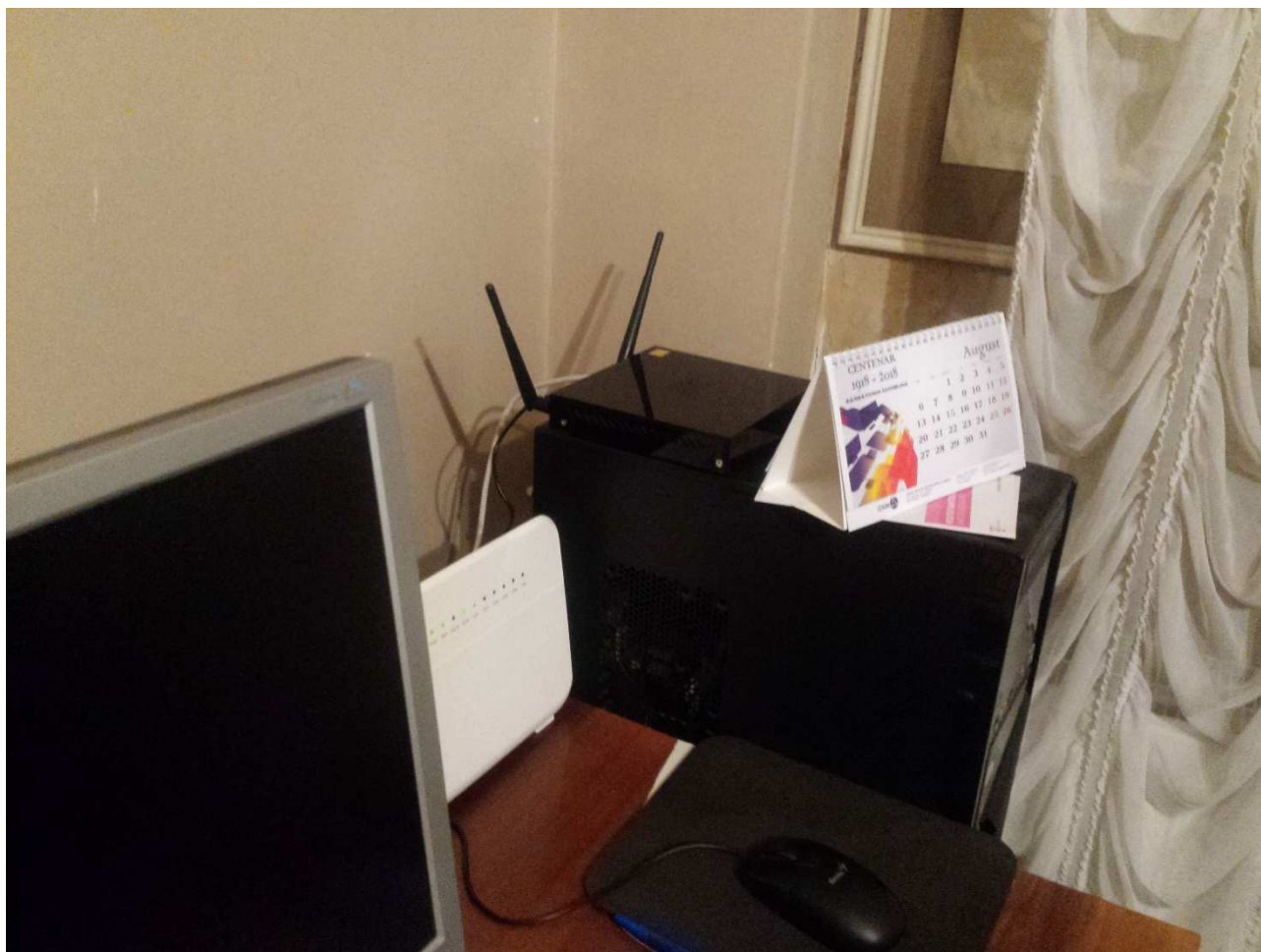
The Kingwear smartwatch is quite large and relatively heavy and we were able to persuade only male users to try it. Unfortunately, because of the pandemic situation we have mapped one apartment only and the tests which were performed were not conclusive for the usage of the smartwatch by people with dementia. There was no wondering reported while the other features of the smartwatch were covered by less bothersome devices (e.g. Mi Band).

