ROBOTS IN ASSISTED
LIVING ENVIRONMENTS

UNOBTRUSIVE, EFFICIENT, RELIABLE AND MODULAR SOLUTIONS FOR INDEPENDENT AGEING

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Guidelines for balancing between medical requirements and obtrusiveness II

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Abstract

This report complements D2.6 in analysing obtrusiveness considerations regarding instrumental activities of daily life (iADLs). Moreover, it also discusses potential obtrusiveness of active actuations from the perspective of both the primary users of RADIO and the caregivers (secondary users).

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Executive Summary

This report complements *D2.6 Balancing between medical requirements and obtrusiveness I* in analysing obtrusiveness considerations regarding instrumental activities of daily life (iADLs) as required in D2.3 (*Early Detection methods and relevant system requirements III*). Moreover, it also discusses about potential obtrusiveness of active actuations from the perspective of both the primary users of RADIO and the caregivers (secondary users).

In addition, we revisit the concept of functional obtrusiveness. Firstly, we consider the accuracy of the state of art methods for monitoring mood and discuss about the functional obtrusiveness involved. We then discuss what 'accurate measurement' means for the items used to assess functional activities of daily living. Understanding several constraints involved in such definition, we can further promote unobtrusiveness and build an ICT system that assesses frailty timely, with accuracy and in a universally accepted way.

Abbreviations and Acronyms

ADL	Activities of Daily Living
IADL	Instrumental Activities of Daily Living
interRAI	International collaborative to improve the quality of life of vulnerable persons through a seamless comprehensive assessment system. Cf. http://www.interrai.org
interRAI HC	The interRAI Home Care Assessment System
interRAI LTCF	The interRAI Long-Term Care Facilities Assessment System
AT	Assistive Technology
HRI	Human Robot Interaction
AAL	Ambient Assisted Living

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1 INTRODUCTION

1.1 Purpose and Scope

This report works towards determining the guidelines that will help the project balance between:

1. The clinical requirements, meaning the detection methods that guarantee that the RADIO system is a sound solution for recognizing functional activity patterns.
2. The obtrusiveness and ethical requirements

More specifically, it investigates the conditions and circumstances under which medical requirements necessitate obtrusive sensing and/or actuation; identifying cases when end-user reactions necessitate that the robot returns to a "safe base" inside the home and an emergency notification is sent; and similar situations where the different requirements and considerations interact in conjunction with the end users' gender and social, cultural, and ethical background.

Based on the Task description above, we could differentiate three different levels at which the RADIO ecosystem could become obtrusive:

- At the level of *Sensing*; that is the raw data collection level. The main question is whether the sensing modalities (audio, visual, depth/range sensor or smart home automation log) are obtrusive for specific interRAI items.
- At the level of *Acting* and *Access Control*; this level includes the actuation of the robot tasks such as detecting the elderly person, decisions about sending notifications to secondary users (relatives, caretakers, clinicians) and so on.
- At the level of *processing and networking the information*; this level ensures privacy throughout the processing of data pipeline and grants access only to authorized parties.

1.2 Approach

This report is prepared within *Task 2.3 Balancing between medical requirements, obtrusiveness, and safety.*

Towards investigating the interaction between medical data collection requirements and unobtrusiveness we take into account:

1. The findings of *Task 2.1* with respect to the medical importance of the various sensing and actuation capabilities of the system and
2. The findings of *Task 2.2* with respect to the obtrusiveness of these capabilities.
3. The sensing demands to record clinical items as enlisted in *Task 3.1*.

Specifically, *Deliverable 2.6 Balancing between medical requirements and obtrusiveness I* built upon the findings of *Deliverable 2.4 Actual and perceived privacy considerations and ethical requirements*, and extended the idea of obtrusiveness. Following that, interRAI LTCF items (D2.2) along with the proposed sensing methods (D3.1) were considered. We assessed whether the data collection in each case might be violating the need for unobtrusiveness, commenting on the least obtrusive type of information (available to the system) that guarantees meaningful and sound clinical information.

