

AAL Project



Indoor and outdoor NITICSplus solution for dementia challenges

WP3: Pilots with primary and secondary users

D3.3: Report on pilots setup and module testing

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Abstract:

The report describes activities carried out within Task 3.3 (Work Package 3). The goal in this task was twofold: (1) to verify and validate with end-users proposed solutions in WP2; (2) collect initial data to be used in T2.4. Users have tested, depending on their preferences and needs, several modules of the platform and, when available, several technological solutions for a given module. For example, some users have tested both the Fitbit and the Xiaomi activity monitoring bracelets. The pilots have been performed in four countries (Poland, Slovenia, Hungary and Romania) between 1.9.2018 and 26.05.2019. The pilots were performed in real-life conditions by users living independently (mostly in urban areas but also in rural areas) and in elderly care facilities (23 elderly in Hungary and one in Poland).

A total of 86 primary and secondary users were involved in the pilots for varying periods of time which lasted from few days up to several months. Out of the 86 users, 67 were primary users which obeyed the inclusion criterion of having a MMSE score of 19-27. There was only one respondent with MMSE = 8 in Poland to check how the MiBand measures activity in a person walking with a walker.

Generally, users involved in the pilots found that the devices used in the pilots are helping them in staying more active, monitoring their health and improving their wellbeing (e.g. sleep quality). Most users have

stated that they would appreciate the device more if it would be part of some integrated service and have expressed their interest in continuing testing the IONIS platform in the following trials. Language issues have been identified as being important for the pilots with the integrated platform (especially, for the IONIS interface).

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. However, the users staying in elderly facilities were performing the health monitoring under the supervision of the facility nurses.

From technical point of view, we have identified several issues which will need to be addressed in the integration of the IONIS platform. In addition, data needed for algorithm development of sleep and activity profiles have been collected during the pilots.

When asked about purchasing (directly and not in installments) the devices the users were willing to purchase the Mi Band which is significantly cheaper than the FitBit. They were also interested to purchase the blood pressure meter. Polish users were less enthusiastic about purchasing the smartwatch, but one user declared being interested in buying a smartwatch for its prize. Romanian users were also not interested to purchase the sleep sensor but would have considered renting it especially after finding out that a monthly fee is anyway associated with the data transmission. Residents who live in St. Hedvig Home are not very interested in purchasing the IONIS system, they said that it is the job of the Home.

Keyword list: IONIS modules, pilots, activity monitoring, health monitoring, sleep monitoring

Executive Summary

The pilots with the individual platform elements have been performed in four countries (Poland, Slovenia, Hungary and Romania) between 1.9.2018 and 26.05.2019. They have started at different dates in different countries due to the availability of the infrastructure whose acquisition turned out to last significantly longer than foreseen.

A total of 86 primary and secondary users were involved in the pilots for varying periods of time which lasted from few days up to several months. Out of the 86 users, 67 were primary users which generally obeyed the inclusion criterion of having a MMSE score of 19-27. There was one respondent with MMSE = 8 in Poland to check how the Mi band measures activity in a person walking with a walker. Out of these, a number of 13 elderly users were living in rural or suburban areas and a number of 23 elderly were living in an elderly care facility in Hungary. In addition, also one Polish user was living temporarily in an elderly home. Out of the independent users, most had a family member offering constant support.

Generally, users involved in the pilots found the devices involved in the pilots useful for staying more active, monitoring their health and wellbeing (e.g. sleep quality). Most users have stated that they would appreciate the device more if it would be part of some integrated service and have expressed their interest in continuing testing the IONIS platform in the following trials. Language issues have been identified as being important for the pilots with the integrated platform (especially, for the IONIS interface).

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. However, the users staying in elderly facilities were performing the health monitoring under the supervision of the facility nurses.

From technical point of view, we have identified several issues which will need to be addressed in the integration of the IONIS platform. In addition, data needed for algorithm development of sleep and activity profiles have been collected during the pilots.

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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
BE	Bluetooth
BLE	Low energy Bluetooth
API	Application program interface

1 Introduction

A user centered design was employed in order to validate the solutions proposed in WP for the individual components of the IONIS platforms. For this purpose, we have engaged both primary and secondary users in testing various components of the platform in real life conditions. A number of at least 20 primary and secondary users have participated at each of the 4 pilots (Poland, Slovenia, Hungary and Romania). In addition to component validation we have aimed to also collect data for algorithm development. End-users organizations (CITST, IZRIIS, DGW, MSI – former ASH) were mainly responsible for end-user involvement while technical partners were involved in technically supporting the pilots.

The following sections are describing the pilot setup and protocol, including user recruitment and tested devices in each pilot country (section 2). Sections 3 to 6 are describing the feedback obtained during the pilots from both primary and secondary users as well as the issues encountered by the end-user organizations in each country. The overall conclusions are presented in section 7.

2 Pilots setup and protocol

2.1 Materials and methods

The pilots' setup consists of a range of hardware components (sensors) installed in the users' homes or in their current living conditions (e.g. hospital, elderly home) of which some were interconnected with the IONIS server. The tables below present the devices used in the pilots along with their name codes which will be in this document and further reporting. Grey coloring is indicating dropped devices, i.e. not used further in the pilots planned for Task 3.4.

Table 1. Sensors and devices considered for IONIS integration.

Device Code	Device Name	Functionality
XMB2	XIAOMI MI Band 2	Activity Bracelet
XMB3	XIAOMI MI Band 3	Activity Bracelet
ADWS352	A&D Precision Health Scale(UC-352BLE and UC-351PBT)	Body Weight Scale with BLE or Bluetooth
ADBP651	A&D Blood Pressure Monitor(UA-651BLE and UA-767)	Blood Pressure Monitor with BLE or Bluetooth
Z-PP102	Z-Wave Fibaro Wall Plug (FGWPF-102)	Smart power plug
Z-DT02	Z-Wave Philio Tech PST02-1C Z-Wave 3 in 1 Sensor	Environmental multisensor (PIR, door/window, temperature and illumination)
Z-PPMIC	Z-Wave NodOn Micro Smart Plug	Smart power plug
Z-MS001	Z-Wave Fibaro Motion Sensor (FGMS-001)	Motion Sensor
EFSM	EMFIT Sleep Tracking & Monitoring with Heart-Rate-Variability	Sleepmonitoring device
KWSMK88	King Wear K88 Heart Rate Smartwatch	Smartwatch GPS
FBFTCH2	Fitbit Charger 2	Fitness tracker
WUIL01	WUT indoor localization infrastructure 01	WUT indoor localization infrastructure 01
NOKSB	Nokia Withings sleep pad	Sleepmonitoring device
EXYX-GW	IONIS Gateway	Data collection

Table 2. Sensors and devices which will be part of the IONIS platform.