Also, the user was not able to use the interface of the smartwatch themselves. Even though the face of the clock is quite large, the function icons are small and assembled in a rotating circle which might be confusing even for people without any cognitive impairment. The smartwatch required daily charging. Charging of the device was somewhat complicated, because the charger provided by the producer required precise placing and fitting of the smartwatch.

Therefore, the interest in wearing a bulky device was pretty low.

### 6.4.6 IONIS GW and interface

The IONIS GW with BLE only was used in all setups which did not include the Fibaro motion sensor. The motion sensor required the usage of a GW with Z-wave connectivity which was larger than the BLE one and also heating up faster. The main complains with the GW were from the CITST members during the installation procedure. There was little feedback about the GW functioning properly. Also, sometimes the sounds indicating correct functioning were heard but the data did not reach the IONIS server. The primary users did not care much about the GW because they were not often checking the IONIS interface (portal). In fact, a pair of elderly users who remained with the health monitoring devices during the lockdown continued measurements during the lockdown although their data did not reach the server. The CITST team members were not able to fix the problem remotely and visiting the users was not an option.



**Figure 36. IONIS BLE GW installed in a user's home.**

The IONIS interface (portal) was considered slow and difficult to use by all primary users. The fact that it was in English language did not bother them so much because we provided translation and because they did not in fact use the interface. Caregivers were able to make better use of the interface although they also complained about the slowness and bad graphics.

#### **6.4.7 Pilots questionnaire**

The questions in the figure below were posed to the users during and in the end of the pilots and used as guidelines in the description of the user experience outlined in the previous sections. The third set of questions did not yield the expected results. The users were not able to estimate how much the IONIS system, being complex and with new devices, would be worth and would cost. Therefore, their input was collected through a different strategy withing WP4.

The satisfaction rate with the IONIS platform was rated to be 75 %. In addition, 72% of the users said that they would use some of the IONIS components on a daily basis. However, 87% of the users did not like the interface and considered it to be difficult to use and slow.

### 1. Platform related questions

- 1.1 Did you encounter any problems or discomfort while using the IONIS platform? If yes, please provide details.
- 1.2 On a scale from 1 (lowest) to 5 (highest), how satisfied were you with the usage of the platform?
- 1.3 Do you think that using IONIS it has improved something in your daily routine/life? If yes, please provide details.
- 1.4 Would you use it on a regular basis in your daily life?

### 2. Interface related questions

- 2.1 Were you able to use the interface provided with the platform?
- 2.2 What did you like about the interface?
- 2.3 What did you dislike?

### 3. Interest to purchase

- 3.1 At what price would you consider the IONIS product/platform to be so expensive that you would not consider buying it?
- 3.2 At what price would you consider the IONIS product/platform to be priced so low that you would feel the quality couldn't be very good?
- 3.3 At what price would you consider the IONIS product/platform starting to get expensive, so that it's not out of the question, but you have to give some thought before buying it.
- 3.4 At what price would you consider the IONIS product/platform to be a bargain-a great buy for the money.

**Figure 37. Pilots questionnaire.**

## 7 Platform optimization during pilots

The architecture of the IONIS platform is described in the deliverable D2.1 "Design of system architecture and integration of core components". The minimal core and interface implementation are described in D2.2 "Implementation of minimum runtime and interfaces (Core subsystem)". The design of the GUI interface (denoted as IONIS interface of portal in the current deliverable) is split in these two deliverables. During the pilots, the users have been using an implementation of the platform described in these deliverables D2.2 and D2.3. To summarize here, for the purpose of pilots the IONIS core server and Web UI, as well as the related modules, database engines and software tools, were installed and hosted on a centralized VPS (Virtual Private Server) accessible from external by https protocol and secured by limiting user access through login credentials.