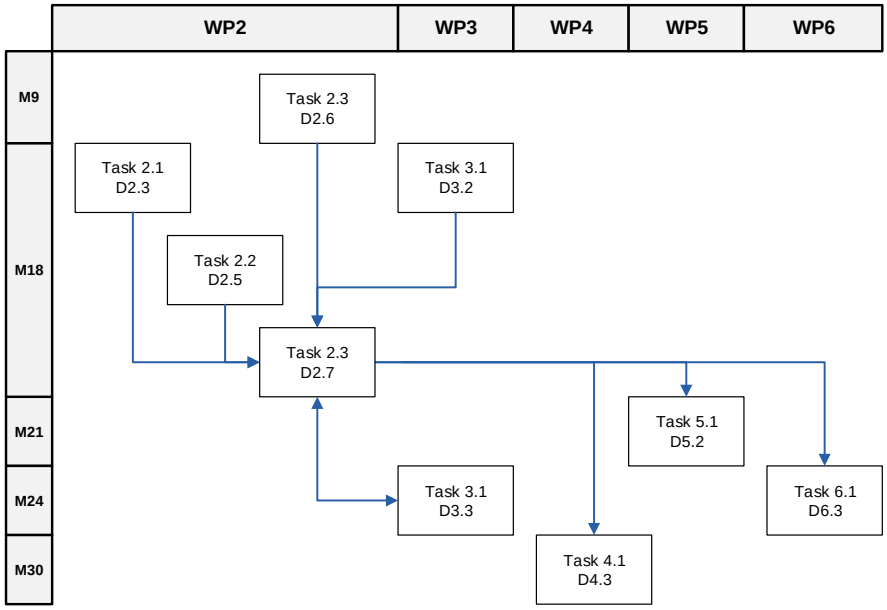

Figure 1: Dependencies between this deliverable and other deliverables.

This report is the second version of the report that specifically works towards defining any obtrusiveness fallacies taking into account the *Sensing* level, of iADLs. Moreover, it also comments on obtrusiveness issues related to *Acting* and *Access Control.* Finally, it revisits issues related to functional obtrusiveness and discusses the balance between clinical efficiency and accurate measurements of (i)ADL items.

1.3 Relation to other Work Packages and Deliverables

This deliverable is informed of *D2.3 Early detection methods and relevant system requirements II, D2.5 Actual and perceived privacy considerations and ethical requirements* and complements the work in D2.6 *Guidelines for balancing between medical requirements and obtrusiveness I.* Moreover, it was informed by *D3.2 Conceptual architecture for sensing methods and sensor data sharing II* about the sensing methods used for detecting iADLs and also read *D3.3 Conceptual architecture for sensing methods and sensor data sharing III* about the state of art related to emotion detection methods.

D2.7 Guidelines for balancing between medical requirements and obtrusiveness II is the final outcome of WP2 and is used by other work packages for informed decisions in the architecture documents (D3.3/4.3/5.2). Moreover, it affects D6.3 Piloting Plan III in developing the final RADIO medical evaluation.

2 INTERRAI INSTRUMENTAL ADLS & OBTRUSIVENESS

This section discusses the obtrusiveness dimensions involved in monitoring instrumental Activities of daily living are a paramount aspect of human behaviour and therefore a fundamental issue on assessing human activity patterns[1]. These instrumental activities occur mainly in the community setting rather than in the institutional setting. Changes in instrumental activities will prelude changes in basic activities of daily living.