Device Code	Device Name	Functionality
XMB2	XIAOMI MI Band 2	Activity Bracelet
XMB3	XIAOMI MI Band 3	Activity Bracelet
ADWS352	A&D Precision Health Scale(UC-352BLE)	Precision Body Weight Scale with BLE
ADBP651	A&D Blood Pressure Monitor(UA-651BLE)	Blood Pressure Monitor with BLE SMART Technology
Z-PP102	Z-Wave Fibaro Wall Plug (FGWPF-102)	Smart power plug
Z-DT02	Z-Wave Philio Tech PST02-1C Z-Wave 3 in 1 Sensor	Environmental multi-sensor (PIR, door/window, temperature and illumination)
Z-PPMIC	Z-Wave NodOn Micro Smart Plug	Smart power plug
Z-MS001	Z-Wave Fibaro Motion Sensor (FGMS-001)	Motion Sensor

EFSM	EMFIT Sleep Tracking & Monitoring with Heart-Rate-Variability	Sleepmonitoring device
KWSMK88	King Wear K88 Heart Rate Smartwatch	Smartwatch GPS
WU1L01	WUT indoor localization infrastructure 01	WUT indoor localization infrastructure 01
NOKSB	Nokia Withings sleep pad	Sleep monitoring device
EXYX-GW	IONIS Gateway	Data collection

2.2 End-user recruitment

Primary end-users (PwD and their caregivers when available) were recruited through the end-user organizations in the four participating countries (Poland, Slovenia, Hungary and Romania). The only criterion for elderly user eligibility was the score in the MMSE test (Mini Mental State Examination) which is indicative of the mental status of the person undergoing the test. Our own criterion for inclusion was a MMSE score in the range of 19-27 points, which indicates mild cognitive impairment or mild dementia. In addition, as suggested during the midterm review, we strived to also include end-users from rural areas in the pilots.

Caregiver selection criteria were: provide regular care for PwD (regular contact, home visit and help if necessary). The target number of users was, according to the DoW, a minimum 20 users (primary and caregivers) per pilot site.

2.2.1 Poland

Participants for the first stage of pilots in Poland were recruited from patients of the outpatient geriatric clinic and in two cases from among residents of a specialized memory care long-term center. The total number of participants was 16 people including 6 women and 10 men aged 64-87 years. Five individuals are living in rural areas. Most participants fulfilled the criteria of mild cognitive impairment or mild dementia (MMSE score is between 19-27). In three cases, participants' caregivers (MMSE = 30) were included in the pilot testing to explore the possibility of analyzing two sensors connected to the IONIS Gateway at the same time. In one case, a participant with low MMSE = 8 was chosen to analyze applicability of activity measuring bands (MiBand 3, Xiaomi) for subjects using walking aids – the results were very interesting and pioneer – activity bands do not measure steps if the upper limbs are not in motion, e.g. immobilized or stabilized on the walker. The same observation was valid for persons with upper limb paresis due to stroke – in these individuals activity bands did not measure mobility in a proper way.

Approximately half of the participants were the same who took part in the assessment of needs and pre-pilot phase of the project, and the remaining were newly recruited. Most participants declared the will to participate in the next stage of pilots with more sensors and integrated IONIS platform. Interestingly, even participants with low level of computer skills and not using novel technologies in everyday life, were interested in the project and declared the will for further participation. The participants also acknowledged their role in the research project as contributors to science and development for future users.

2.2.2 Slovenia

In Slovenia the primary end-users were recruited from among the participants in the multinational survey (WP1, T1.2). ASLO has collaborated with the Slovenian Working Group of People with Dementia (operating within Spominčica), Spominčica association members, users of activities and support groups of Spominčica and IZRIIS. All the primary end-users fulfilled the inclusion criteria outlined above. Secondary end-users were the family caregivers. In the recruitment interview, before the beginning of pilots, the participants were informed about IONIS and the purpose of the pilots, the 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 uninstalled and returned to Spominčica. None of the participants was unable to decide for her/himself about participation in pilots. All participants signed an informed consent.

2.2.3 Hungary

There were two ways to recruit participants for the pilots in Hungary. The MSI professionals have selected the pilot participants from among the residents of the St. Hedvig Home (formerly ASH member institution) based on the criteria given by the consortium, i.e. MMSE score between 19 and 27. Mostly, the residents of the home who had participated in the questionnaire survey were included in this pilot. Participation was on a voluntary basis, as before in the surveys (WP1, T1.2). Only those residents who have signed the informed consent statement were allowed to enter the pilot studies. In addition to the rThe 2 independent participants

were treated by the Neurological Department of the County Hospital. We reached them through the project's medical expert, Attila Valikovics, PhD. They also participated in the T1.2 questionnaire survey, and later volunteered to join PILOT.

2.2.4 Romania

The primary end-users recruited in Romania for the pilots were from among the participants in the multinational survey (WP1, T1.2). We have contacted those users who have expressed after the survey their interest in being involved in the IONIS project. The contact was done via phone calls when we also explained briefly the expected involvement. Selection of primary users from among the WP1 participants had the advantage of having already the inclusion criteria fulfilled (MMSE score in the range 19-27 points). A total of 16 primary users were contacted and 13 expressed their willingness to participate in the pilots. Out of these 7 participated with their informal caregivers. In addition, one informal caregiver also participated alone wanting to test some of the IONIS sensors herself. A face-to-face meeting was established with the participants. They were informed about IONIS 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.

2.3 General methodology followed by the end-user organizations

Following participant recruitment, a meeting was arranged with both the elderly and the caregiver (if available). The end-user organization representatives have scheduled a 1-1.5 hours meeting which involved:

- Explaining to the end-users the background and purpose of the IONIS project and pilots.
- Presentation of available technologies and selection of the ones suitable for the users.
- The duration of the pilots is agreed with the users.
- Any end-user questions and concerns are answered and addressed.
- The informed consent is obtained prior from both PwD and caregiver.
- Hardware is installed and its function as well as usage is explained to the users.
- Contact information in case of questions or technical problems is provided.