Users performing pilots were equipped with IONIS gateways and sensor devices, and could access the IONIS platform via the Web UI at URL: <https://prod.eclexys.com>. Personalized access credentials were assigned to every primary and secondary user involved.

One of the goals in performing the pilots was to get feedbacks about the IONIS platform and UI experience from primary and secondary users. These feedbacks were collected by the consortium partners and forwarded to the system administrators (EXYS), who, based on them, maintained an issue tracking (bug list) document. The issue tracking document allowed EXYS to fix bugs in the systems and to bring improvements while pilots were running. A sample of this document is presented in the table below.

**Table 1. Sample of the issue tracking document.**

Priority	Status	Reporter	Date create	Date fixed	Owner	Description	Comments
Low	Fixed	EXYS	2019.11.11	2019.11.12	SOFTIC	The drop-down list for setting the event's recursively is empty. It should offer Yearly, monthly, daily (like for example the google calendar).	not empty on EXYS server



Improve ment	Open	EXYS	2019.11.11		SOFTIC	Calendar should allow to delete events by right-click on the event.	Adding right click function is more complicated, because we are using the default plugin event handler, which means we have to separate a lot of built-in components with built-in functions to overwrite integrated ones and event handlers of the Calendar, which takes a lot of time. We can't do this now.
Normal	Fixed	EXYS	2020.11.11	2019.11.12	SOFTIC	Event's priorities cannot be "None". Priority must be 1, 2 or 3. Refer to the "message priority definition" document sent by EXYS on Sept 27th. The field Reminder (that in reality means "Notification type/way") it is implicit in the priority.	"None" option was removed from the list. After the new version is implemented, it will work.
Normal	Fixed	CITST	2019.11.14	2019.11.15	EXYS	It would be good for the users to remain logged	
Improve ment	Fixed	CITST	2019.11.14	2019.11.28	EXYS	Interface takes too long to load even for 1 day. The message that it might take too long appears even when selecting 1 day	With the new https server and after optimizing the code the response time was reduced. Further optimizations can probably be performed.
Normal	Fixed	CITST	2019.11.14	2019.11.16	EXYS	Measurements panel does not disappear left by pressing the arrow.	
High	Fixed	CITST	2019.11.14	2019.11.15	EXYS	The interface does not show the recorded data unless reload is pressed.	Yes. This is not a bug. The page is designed on purpose like this.
Normal	Fixed	CITST	2019.11.14	2019.11.16	EXYS	Interface might get stucked in the "Waiting - wait while data is loading" and one cannot escape from there	
Normal	Fixed	CITST	2019.11.14	2019.11.16	EXYS	Zero pulse from the Mi Band	
Improve ment	Fixed	CITST	2019.11.14	2019.11.18	EXYS	Too small points for the health data.	Changed to improvement because it is a representation issue
High	Fixed	CITST	2019.11.14	2019.11.16	EXYS	Bogus points	We were not able to duplicate this issue. We consider it as closed
Improve ment	Fixed	CITST	2019.11.14	2019.11.18	EXYS	Rather a line plot than singular plots for health data	Changed to improvement because it is a representation issue