2.1 Balancing between iADLs and Obtrusiveness

As pointed out by Lawton and Brody human behaviour varies in the degree of complexity required for functioning from basic life maintenance to instrumental activities and social behaviour. In the aged, maintenance of earlier life levels of adequacy in instrumental activities such shopping, cooking doing laundry, managing finances, transportation could be the best way to asses functioning. The Instrumental Activities of Daily Life[6] scale from Lawton and Brody was published in 1969 and probably is the most commonly used instrument for assessing this domain. There are gender and cultural issues however, in these instrumental activities, making sex-linked content (food preparation, laundry and housekeeping) responsible for some questioning about the validity of the scale making (male scale: 5 items, female: 8 items) but the practical utility of this scale has been proven and it is nowadays, almost 50 years later, universally adopted.

More recently in 2013, researchers in the field of ageing such as Morris from the international interRAI non-profit consortium, introduced the concept of progressive functional loss inside instrumental activities creating an iADL hierarchical capacity scale[7]. He uses 5 items: meal preparation, ordinary housework, managing finances, managing medications and shopping. Morris uses capacity (the person's presumed ability to carry out the activity) reported by the assessor versus performance avoiding somehow gender issues. Regarding the progressive pattern of functional loss, the earliest loss iADLs are shopping and housework followed by meal preparation, managing finances and managing medications.

Early detection of changes in functioning could rise relevant concerns indicating need for further comprehensive assessment in order to make early diagnosis and early intervention to avoid progression from impairment to disability and handicap[2-5]

iADLs were added in *D2.3 Early Detection Methods and Relevant System Requirements III* as extra medical requirements for the RADIO system and here we discuss about obtrusiveness dimensions involved in their monitoring and pursuit balancing between these medical requirements and obtrusiveness taking into account also the technical methods used for extracting related information.

The technical methods for extracting data for the required clinical information described in D2.3, meaning iADLs, are described in D3.2: Conceptual architecture for sensing methods and sensor data sharing II. As extensively described in D3.1 and summarized in D2.6, raw data in RADIO Home are collected by either robot mobile sensors (MS) or fixed Smart Home (SH) sensors. We discriminate raw data collection between four main sensing sources: a) *Audio data*, collected by microphones, b) *Visual data*, collected by cameras, c) *3D / Range data*, collected by 3D cameras and laser scanners and d) *Automation usage log*, collected by Smart Home's automation. In this section we extended the analysis of *Section 3.2 of Deliverable 2.6: Guidelines for balancing between medical requirements and obtrusiveness I*, to explore the iADLs for their obtrusiveness.

In this section we assume as a starting point the tables produced at D3.2 that analyze which sensor data analysis component is going to be used for monitoring the iADL InterRAI items and

Deliverable 2.6: Guidelines for balancing between medical requirements and obtrusiveness I, to explore the iADLs for their obtrusiveness. Table 1 contains:

1) The **technology** (type of sensors) needed to record each iADLS: a) audio (A), visual (V) or 3D/range (DR) sensors and whether they are fixed sensors (FS) or mobile sensors (MS). Moreover, if some the Smart Home Automation Log (SMAL) can add information about an InterRAI item this is noted as separate comment.
2) **Comments on the obtrusiveness dimensions** at stake for each iADL, taking into account the sensing method (based on D2.6/ Section 2 and similar to D2.6/Section – please refer at these sections for further details).
3) The **type of information** needed to extract medically informative content. The information collected for RADIO can be presented in the following formats: a) Raw data (raw content), b) A list of time-stamped activities (usage log) and c) Aggregates on the logs (see D2.6/Section 4 for further details)