2.4 Pilot stages

The pilots with individual platform elements (current task) were performed in two stages. The first stage has involved piloting of various devices and sensors which were considered for the integration in the IONIS platform. The second stage has restricted the pilot devices and sensors to the ones selected for integration based on the device availability and performance (e.g. BLE versus BE), integrability (open, API, etc), expertise in the consortium. The tables below are presenting the devices used in the first and second stage of the pilots in the four end-user countries.

Table 3. Pilot data in Poland. From among the informal caregivers, 3 have participated in the pilots.

Username	Primary/ Secondary	Device 1	Device 2	Device 10	Pilot start date	Pilot end date	Notes
		XMB2	XMB3	KWSMK88			
User_PL_001 to User_PL_004	Primary	Sleep monitoring devices developed by WUT			November 2018	December 2018	1-6 nights per user. These were preliminary trials which, due to lack of positive feedback have been dropped
User_PL_01	TK - Primary&Second		x		16-04-2019	20-04-2019	Connected to the IONIS Gateway - connection of the Gateway to Internet failed
User_PL_02	LK - Primary	x			16-04-2019	20-04-2019	Connected to the IONIS Gateway - connection of the Gateway to Internet failed
User_PL_03	ZW - Primary&Second		x		16-04-2019	20-04-2019	Tablet application for Mi Band
User_PL_04	JW - Primary&Second			x	19-04-2019	23-04-2019	Tablet application for SW- KW88 - data for only one day registered

User_PL_05	MB - Primary&Second		x		20-04-2019	25-04-2019	Tablet application for Mi Band
User_PL_06	SB - Primary&Second		x		28-04-2019	01-05-2019	RURAL AREA - Tablet application for Mi Band
User_PL_07	TK - Primary		x		01-05-2019	05-05-2019	Tablet application for Mi Band
User_PL_08	IF - Primary&Second		x		01-05-2019	07-05-2019	Connected to the IONIS Gateway - connection of the Gateway to Internet failed
User_PL_09	IF - Primary&Second		x		07-05-2019	09-05-2019	Tablet application for Mi Band
User_PL_10	TK - Primary			x	15-05-2019	20-05-2019	Tablet application for SW-KW88 - data for only one day registered
User_PL_11	JW - Primary&Second	x			15-05-2019	18-05-2019	Connected to the IONIS Gateway - correct transmission of data
User_PL_12	MW - Primary		x		15-05-2019	18.05.2019	Connected to the IONIS Gateway - correct transmission of data
User_PL_13	RM - Primary&Second		x		18-05-2019	25-05-2019	RURAL AREA - Care Home. Tablet application for Mi Band MiBand does not count steps when the upper limbs don't move while walking, e.g. in an older adult with post cerebral stroke paresis
User_PL_14	HP - Primary&Second		x		18-05-2019	21-05-2019	RURAL AREA - Care Home. Connected to the IONIS Gateway - correct transmission of data. Mi-band does not count steps when the patient is walking with a walker.
User_PL_15	MC - Primary	x			21-05-2019	26-05-2019	RURAL AREA - Connected to the IONIS Gateway - correct transmission of data. Mi-band does not count steps when not worn on wrist (e.g. in a pocket, in a sock)
User_PL_16	AC - Primary&Second		x		21-05-2019	26-05-2019	RURAL AREA - Connected to the IONIS Gateway - correct transmission of data

Table 4. Pilot data in Slovenia.

User name		Device 2 XMB3	Device 11 FBFTC H2	Device 13 NOKSB	Device 14 iPhone 5 SE	Device 15 ASUS Z301M F	Device 16 Samsung Galaxy A5 2017	start date	end date	Notes
User_S_L_01	Primary			1	1		1	1.9.2018	30.4.2019	Device14 replaced with Device16 after 3 months
User_S_L_02	Secondary			1				1.9.2018	30.4.2019	
User_S_L_03	Primary		1			1		1.9.2018	30.4.2019	Fitbit Alta HR
User_S_L_04	Secondary		1		1	1		1.11.2018	30.4.2019	Fitbit Alta HR
User_S_L_05	Primary	1						23.1.2019	30.4.2019	
User_S_L_06	Primary	1						23.2.2019	3.4.2019	
User_S_L_07	Primary	1					1	23.2.2019	3.4.2019	
User_S_L_08	Secondary	1					1	23.2.2019	3.4.2019	
User_S_L_09	Primary			1		1		13.3.2019	3.4.2019	
User_S_L_10	Secondary			1		1		13.3.2019	3.4.2019	

User_S L_11	Primary			1				14.3.2019	3.4.2019	
User_S L_12	Second ary			1			1	14.3.2019	3.4.2019	
User_S L_13	Primary			1				3.4.2019	18.4.2019	
User_S L_14	Second ary			1			1	3.4.2019	18.4.2019	
User_S L_15	Primary			1		1		3.4.2019	18.4.2019	
User_S L_16	Second ary			1		1		3.4.2019	18.4.2019	
User_S L_17	Primary	1			1			3.4.2019	30.4.2019	
User_S L_18	Second ary	1					1	3.4.2019	30.4.2019	
User_S L_19	Primary			1		1		18.4.2019	30.4.2019	
User_S L_20	Second ary			1		1		18.4.2019	30.4.2019	

Table 5. Pilot data in Hungary.

NFC tag	INDEPENDENT/ MSI	Start date - Ongoing	User ID	Male/ Female	Age	MMSE score	Elderly Home (EH) or Urban(U)	Samsung Galaxy A3 & ADBP651	Notes
BETEG1	<i>independent</i>	21/12/18	User_HU_01	M	80	26	U	X	From 20th March body weight scale too.
BETEG2	<i>independent</i>	08/01/19	User_HU_02	M	73	20	U	X	
BETEG3									A woman will be soon involved
BETEG102	MSI	28/01/19	User_HU_03	F	80	27	EH	X	
BETEG103	MSI	28/01/19	User_HU_04	F	74	27	EH	X	
BETEG104	MSI	28/01/19	User_HU_05	F	67	27	EH	X	
BETEG105	MSI	28/01/19	User_HU_06	M	88	24	EH	X	
BETEG106	MSI	28/01/19	User_HU_07	F	69	26	EH	X	
BETEG107	MSI	28/01/19	User_HU_08	F	74	19	EH	X	
BETEG108	MSI	28/01/19	User_HU_09	F	91	27	EH	X	She expressed her intention to quit verbally to the Head of the Home on the 4th February, 2019
BETEG109	MSI	28/01/19	User_HU_10	F	88	24	EH	X	
BETEG110	MSI	28/01/19	User_HU_11	M	86	26	EH	X	
BETEG111	MSI	28/01/19	User_HU_12	F	85	24	EH	X	
BETEG112	MSI	28/01/19	User_HU_13	F	73	27	EH	X	
BETEG113	MSI	28/01/19	User_HU_14	F	86	20	EH	X	
BETEG114	MSI	28/01/19	User_HU_15	F	84	26	EH	X	
BETEG115	MSI	28/01/19	User_HU_16	F	75	19	EH	X	
BETEG116	MSI	28/01/19	User_HU_17	F	84	25	EH	X	
BETEG117	MSI	28/01/19	User_HU_18	M	83	24	EH	X	
BETEG118	MSI	28/01/19	User_HU_19	M	79	19	EH	X	
BETEG119	MSI	28/01/19	User_HU_20	F	77	27	EH	X	
BETEG120	MSI	28/01/19	User_HU_21	F	83	20	EH	X	