Low	Open	CITST	2019.11.14		EXYS	Meaning of mean btw systolic and diastolic does not have a regular meaning	Please make explain this further.
High	Fixed	MSI	2019.11.15	2019.11.18	EXYS	Blood Pressure data sending problem. The sent and displayed measurement results are different than what the device shows.	The cause of this is that there was an old measurement done out of range of the GW, and the stored value was sent to the GW instead of the new one. We'll deploy a new version of the Bluetooth library to the GW to fix this.
Normal	Fixed	MSI	2019.11.15	2019.11.21	EXYS	Blood Pressure data Pulse value problem. On a device at every measurement only the pulse value is wrong and shows the same not real value.	This is a device issue, the GW receives the value from the blood pressure meter and sends it to the portal.
Improve ment	Fixed	BZN	2019.11.15	2019.11.21	EXYS	Device add page/Smartwatch - Switch UUID label to IMEI	It was left as UUID for compatibility, now it indicates IMEI.
Normal	Fixed	WUT	2019.11.19	2019.11.21	EXYS	After removing (Unpairing, Forgetting) the Mi Band from the GW (using the Gateway Portal) it keeps reappearing after some time.	Solved, it was a Bluetooth library issue.
Improve ment	Fixed	ASLO	2019.11.21	2020.12.14	EXYS	Data from sensors should update/refresh on the portal web interface automatically without pressing refresh button. (Discussed at consortium meeting)	
Improve ment	Open	ASLO	2019.11.21		EXYS	Develop a Web App to facilitate the access to access the IONIS portal. (Discussed at consortium meeting)	
High	Fixed	ASLO	2019.11.21	2019.11.30	SOFTIC	Calendar: displayed event in the calendar should not be smaller than half hour, even if the interval defined by the end user is for 5 minutes	The minimum height is half hour. After the new version is implemented, it will work.
High	Fixed	ASLO	2019.11.21	2019.11.30	SOFTIC	Calendar: when inserting the time of the reminder the time is in 12h AM/PM format, calendar is in 24h	Insertion is now in 24h format. After the new version is implemented, it will work.
Improve ment	Fixed	ASLO	2019.11.21	2019.11.30	EXYS	Calendar: Reminders should be also displayed as a list	Reminders will be notified as popup at least for the near future. We take this suggestion in consideration for future developments.

High	Fixed	ASLO	2019.11.21	2020.01.26	EXYS	Outdoor localization - Manage perimeter - New: Map shows Lugano and not end-user location, you can't enter the location/address	Now map it centered on the last position of the device (if any, otherwise it is centered to Lugano). Obviously can't be set to the user browser's position, for security reason.
High	Fixed	ASLO	2019.11.21	2020.01.26	EXYS	Outdoor localization - Manage perimeter - New: Fields Location / Lat / Lon - is this the location from the device	Lat and Lon are those of the last position of the device (where now map is centered, see bug 26)
Improve ment	Open	ASLO	2019.11.21		EXYS	Portal - translation in national languages	
High	Fixed	ASLO	2019.11.21	2019.11.18	SOFTIC	Calendar: dashboard notifications not working. (Discussed at consortium meeting)	Cron job was not running. EXYS confirmed, this is working. Or it is EXYS's website notification system bug.
Improve ment	Fixed	WUT	2019.12.01	2019-12-03	SOFTIC	After extending/shortening created event by dragging it, "!" are added in front of the events title, can be seen in the attached link ( <a href="https://wutwaw-my.sharepoint.com/:i:/g/personal/01003268_pw_edu_pl/EWUk63u3kcFLtMT3g_Cg7JABW99RDHrDURg09T-bE24dw?e=KJdEjC">https://wutwaw-my.sharepoint.com/:i:/g/personal/01003268_pw_edu_pl/EWUk63u3kcFLtMT3g_Cg7JABW99RDHrDURg09T-bE24dw?e=KJdEjC</a> )	Exclamation mark is not incrementing after update an event. After the new version is implemented, it will work.
Improve ment	Fixed	WUT	2019.12.01	2019.12.09	SOFTIC	Changing End Time of the event changes the Start Time. Maybe this is intentional but it can be a bit confusing, as people probably first set the Start Time and then End Time	Can you be more specific about the issue please? I made an event from 10:00 to 11:00, then changed the end time to 13:00, then to 10:30 and start time is still 10:00
Improve ment	Open	WUT	2019.12.12		EXYS	There should be some indicator on the portal that would show current status of the connection with the GW. For example - Green circle for "All OK - GW connected to the internet, has connection with EXYS and data is streaming", Yellow circle for "GW has connection with EXYS but data is not streaming" and Red circle for "no connection with GW at all". This way we could easily now the live status of the GW. It would be also great to have such indicator not only at the User's account but also at the Carer's account where	