Table 1: Instrumental Activities of Daily Living and obtrusiveness

iADL Assessment Item	Technology	Comments on obtrusiveness	Type of information for clinically sound decisions	Other comments related to iADLs
Meal preparation	Audio-visual event recognition (A/V- MS) SMAL.	POTENTIALLY INTRUSIVE *Privacy Dimensions*: Intimacy issues with visual recordings *Function Dimension*: suboptimal performance in activity pattern recognition. *Human Interaction Dimension*: meals preparation and lunchtime use to be social activities that facilitate human relationship.	Aggregates on the logs / Or usage log	Usage logs of sequence of events (use of fridge, kettle, cupboard, toaster) during a specific time interval 5 min.
Ordinary housework	Audio-visual event recognition (A/V-MS) SMAL: Smart Presence sensors and electric consumption	POTENTIALLY INTRUSIVE *Privacy Dimensions*: Intimacy issues with visual recordings. *Usability Dimension*: Robot following patient around the house for housework duties, (kitchen, bedroom, dining room). Function challenges as well in order to detect these activities	Aggregates on the log	
Managing finances	Visual event recognition	POTENTIALLY INTRUSIVE *Privacy Dimension*: Intimacy issues with visual recordings	Raw data	This iADL has shown to be predictive of conversion to dementia from MCI at baseline assessment (2) However managing finances has limited performance in the nursing home scenario.

Managing medications	Visual event recognition (V-MS)	POTENTIALLY INTRUSIVE *Privacy Dimension:* Intimacy issues with visual recordings *Self- Concept Dimension*: As any other cueing system, these signals, despite being helpful to improve your performance they act as constant reminder of your loss. When you get a notification/reminder you also become conscious of your deficit. Even more if the alarm or reminder sounds in a public place or there is somebody around, you could feel shame of your deficit and your self-concept and self-esteem can be damaged.	Usage Log	This item is assessed indirectly via pill intake occurrence. Always a difficulty because discrepancies between prescription versus administration, versus adherence versus intake Impairment in these activities could reflect early cognitive deterioration and potential serious medical problems (decompensating chronic conditions HBP, Diabetes mellitus)
Phone use	Visual event recognition (V-MS)	POTENTIALLY INTRUSIVE Privacy Dimension: Intimacy issues with visual recordings	Aggregates on the log	
Stairs	Visual event recognition /Depth pattern recognition (V- MS)	POTENTIALLY INTRUSIVE Privacy Dimension: Intimacy issues in case visual of recordings and	Raw content	
Shopping	N/A, RADIO operates indoors			
Transportation	N/A, RADIO operates indoors			

Conclusions

Overall, regarding potential obtrusiveness, the use of the RADIO platform for recognising ADLs could affect four obtrusiveness dimensions: privacy, function, human interaction and self-concept.

From the *privacy* point of view if visual sensors are used, privacy could be affected. Raw visual data obtrude user's *intimacy*. For instance, when the user wakes up and gets out of bed for taking his medication he can be wearing or not different parts of his pyjama and naked areas of his/her body could be exposed. Naturally, this aspect is amended if rather than raw visual signals we use more abstract information in order to identify specific activity patterns-which is the case in RADIO.

Functional obtrusiveness, is another source of obtrusiveness especially in case that an activity is inferred implicitly based on the occurrence of distinct events. For example, meal preparation uses domotic signals (Smart home sensors on fridge, cupboard, kettle, microwave, etc.) to build up an equivalent of the instrumental activity. Suboptimal performance of such equivalents (because low motion action recognition) will limit its use from a technological point of view, mainly because low precision or accuracy.

Another important consideration regarding obtrusiveness on iADL is that this type of solution could interfere negatively on human interaction. Meal preparation and lunchtime are important social activities that facilitate human relationships. Social interaction, for instance is regarded as

part of the therapeutic plan in people with mild cognitive impairment. So, we must balance between monitoring these activities with the potential discouragement of social interaction due to this monitoring.

We could assume that pill intake recording from the camera could be one of the best assessment for medication management. This is because intake is the final stage of the medication management process. When assessing this iADL many people focus on preparation, storage, planning but intake could be equivalent to adherence.

Of course taking pills does mean that they are taken the proper pills or the proper schedule but if we cross data time with pill intake we know if adherence to the prescription happens. Future research could explore improvement on patients' adherence to medication using domotic reminders plus pill intake recording.