BETEG121	MSI	28/01/19	User_HU_22	F	79	25	EH	X	
BETEG122	MSI	28/01/19	User_HU_23	F	91	24	EH	X	
BETEG123	MSI	28/01/19	User_HU_24	M	57	27	EH	X	
BETEG124	MSI	28/01/19	User_HU_25	F	87	19	EH	X	
BETEG125	MSI	28/01/19	User_HU_26	F	86	25	EH	X	

Table 6. Pilot data in Romania.

Username	Primary/Secondary	Device 3	Device 4	Device 9	Device 11	Pilot start date	Pilot end date	Notes	
		ADWS352	ADBP65 1	EFSM	FBFTCH2				
User_RO_01	RU/OU	x	x	x	x	1.11.18	8.11.2018	Emfit 1 week only and then given to TO	
User_RO_02	TO/OU	x		x	x	1.11.18	ongoing Emfit	ONGOING Fitbit 1 month and then given to GM. Continuous use of Emfit.	
User_RO_03	GM				x	1.12.18	20.12.18		
User_RO_04	EC/BC	x	x			1.11.18	ongoing	BT models	
User_RO_05	RC/BC	x	x			1.11.18	ongoing	BT models	
User_RO_06	IMs secondary			x	x	20.12.18	ongoing	Fitbit for the given dates but Emfit from November 2018	
Username	Primary/Secondary	Device 1	Device 2	Device 3	Device 4	Device 11	Pilot start date	Pilot end date	Notes
		XMB2	XMB3	ADWS35 2	ADBP65 1	FBFTCH2			
User_RO_07	DH/OC	x					18.03.19	25.03.19	
User_RO_08	MI	x		x	x		26.03.19	2.04.19	
User_RO_09	TS/CS				x	x	2.04.2019	15.04.2019	
User_RO_10	GR/RG	x					3.04.2019	20.04.2019	switched Xiaomi with Fitbit on 16.04
User_RO_11	TCr				x		21.04.2019	28.04.2019	
User_RO_12	ICr				x		21.04.2019	28.04.2019	
User_RO_13	Mar1/Mar	x					1.04.2019	8.04.2019	a second Xiaomi was purchased
User_RO_14	Mar2/Mar	x					10.04.2019	17.04.2019	

3 Pilots in Poland

The pilots in Poland have started in November 2018 with 4 elderly users who have tested the sleep monitoring sensors developed by WUT: ballistocardiography sensor and UWB radar sensor. The users were cooperating during the pilots but the usage of the sensors proved to be cumbersome. Therefore, they were discontinued from further usage.

During a second stage of the pilots, the number of participating users was 16, 13 primary and 3 secondary. The profile of the users was the following: age 64-87 years, gender: six females and 10 males, occupation: engineers, physicists, teacher, rural worker, housewife. MMSE 8-30 points, most respondents fulfilled the criteria of MMSE = 19-27 (average MMSE for these participants was 24.25), three participants with MMSE = 30 were included, who were caregivers of the participating users (to use concomitantly the two MiBands connected to one Gateway) and one respondent with MMSE = 8 to check how the MiBand measures activity in a person walking with a walker. Most users lived with family members, two users lived alone and two users stayed temporarily in a care home. Five of the users lived in rural areas.

The outcome of the pilots based on the user's feedback. Most users were highly satisfied with performing pilot studies with activity bands and a smartwatch. Most users had neutral attitude to the wearable devices measuring activity. Two users complained that the wrist band was causing some mild discomfort, several users took the MiBand off for a couple of hours a day. Advantages from the users' perspective included: motivation for increased motor activity while wearing activity monitoring device, increased awareness about one's activity, possibility of using the device as a watch, perception of contributing to the progress of research that might be useful for future users. Most caregivers of the participating users had neutral attitude to pilots. Advantages from the caregivers' point of view included: perspective for the future increase of safety with the use of tested devices and increased activity and participation of older adults. Disadvantages from the users' point of view included: the device falling out of the wrist band (in case of two users), mild discomfort (two users).

Most users expressed their interest to use the same devices in the next phase of pilots. About half of the users declared that they would like to purchase a device identical with the tested one for their private use and monitoring activity. Most of the users expressed their readiness to buy MiBand for its price (not divided into partial payments). They were a little less enthusiastic about the smartwatch, but one user declared being interested in buying a smartwatch for its price.

There were important observations made by the research DGW team, listed below:

1. IONIS Gateway and Internet connection and transmission:

- a. The IONIS Gateway indicates the "ON" status by emitting a series of sounds. It would be valuable if the Gateway had a light signal indicating that it is "ON".
- b. The IONIS Gateway does not indicate active connection to the Internet. It happened twice that an Internet router showed that the Gateway is connected, but the transmission of data was not possible, probably due to configuration problems. Therefore, after the failed trials, the transmission of data via gateway had to be confirmed by entering the individual user's profile on Eclexys web page.
- c. The operating IONIS Gateway is producing heat. Therefore, it serves best when placed on a window sill with free air flow.
- d. Internet coverage in rural areas is adequate and enables transmission of data from the IONIS Gateway.

Figure 1 is presenting the IONIS Gateway and internet router used in the Polish pilots.



Figure 1. IONIS Gateway (right) and internet router (left).