						he could see in the "Users" menu statuses of their respective GWs.	
Improve ment	Open	WUT	2019.12.17		BZN	IONIS-App for smartwatch should automatically start on the boot-up of the smartwatch. End-users often do not manage to recharge the smartwatch on time (before it shuts down) and after they turn on the smartwatch, they need to manually turn on the IONIS-App.	
High	Fixed	WUT	2020.02.10	2020.03.04	EXYS	User is being logged out after some time, which makes the calendar hard to use, as user has to repeatedly sign in.	
Improve ment	Open	WUT	2020.02.10		SOFTIC	It would be good, if the calendar could automatically scroll to the current time of the day, so that the user could see at a glance if he/she has some reminders programmed for the current moment.	
Normal	Open	WUT	2020.02.10		SOFTIC	After the recurring event is added to the calendar it cannot be modified (neither the single one, nor all of the occurrences)	
Normal	Fixed	WUT	2020.02.10	2020.03.10	EXYS	After the new event is added to the calendar it does not immediately appear on the portal - the page needs to be refreshed - this may be an issue for end-users.	This still remains a thing, example: I have User_PL_02 logged on the tablet, with a calendar view. I am logged as a Carer_PL_A on my PC and from that account I add an event to the User_PL_02's calendar. Added event does not immediately appear on the User_PL_02's view, it shows after

							reloading the page.
High	Fixed	WUT	2020.02.10	2020.03.10	EXYS	Calendar notifications are not appearing on the dashboard/calendar page.	There is a observable delay ranging between 1 - 5/6 minutes, before the notification appears.
Low	Fixed	WUT	2020.02.18	2020.03.10	EXYS	Portal does not work anymore on PC on Edge or Internet Explorer browsers ( <a href="https://wutwaw-my.sharepoint.com/:i:/g/personal/01003268_pw_edu_pl/EW1KJHYTsUZIsU3y2_QmG_IBgeRaya_n8Ey7pisP8mSoUQ?e=rdWbNV">https://wutwaw-my.sharepoint.com/:i:/g/personal/01003268_pw_edu_pl/EW1KJHYTsUZIsU3y2_QmG_IBgeRaya_n8Ey7pisP8mSoUQ?e=rdWbNV</a> ). It works on Mozilla Firefox. On Android it works on Chrome and Edge.	The portal now correctly works on Edge, unfortunately IE is not supported anymore.
Low	Open	WUT	2020.02.18		SOFTIC	When adding an event to the calendar, "Recurring" field shows as empty on the Firefox browser ( <a href="https://wutwaw-my.sharepoint.com/:i:/g/personal/01003268_pw_edu_pl/EdGGLIT_erFLnsd_RZWfBqEB3mmERpjBQ4zhfNBu_dltjw?e=jc17qg">https://wutwaw-my.sharepoint.com/:i:/g/personal/01003268_pw_edu_pl/EdGGLIT_erFLnsd_RZWfBqEB3mmERpjBQ4zhfNBu_dltjw?e=jc17qg</a> )	
Improve ment	Fixed (partially )	EXYS	2020.02.18	2020.05.15	SOFTIC	RE should have minimal logic operation for multi-rule decisions (AND, OR, etc.)	The issue was fixed partially by allowing operators to implement multi-rules by programming a running python script

## 8 Overall conclusions and lessons learned

The performed pilots have involved 65 primary users, 30 secondary users (26 informal and 4 formal) from Poland, Slovenia, Hungary and Romania. Out of these, 18 users were from the rural area. A large variety of setups was used in the pilots based on the identified users' needs and requirements. Several functionalities of the platform were identified as being relevant to the dementia patients and their caregivers, as summarized below.

The EMIFIT sleep sensor can aid in identifying worsening of some symptoms associated with dementia. For example, an end-user performing many bed-exits during the night might require differential diagnosis of disrupted sleep and bed exits, e.g. it might be due to behavioral symptoms such as agitation or wandering. Multiple bed exits during the night indicate also an increased fall risk and should prompt activities to reduce the risk of falling e.g. supportive devices (e.g. handrails, portable toilet).