2.2 Balancing between monitoring iADLs and dignity

The methods for recording iADLs as described in Table 1 use visual recognition of events that and therefore could violate the privacy of the person. However, as discussed in D2.6, this issue is tackled by informing users in detail about the in situ transformation and protection of the images, so that their acceptance implies consent and also they have the guarantee that their information will not be misused.

However, the Hensel model of obtrusiveness goes beyond the scope of confidentiality and presents a multidimensional concept of privacy that point at the concept of human dignity. We can easily guess the repercussions of the use of tools for functional assessment of daily life in the field of dignity. Dignity, like obtrusiveness, is an extremely complex concept. Nordenfelt in an attempt to framework dignity list up to four forms: dignity of merit, dignity of moral stature, dignity of personal identity and human dignity[8, 9]. The first, dignity of merit highlights the fact that a person's status depends upon their economic and social position. Dignity of moral stature emphasizes the importance of the person's moral autonomy or integrity. In the context of elderly people dignity of personal identity seems to be more relevant and is related to self-respect and reflects an individual's identity as a person. At last but definitely not least we have Menschenwürde or human dignity, which refers to the inalienable value of human beings. It is this aspect of dignity that provides a justification of the moral requirement to respect all human beings, regardless of their social, mental or physical properties[10]. We refer the reader to the works of Tadd et al[11-15] for more information.

Respect is the word most often used to describe dignity; both by the elderly, by health professionals and by the general population. The moral obligation we all have of respect for the person flows from the term Menschenwürde "human dignity" previously defined. Respect is also one of the most common constructions regarding dignity in quality of life instruments.

One of the outcomes expected from RADIO system is to improve self-reported quality of life once implemented. So if respect is an important part of quality of life instruments the platform should, at least, not cause any damage regarding respect. Is RADIO system affecting staff paying attention on me? Does the system interfere expressing my opinions without fear or consequences? Does it make any difference with staff respecting what I like and dislike?

It has been recognized that of the personal skills and values of health professionals, communication and behavior especially, had repercussions on the experience of dignified care by the elderly[16]. Dignity, primordial in the perception of the quality of attention, would be within the dimension of the "human interaction" of Hensel's framework of obtrusiveness. This would deal with the threat posed by robotic technologies to replace human contact between people, including the lack of human response in emergencies and the adverse effects on relationships[17]. These negative effects could be more relevant in the nursing home than in the community.

If this technology proofs to be helpful to health care professional it would be expected that the tool facilitates communication and safety, enhancing confidence between both patients and carers. It has been always said by healthcare workers the need to become more efficient in Nursing Homes in order to have more time to expend in a face to face relationship with residents[18, 19]

3 POTENTIAL OBTRUSIVENESS OF ACTIVE ACTUATIONS.

Active actuations performed by the system will consist mainly of notifications sent to caregivers via GUI. Obtrusiveness related to active actuations has an impact to both caregivers and primary users. Privacy issues and human interaction are the domain more frequently related to the user. As with monitoring, active actuations should be authorised by RADIO user upon agreeing to use the system.

The potential obtrusiveness related to the user regarding active actuations is presented in Table 1. Notification indicated in active actuations are send to caregivers (formal or informal) through the caregiver interface (see *D2.3 Early Detection methods and relevant system requirements III* for details about the events triggering these notifications and the recipients of the notifications).

For active actuation, we should consider also obtrusiveness on the caregiver mainly related with routine dimension (interference on daily activities, new habits), sustainability dimension (future needs), function dimension (suboptimal performance, inaccurate alarms) and usability dimension (additional demands on time and effort).

Table 2: Obtrusiveness related to active actuations.