2. MiBand

- a. The MiBand does not measure steps in the following situations (These observations have not been described in the MI band user manual, and therefore should be treated as pioneer observations):
 - i. the user does not balance his/her upper limbs while walking. This may happen in a situation of neurological disorder e.g. paresis of an upper limb after stroke or in case of very slow walking.
 - ii. the user uses a walker to walk. Using a walker stabilizes both hands and no movement of upper limbs is made during walking. This prevents the MiBand device from measuring steps.
- b. The MiBand must be worn on the wrist. Otherwise, e.g. when worn in a pocket or attached to clothes, it does not measure steps.
- c. When the MiBand is working with an application for a mobile device (e.g. tablet) the transmission of data is activated after opening the application. The application might require up-grading and reintroducing a password in any moment resulting in a loss of access to the previously stored data.

In the four pictures below (Figure 2) the Xiaomi Mi Band is used by the Polish primary users (PwD).

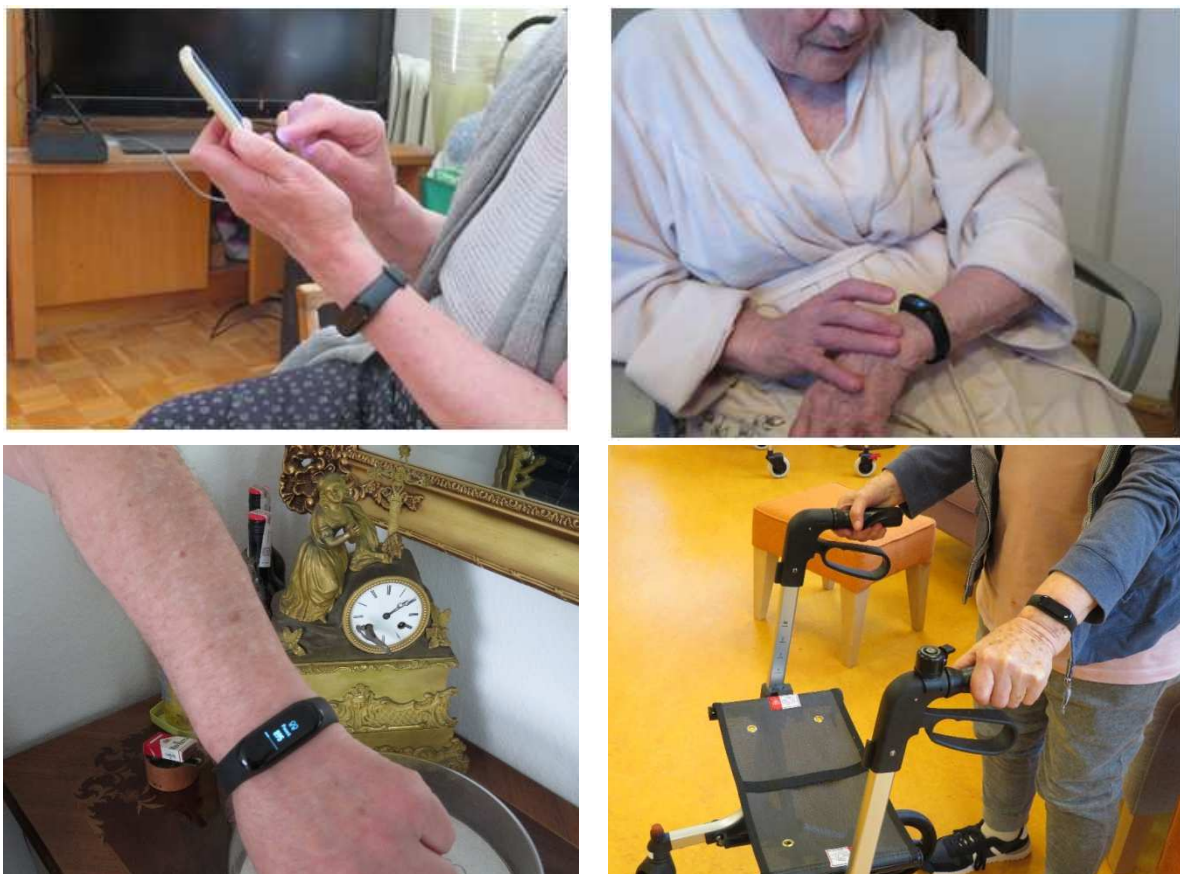


Figure 2. Use of Xiaomi MiBand by various Polish users.

3. Smartwatch KW88

Figure 3 is presenting the use of the Smartwatch KW88 by two Polish primary users. The feedback received during the pilots is summarized below.

- a. The SW KW88 stores data only for 24-hour period and is zeroed at 24:00 (12:00 a.m.) each day.
- b. In order to automatically transmit data the Bluetooth functions must be constantly "ON" in the smartwatch as well as in the mobile device (e.g. tablet). Accidental loss of connection between the two devices causes loss of all stored data. After restarting the Bluetooth function only the data for the current day are retrieved. Therefore, the SW KW88 does not provide an optimal solution for older adults with cognitive impairment or people who are not familiar with novel technologies.

- c. The Smartwatch KW88 is rather big and might be too big and too heavy for people who are not accustomed to this type of devices. Even though, the users participating in the pilot tests did not complain about the big size or weight of the device, it should be considered as potential obstacle for future users, especially people in advanced age, frail or with decreased fat tissue.



Figure 3. Smartwatch used by various Polish users.

4. Conclusions

The Pilot tests performed in Poland proved very valuable in terms of confirming good tolerance of the devices measuring activity (MiBand, smartwatch) and disclosing limitations of use of such devices as described above in detail. The pilots indicate the need for continuing research and careful planning of the further stages of the project.

4 Pilots in Slovenia

The pilots conducted in Slovenia started in September 2018 and lasted until the end of April 2019. The total number of participants in the pilots was 20 end-users. Among the participants there were 12 primary end-users and 8 secondary end-users (family members).

Average age of primary end-users was 74 years, the youngest was 63 years old, the oldest one was 82 years old. The MMSE score of the primary users was from 20 to 27. Age of caregivers was from 45 years to 79 years. 14 participants lived in urban areas, 4 in sub-urban and 2 in rural area. All primary end users were in pension, 5 caregivers (spouses) were also in pension, 3 caregivers (children) were employed. One primary end-user was living alone and did not have caregivers. One primary end-user, also living alone, did not want to include the family caregiver. 10 primary end-users were living with their spouses, who were also their caregivers and secondary end-users. Two primary end-users were living alone; their caregivers were children living in different household.