The Mi Band activity monitoring bracelet can indicate if the users stay active or if they are at risk of developing depression which is marked by increased lack of activity.

The smartwatch has a huge potential for people with dementia in identifying wandering both indoors and outdoors. However, the current limitations in battery lifetime and the difficult usage by elderly people are restricting its usage.

The satisfaction rate with the IONIS platform was rated to be above 70 %. The individual components of the platform were rated higher while the interface (portal) much lower. Thus, recommendations for improving the interface have to be first taken into account when bringing the IONIS products on the market.

In general, the elderly users living independently were able to use the devices on their own or with occasional help from their family members or friends. Digital literacy was identified in Hungary as being the main barrier in using the IONIS platform. However, one has to take into account that most of the users in Hungary were located in nursing homes and thus had a high level of dependence.

## 9 Document History

Date	Changes	Version	Author
M 30	Table of contents initialized	1	CITST
M31-M34	Partners, contributions added	2-5	CITST
M34	Final version	7	revision by CP

## 10 ANNEX 1

### 1. HEALTH SCENARIOS

#### Scenario 1 (IZRIIS)

The system reminds the user every morning at xx o'clock to measure his health parameters and to perform a planned set of exercise or a planned meal / food and beverage intake. After the completion of the exercises, the system asks the user to:

- measure his blood oxygen level with the oxymeter
- or to put in the a planned meal / food and beverage intake
- or to put in the exercise etc.

CAREGIVER can access a report giving the results (in tabular and graphical form) of THE USER health and activity parameters.

Sensor	Comment
Calendar with reminders on elderly user interface (smartphone, tablet, etc)	OK. version 1 available.
Caregiver interface	
Activity band: XMB2, XMB3, FBFTCH2	Mi Band OK FitBit Not OK (difficult collecting data)
Health monitoring devices: ADBP651	OK
Oximeter needed	TBD
EXYS GW required	YES

## **Scenario 2 (IZRIIS)**

Same as Scenario 1, but now THE USER forgets to perform the planned routine / tasks

- the system sends a vocal (TTS) alert three times (with a gap of xxx minutes one from the other) to THE USER, but receives no acknowledgement from him back. So, the system sends an alert on the Web dashboard to CARE-GIVER, in order for her to intervene.

Sensor	Comment
Calendar with reminders on elderly user interface (smartphone, tablet, etc)	OK. version 1 available.
Caregiver interface	
EXYS GW required	OK

## **Scenario 3 (CITST)**

Elderly user is waking up in the morning

A movement sensor or a sleep sensor is used to detect this fact

A reminder for health measurements is issued through the end-user interface.

Sensor	Comment
Motion sensors: Z-MS001	OK
or	
activity band (XMB2, XMB3, FBFTCH2)	Mi Band OK, FitBit Not OK
or	Preferred option to detect that users are awake
smartwatch (KWSMK88)	OK but limited autonomy due to battery lifetime (ca. 6h)
Health monitoring devices: ADBP651	OK
Interfaces (smartphone, tablet, etc)	DRAFT 1 available.
EXYS GW required	YES

## **Scenario 4 (CITST, MSI)**

Correlation of health data with other data, e.g. sleep and issuing of messages:

- your sleep has improved when you did more than 5000 steps
- your blood pressure is decreasing when sleeping or exercising longer, etc.