Users using the sleep sensor (Device13 - Withings sleep pad) and Withings sleep app were very satisfied with the device. We have provided them also with smartphones, tablets, some of them were using their mobile devices or computers. One end-user found iPhone 5SE difficult to use with small screen and we have changed the device with Galaxy A5 2017, as it still has physical button and the user's friend had Android devices and provided help. The device (installed under the mattress) was unobtrusive and did not disturb them during sleeping. Few of them expressed small concern regarding radio emissions and health. They were regularly checking their sleep score. Secondary end-users not living in the same household stressed the advantage of being able to check if the caretaker is in bed or not during the night sleep and during the day.

"Before going to sleep I could make sure my mother was in bed and I could see if she is already sleeping."

"I could check on the phone if my wife is still sleeping when I went out on errands."

"If my father didn't answer the phone I've checked if he is taking a nap. It would be great if I could also check if he had left home and forgot to take his mobile along."

"I could show evidence to my husband that he snores a lot during the night."

Two primary and secondary end-users didn't check the app for metrics as they found it too complicated. Other regularly checked the sleep score on the tablet, smartphone or on the computer (see Figure 4). Some of them (2 pilot sites) have also tried methods on how to improve their sleep, e.g. with physical activity and timings for supper. Most of the end-users living together would be glad to have both of them devices so that they can also monitor their own sleep and compare. We have noticed that some of the users swapped using one device during the pilot.

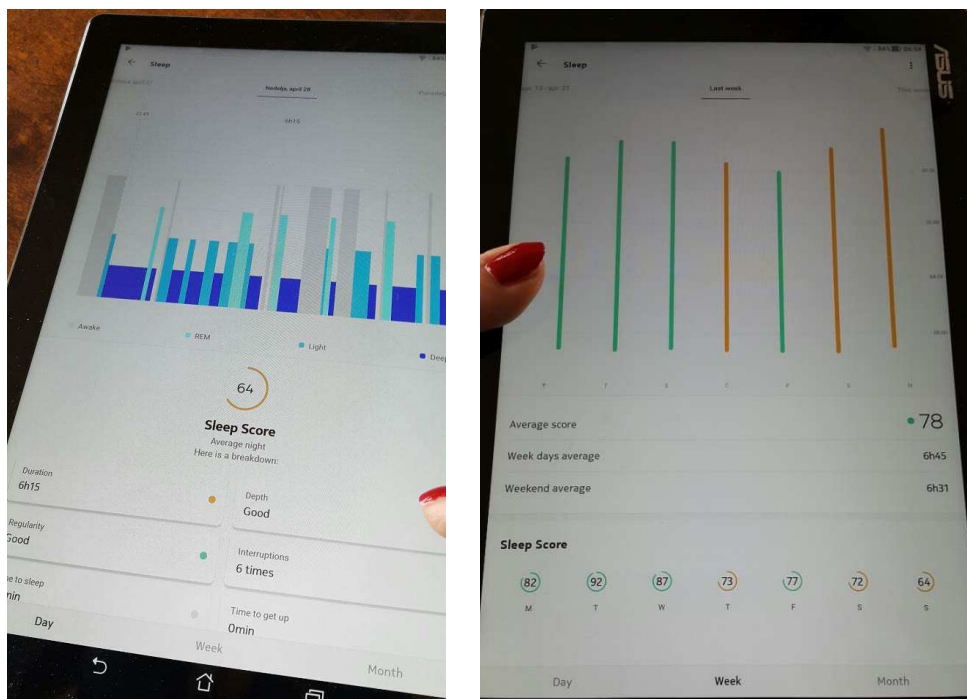


Figure 4. Sleep monitoring interface.

Xiaomi MiBand2, MiBand3 and Fitbit Alta HR were used for tracking the activity of end-users. The activity bands were used as standalone devices and paired with mobile devices (phone, tablet). We have shown users how to check the distance they have walked, how to measure their heartrate and also for sleep monitoring - sleep length and score. We have also set goals to users (6000 - 8000 steps). In two pilot settings we have connected the activity band with primary end-user smartphone.

"My band started to vibrate when I have received a phone or an SMS, it was easier not to miss it." "My husband answered the phone a lot more times, since his band started to vibrate and I was stressed on less occasions"

"It really motivated me to achieve the goal each day and I think we have been more active with my dear."

"On the days we've exceed my walking goal, we usually slept calmer and better."

"I prefer to wear my watch, I'm used to look at the dial and hands, I'm glad I'm giving it back."

"On a sunny day it is impossible to see anything on this band. I'm making a shadow with my hand, but it is often useless."

Users complained about small digits and poor sunlight visibility of MiBand. On the other hand, they were using it as a band and checked the distance walked on a device. The have found very useful that it vibrates for notifications and calls. Some of the users didn't like to wear it as it was ugly, unpractical as a watch. We have proposed them to wear the band on the other hand as their watch (analog), but 3 of them couldn't get used to. About half of users found the activity monitoring somehow useful and would like to have a similar device.



Figure 5. Use of Xiaomi MiBand by the Slovenian PwD.

Conclusions

Generally, users involved in the pilots found the devices useful. About a third found very complicated or were unable to use the apps with the devices. The reason was the language (not in Slovenian) and they didn't know how to use the mobile devices, they were afraid something could go wrong. More than a half said they could improve their wellbeing (are more active, plan their activities and meals, sleep better) with the use of the tested devices. All have stated that they would appreciate the device more if it would be part of some integrated service.

5 Pilots in Hungary

The situation outlined below is presenting the pilots in Hungary until the end of April 2019. It is important to note that the pilots are currently ongoing. There are 23 primary users in St. Hedvig Home who are involved in the IONIS pilots. Their involvement started on the 28th of January, 2019. On January 28th 2019 the pilots started with 24 residents but, on 4th February 2019, a person left the program. This user was 91 years old. In addition, there are 2 independent living participants (living in their own homes) who are taking part in the pilots. The first participant was involved on the 21st December, 2018. The other independent participant was involved on the 8th January, 2019. All participants are retired. The participants' average age is 79.25 yrs. There are 7 males and 18 females. The MMSE score of all participants was between 19 and 27. The average MMSE score is 23.9. The MMSE evaluation was done by the mental health professionals of MSI.

The devices used during the pilots performed in St. Hedvig Home were: Samsung A3 2017 – mobile phone; Blood pressure monitor (A&D UA-651BLE); A&D Precision Health Scale (UC-352BLE). Additionally, one of the independent participants has used a blood pressure monitor (A&D UA-651BLE), while the other independent participant has used a blood pressure monitor and a weight scale (A&D UA-651BLE, UC-352BLE).