Sensor	Comment
Sleep monitoring sensor: EFSM, NOKSB	OK
Activity band: XMB2, XMB3, FBFTCH2	Mi Band OK FitBit Not OK (difficult collecting data)
EXYS GW required	Can be used, for Mi Band, as alternate solution to a smartphone

## **2. DOMOTICS**

### **Open door scenario IZRIIS but also ASLO similar**

- leaving the house open when leaving or when entering (in a house with multiple entries or levels)
- notification on the phone to the care-giver and elderly – after xx minutes

Sensor	Comment
Contact sensor at the door: Z-DT02	OK
Motion sensors or localization sensors to know that the person has left the house: Z-MS001, WUIL01	OK
Interfaces for both elderly and caregivers (smartphone, tablet, etc)	DRAFT 1 available.
Alternative to the above: smartwatch to know that the person is outside: KWSMK88	OK Limited autonomy due to battery lifetime (ca. 6h)
EXYS GW required	YES

Similar scenarios can be used for windows, opened refrigerator door, other electrical appliances and in combination with air quality (CO<sub>2</sub>, CO, smoke) detection.

### **Sensors in the bathroom/kitchen/toilet (ASLO)**

- detection of water flow in the bathroom
- sensors detect the person has left the bathroom
- water flow in the bathroom is still ON
- after N (2) minutes the reminder appears on the tablet/smartphone displaying the end-user interface, audio reminder for end-user is triggered
- if the person turns the water OFF the process is terminated
- if the bathroom water OFF not within a given time then a second reminder is issued / notification to caregiver is issued
- if the person leaves the apartment: notification to caregiver is issued

#### **Sensors**

- Water flow sensor
- Motion sensor in the bathroom: Z-MS001 - OK
- Interfaces for elderly and caregivers (smartphone, tablet, etc)
- Contact sensor at the entry door - OK
- WUT indoor localization infrastructure to know who has left the apartment:

### **Sensors to detect the electrical power consumption (ASLO) – not possible in all countries because in Romania gas stoves are mostly used**

- detection of electrical power consumption by the stove is detected
- stove may not be the most critical, other devices like iron and electrical heater, air conditioning may be more useful
- after N (30) minutes the reminder appears on the tablet/smartphone displaying the end-user interface, audio reminder for end-user is triggered
- the reminder has to be acknowledged by pressing a touch button on the interface
- if the electrical power consumption by the stove OFF not within a given time
  - a second reminder is issued / notification to caregiver is issued
  - if the person leaves the apartment -> notification to caregiver is issued

It can be applied also for water, coffee maker, water heater, iron

Sensor	Comment
Smart plug although I do not think this is OK for a stove: Z-PP102	OK
Interfaces for both elderly and caregivers (smartphone, tablet, etc)	DRAFT 1 available.
Contact sensor at the entry door	OK

WUT indoor localization infrastructure to know who has left the apartment: WUIL01 OR smartwatch (I am not sure)	Integration of WUT in the GW ongoing. Good progress status.  Presence of the Smartwatch KW88 could be detected by the GW (time required: few days)  If a Mi Band is used with the GW, this feature is covered for free
touch button	NO
Power plug tracked by the system	OK
EXYS GW required	YES

### **Light to prevent falls (ASLO)**

Very common issue is fall detection and fall prevention. A scenario for automated lights in case of reduced illumination for fall prevention should be implemented, for example:

- system detects the illumination of the room is below accepted value
- system detects the movement of person in the apartment
- lights in the room where the movement is detected are turned ON.

Sensor	Comment
Light and movement sensor	OK
Power plug switching light ON/OFF	OK
EXYS GW required	YES

## **3. CALENDAR REMINDERS**

- appointments / tasks (visit the doctor, pick up grandchildren at school, tennis with friends...)
  - reminder for activity if the person doesn't leave the apartment in time X min before (estimated time for travel + Z minutes for "preparation")
  - reminder for the caregivers X+n min in cases the user shouldn't meet the appointment /task (like pick up grandchildren at school)
- taking pills: reminder if the user forgets or if user leaves the apartment X min before the time for taking the pills
- taking health measurements (glucose, blood pressure...): reminder if the user forgets or leaves the apartment X min before the time for taking the pills

## **4. BEHAVIORAL SCENARIOS (DGW)**

### **Scenario 1 - (DIURNAL ACTIVITY DECREASED)**

An older individual gets up in the morning and begins his/her usual activity: goes to the bathroom, to the kitchen, to the bedroom and to the living room - activity meter measures normal activity. After breakfast the individual sits in the living room usually for about one hour). A notification is sent to the caregiver in case the individual's activity deviates from normal, diurnal activity is decreased as follows:

- staying in one place for more than e.g. 1,5 hours (sitting)
- getting back to bed (this could additionally trigger a separate alarm from the bed sensor).