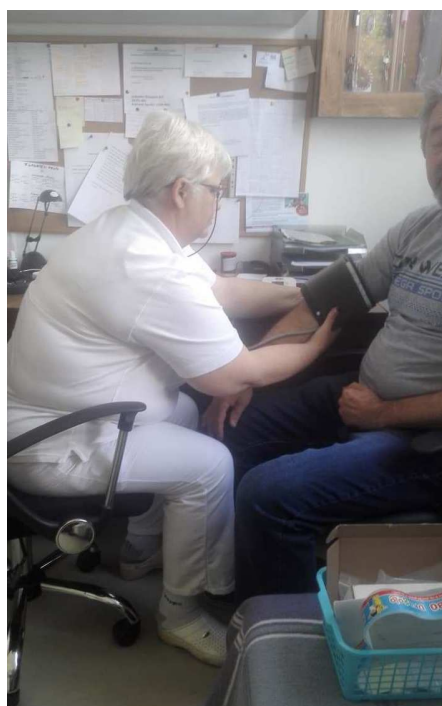
The first two pictures below are showing the interest of the users from St. Hedvig Home for the usage of the health monitoring devices provided during the pilots (Figure 6 a,b). The measurements are performed by a nurse (Figure 6c) while users living in their homes are measuring their blood pressure and pulse independently (Figure 6d).



(a)



(b)



(c)



(d)

Figure 6. Pictures taken during the pilots in Hungary.

1. Outcome of the pilots based on the primary users' feedback

The participant, who has left the program, said: "I'm over 90 years old, I'm not going to live long, I feel very bad, and I do not want to go on with the measurements."

Some of the users are very interested in the project, but there were a few who did not say about the PILOT anything worthwhile because they started talking about something else. For example: "I'm very weak now my son is a doctor, I don't know how good this is for me?"

Some quotes:

"My blood pressure was always high at home, and it's good to have blood pressure measurement here."

"I like to use the tool it's not causing me problem. I give 5 on the scale for it. I haven't really thought about buying it yet, how much will it cost?"

"It's good to measure blood pressure, am I diabetic, when will my blood sugar be measured?"

"Good tool, coming to the measuring is not a burden for me. I am looking forward to the rest devices, I am happy to participate in further testing."

In summary:

Overall, users were very happy with the measurements. They all know about the project and the purpose of the PILOT and the project. The majority is very happy to take part in the "big research".

2. Feedback from the nurses leading the measurements at St. Hedvig Home

"The users are happy to be provided with the measurements. Also, there are more people with the residents who take care of them. They do not complain and the measurements have become a daily routine. I think the device is very useful for the elderly, as vital parameters are followed."

"The residents are interested, every day they are waiting for blood pressure measurements in line, they want to see the results, compare them with previous day results. They expect further devices as blood glucose meter, balance scale, smart watches, especially men, as they are more interested in technical matters. The device is also useful for the caring service and for the care."

"The users are very pleased with the measurements, they expect them, come, interested, the measured values are considered to be important for them, and the device is very practical."

3. Conclusions

- The participants in the St. Hedvig Home perform the measurements under the supervision of four official caregivers. Some of them are able to do it on their own, but most of them need help.
- The two independently living participants do the measurements on their own.
- Some of the participants are quite withdrawn, and do not want to be photographed. We respect their request (sometimes their strict prohibition) as we are happy that they wanted to be involved in the trials.
- Residents sometimes go on vacations, some of them are sometimes taken to hospital for a shorter or longer period of time. At the end of this pilot there was one person who was permanently in hospital.
- None of the participants who participated until the end of this pilot indicated that they wanted to quit.
- Residents who live in St. Hedvig Home are not very interested in purchasing the IONIS system, they say it's the job of the Home.

6 Pilots in Romania

A total of 21 primary and secondary (family members) users took part in the pilots performed in Romania. Out of these, 13 were primary users living independently at home (not institutionalized). Four primary users did not have a constant caregiver. Three pairs of primary users were having 1 caregiver per pair, *i.e.* the son or the daughter. Two primary users live in rural areas.

The average age of the primary end-users was 76 years, the youngest was 65 years old, the oldest was 89 years old. The MMSE score of primary users was 19 to 27 with an average of 25.25. The age of caregivers was between 45 and 68 years.

1. Primary users' feedback regarding activity monitoring

The activity bracelets tested by primary users in Romania were FitBit Charge 2 and Xiaomi Mi Band 2. A 7000 steps goal per day was set for each user. The general attitude was very positive with the users feeling motivated to be more active. Some users reported that they now have a better understanding about how much they should move during a day such that they reach at least 7000 steps per day. One user said that before wearing the FitBit she did not imagine how many steps she was doing by just being involved in her daily house work and routine. Also, wearing the FitBit she was motivated to take an additional walk to reach the set goal. Several users of the FitBit bracelets also liked the continuous pulse monitoring capability (see Figure 7). Some also appreciated the watch capability of both FitBit and Mi Band.



Figure 7. Pulse rate displayed on the FitBit screen.

Some quotes from the participants:

- “It has not bothered me at all. It has been quite fun to look at it once in a while and see how I stand”
- “You cannot help keeping an eye on it. A little competition can not harm. To compete with yourself is in itself a reasonable thing. Just as long that it is not too much.”
- “I have tachycardia and I feel much safer being able to check my pulse whenever I want without the need to also measure my blood pressure.”

On the caregiver's side, they were able to check the activity of the primary users on the tablet or smartphone interface. They appreciated to be able to also check the history of the activity in between visits. They said that they are feeling more relaxed when seeing that the elderly are keeping active and not sitting all day in bed or in front of the TV. Also, knowing that they can check how active the elderly was is helping with spotting signs of depression or other illnesses.

Issues reported during the trials were:

- FitBit is a bit too bulky and is sometimes causing irritation of the skin, especially when worn over longer periods of time or in warm temperatures. Bulkiness was also preventing users to sleep with it.
- FitBit is not waterproof and several users forgot to put it on after taking it off for shower/bath.
- Mi Band is very difficult to charge but more comfortable to wear. In addition, it is also water proof users did not have to take it off during showers or bath.
- Mi Band is not counting floors nor is it showing continuously the heart beat.
- Mi Band has very poor screen visibility on sunny days.

2. Primary users' feedback regarding health monitoring

All users appreciated the history capability of their heart and pulse measurements. There were no complaints regarding the use of the devices and the users said that they are very similar to use as their already owned devices.

3. Primary users' feedback regarding sleep monitoring

The Emfit sleep sensors which are installed under the user's mattress were used during the Romanian pilots (see Figure 8). Users did not complain about the sensor bothering them during sleep. They said that they do not feel it at all. However, one user complained that he doesn't feel very comfortable to move in bed or read since he knows that the sensor is registering everything. One other user complained that the sensor is occupying the plug next to the bed and he had to install a plug multiplier.



Figure 8. Emfit sleep sensor placed under the mattress.

The own Emfit interface was used by the users to monitor their sleep. However, primary users complained that they need to log through a web browser to check their sleep quality and that they would have preferred to have the main data sent to a phone or tablet. Also, they said that the displayed data is a bit too complicated for them (see Figure 9).



Figure 9. Emfit interface.

However, some of the users were interested in the displayed data and were asking several questions about the sleep stages, how the data is calculated, etc. Two elderly were especially interested in the heart rate recorded during their sleep and wanted to know more about the peaks observed in the plots (see Figure 10). They said that they will show the data to their doctors at the next visit.



Figure 10. Heart rate recorded during sleep.

On the caregiver side, they were very interested to be able to check remotely the sleep patterns, score and heart rate of the elderly. Also, one caregiver reported being interested in the number of bed exists because his father had a prostate problem and was waking up often during the night. Another caregiver was content to know by checking the interface when her mother walked up such as to call her and remind about taking the medication and other important daily issues.

Both caregivers and elderly would like to have an interface in Romanian language.

Technical issues reported during the trials were:

- The User_RO_02 has been using continuously an Emfit sensor such that we can evaluate the performance over extended periods of time and also collect data for algorithm development. After 1-2 months of use the sensor started to disconnect from the network every few days. No pairing was needed but it had to be unplugged and then plugged again. Often the users did not report that the device was not working anymore. We concluded that it would be useful to have an automatic notification to the system admin that no data is received.
- For a second Emfit sensor we had lots of problems during the installation because the sensor was not able to connect to the user's network. We had to purchase an additional router with mobile data to solve the problem.

4. Conclusions

Generally, users involved in the pilots found the devices useful. All users found that they can stay more active with the use of activity bracelets. Health monitoring was appreciated but considered more interesting if coupled with an interface and the other devices which they tested (e.g. activity monitoring). Sleep monitoring was found very useful by the caregivers while elderly were more interested in monitoring their heart rate during sleep. All users were interested to continue with the integrated trials. Some users asked to keep the devices until the next pilots. When asked about the purchasing of the devices the users were willing to purchase the Mi Band which is significantly cheaper than the FitBit. They were also interested to purchase the blood pressure meter. They were not interested to purchase the sleep sensor but would have considered renting it especially after finding out that a monthly fee is anyway associated with the data transmission.

7 Overall conclusions and lessons learned

The pilots with the individual platform elements have been performed in four countries (Poland, Slovenia, Hungary and Romania) between 1.9.2018 and 26.05.2019. They have started at different dates in different countries due to the availability of the infrastructure whose acquisition turned out to last significantly longer than foreseen.

A total of 86 primary and secondary users were involved in the pilots for varying periods of time which lasted from few days up to several months. Out of the 86 users, 67 were primary users which generally obeyed the inclusion criterion of having a MMSE score of 19-27. There was one respondent with MMSE = 8 in Poland to check how the MiBand measures activity in a person walking with a walker. Out of these, a number of 13

elderly users were living in rural or suburban areas and a number of 23 elderly were living in an elderly care facility in Hungary. In addition, also one Polish user was living temporarily in an elderly home. Out of the independent users, most had a family member offering constant support.

Generally, users involved in the pilots found that the devices used in the pilots are helping them to stay more active, monitor their health and improve their wellbeing (e.g. sleep quality). Most users have stated that they would appreciate a device more if it would be part of some integrated service and have expressed their interest in continuing testing the IONIS platform in the following trials. Language issues have been identified as being important for the pilots with the integrated platform (especially, for the IONIS interface).

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. However, the users staying in elderly facilities were performing the health monitoring under the supervision of the facility nurses.

From technical point of view, there were some problems with internet connectivity which were solved by providing an own mobile data router. Installation of the devices did not pose any other major problems after the internet connectivity was solved. Getting users accustomed with the interfaces offered by the activity bracelets and sleep sensors proved to be difficult. In the case of the activity bracelets the elderly users preferred to check the bracelet screen instead of the interface. However, the caregivers did check the interface and appreciated the history function offered through it.

None of the activity bracelets used in the pilots has received a fully positive feedback. However, in the case of FitBit things proved complicated also on the integration side due to the proprietary nature of the software. Thus, it was decided to continue the integration with the Xiaomi bracelets which are easier to integrate, cheaper and continuously evolving through updated models. In addition, also the health devices which were used in the Romanian pilots during phase 1 and which were based on the older BE technology instead of BLE will be dropped from the integration.

The health devices did not raise any problems during the pilots and the main feedback was related to their integration with the other sensors and in a user-friendly interface.

For the sleep sensors, the main drawback of the Emfit sensor is the monthly fee which needs to be paid for to collect data on the IONIS server. For the Withings sensor, some of the data (type of sleep and sleep period) can be retrieved free of charge through an API while other type of data (apnea, snoring, turns, etc) is only available through the Withings user portal. Also, heart rate data is reported only as an average value over the entire sleep interval, i.e. no discrete measurements are provided.

From technical point of view, we have identified several issues which will need to be addressed in the integration of the IONIS platform. In addition, data needed for algorithm development of sleep and activity profiles have been collected during the pilots.

When asked about purchasing (directly and not in installments) the devices the users were willing to purchase the Mi Band which is significantly cheaper than the FitBit. They were also interested to purchase the blood pressure meter. Polish users were less enthusiastic about purchasing the smartwatch, but one user declared being interested in buying a smartwatch for its prize. Romanian users were also not interested to purchase the sleep sensor but would have considered renting it especially after finding out that a monthly fee is anyway associated with the data transmission. Residents who live in St. Hedvig Home are not very interested in purchasing the IONIS system, they said that it is the responsibility of the Home.

8 Document History

Date	Changes	Version	Author
M18	Table of contents initialized	1v.1	CITST
M20	Partners, contributions added	1v.2	ASLO
M21	Final version	1v.3	CTST
M21	Final version with typos corrected	1v.4	MSI
M21	Final review by the IONIS Internal Review Committee (IRC) and approval of it by the consortium partners.	1v.5	All partners

- End of document -