Such a situation might indicate that the older individual does not feel well, feels weak or has difficulty walking. This might be due to: dehydration, electrolyte imbalance, fever, infection, confusional state, stroke or heart problems.

Sensor	Comment
Motion sensors might be also needed: Z-MS001 or other	OK
Activity band: XMB2, XMB3, FBFTCH2	OK ; Mi Band OK; FBFTCH2 NOK
Smartwatch (not sure): KWSMK88	OK, what accuracy needed? - exact indoor localization? - simply presence in a room? - simply presence in the flat?
Sleep monitoring sensor: EFSM, NOKSB (not sure if it would work like in the scenario)	OK
Interfaces (smartphone, tablet, etc)	DRAFT 1 available.
EXYS GW required	YES

## **Scenario 2 (DIURNAL ACTIVITY INCREASED)**

Same spirit as above

## **Scenario 3 (NOCTURNAL ACTIVITY)**

An older individual usually gets up during the night twice to go to the toilet. The alarm is sent to the caregiver in the morning if:

- the individual does not get up at all during the night (nocturnal activity = none)
- the individual gets up during the night 5 times or more (nocturnal activity increased)

The above deviation from normal activity during the night might be suggestive of: dehydration, fever, confusion state (hypoactive delirium), stroke or some other urgent debilitating condition - in case of decreased nocturnal activity OR urinary tract infection, diarrhea, pain, confusion state (hyperactive delirium) - in case of increased nocturnal activity.

Sensor	Comment
Motion sensors in the bathroom/toilet: Z-MS001	OK
Sleep monitoring sensor: EFSM, NOKSB	OK
Interfaces (smartphone, tablet, etc)	DRAFT 1 available.
EXYS GW required	YES

## **5. OUTDOOR (CITST, MSI)**

- if the elderly leaves the apartment, a notification is sent to the caregiver
- if the elderly goes outside the secure zone the IONIS system is sending a notification to the caregiver and the smartwatch of the elderly if vibrating
- system checks calendar for planned activities and locations
- smartwatch/band vibrates and message is displayed: would you require help / assistance?
  - o voice navigation to home/desired location
  - o message to caregiver for assistance

Sensor	Comment
Contact sensor at the door: Z-DT02	OK
Motion sensors or localization sensors to know that the person has left the house: Z-MS001, WUIL01	OK
Or	
Other presence sensor	Mi Band suggested, Smartwatch if available



Smartwatch (not sure): KWSMK88	OK, what accuracy needed? - exact indoor localization? - simply presence in a room? - simply presence in the flat?
Elderly user and caregiver interfaces (smartphone, tablet, etc)	DRAFT 1 available.
EXYS GW required	YES

## 6. FINDING OBJECTS (CITST, MSI)

The calendar is reminding the elderly person about his appointment at the dentist

The elderly person wants to leave for the appointment but is not able to find his keys. He is using the IONIS interface to find them.

Sensor	Comment
Calendar with reminders on elderly user interface (smartphone, tablet, etc)	OK. version 1 available.
WUT indoor localization infrastructure 01 might solve fully the scenario: WUIL01	
Interfaces (smartphone, tablet, etc)	DRAFT 1 available
EXYS GW required	Can be used, as alternate solution to WUT server + smartphone/tablet

## 11 Document History

Date	Changes	Version	Author
M28	Table of contents initialized	1v.1	CITST
M28	Partners, contributions added	1v.2	All partners
M30	Final version	1v.3	All partners
M33	Final version with typos corrected	1v.4	All partners
M33	Final review by the IONIS Internal Review Committee (IRC) and approval of it by the consortium partners.	1v.5	All partners

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