Active actuations	Obtrusiveness on Patient
Notification related to locomotion/walking.	Privacy
Notification related to personal hygiene.	Privacy
Notification related to meal preparation.	Privacy Human interaction
Notification related to get out of bed.	Privacy
Notification related to get up from the chair.	Privacy
Notification related to take medication.	Privacy
Alarm required in case of fall: notification / RGB camera signal to caregiver.	Function dimension (suboptimal performance)
Panic Attack Call: notification / RGB camera signal to caregiver.	Human interaction Function dimension (suboptimal performance)
Notification related to drug compliance.	Privacy Self - concept
Light/or sound coming from robot indicating that an ADL/mood item has been evaluated.	Physical dimension in terms of discomfort and excessive noise.

4 FUNCTIONAL OBTRUSIVENESS

In this section we consider several additional aspects related to functional obtrusiveness. We remind that this concept is related to malfunction or suboptimal performance, inaccurate measurement, restriction in distance or time away from home, and perception of lack of usefulness[20] (see also Section 2.3.4. in *D2.6 Balancing between medical requirements and obtrusiveness I.*

The first paragraph of this section revisits interRAI LTFC and HC Mood items and discusses about functional obtrusiveness consideration given the state of art of the related detection methods. This section complements analysis in D2.6, in light of *D3.3 Conceptual architecture for sensing methods and sensor data sharing III.*

The following paragraphs of this section examine several concepts related to *what is measured by the interRAI items* in attempt to define what consists an accurate measurement and what is the expected outcome of RADIO output in order to be functionally unobtrusive from the perspective of clinical interpretation of this outcome. This is also related to the usability of the system by clinicians and the sustainability of the system.

4.1 Revisiting Obtrusiveness concerns related to Mood items.

The standard comprehensive geriatric assessment (CGA) process, both in the outpatient and institutional settings, involves the use of validated tools that help us to detect potential health problems. In the case of mood, the CGA performed through the interRAI LTCF or HC instruments considers 7 items: negative comments, persistent anger, unrealistic fears, health complaints, anxiety complaints, sadness-worries and crying. The combination of these clinical variables will help us to establish the diagnosis of a problem.

The precision of an assessment model tends to increase when independent predictors (assessment items) are added to the equation. On the other hand, if we reduce these predictor variables, the power of the tool decreases. For example, the Yesavage geriatric depression scale originally consists of 30 items and has a cut-off point of 15 above which we suspect depression in the patient[21]. There are reduced versions of the Yesavage scale with 15 items and even versions of 10, 5, 4 and 1[22, 23] items, but as we lower the number of variables we decrease sensitivity and specificity decreasing the definitive clinical usefulness of the test. Therefore, these scales are tools of early detection or screening, not strictly diagnostic.

Obtaining information regarding affective state (negative comments, persistent anger, unrealistic fears, health complaints) through audio-visual sensors by means of interaction of the person with the robot (human-robot-interaction HRI) by voice, speech, facial expression[24, 25], or by text analysis and doing so “unobtrusively" is a great challenge.

State-of-the-art research related to emotional/mood detection reports accuracy percentages ranging between 50-60%. Accuracy rates around 80% have been reported but these results are extracted on emotions deliberately pronounced in controlled environments and for particular sentences (see D3.3 for more details on this topic).

Therefore, based on current methods for detecting mood, reliable observations could not be guaranteed, rendering subsequent clinical usefulness uncertain. According to the Hensel model this is related to the functional obtrusiveness dimension. Using a tool with such accuracy levels would impose decreasing the number of assessment items used. This would invalidate its reliability, validity, sensitivity and ultimately its clinical usefulness. It follows that if from the seven interRAI items we lose several due to detection methods immaturity/inaccuracy, the clinical usefulness is not as desired.

4.2 Reflections on pre-frailty and frailty

We can say that frailty remains one of the most relevant challenges in the field of geriatrics. Although the term was introduced by Woodhouse 30 years ago[26, 27], a consensus and universal definition has not yet been achieved [28]. Frailty is accepted as a state of vulnerability resulting from the decrease of the physiological reserve in different organs and clinically correlated with a decrease in intrinsic capacity [29] and difficulty in maintaining homeostasis[30].

Terms such as multimorbidity, functional impairment, and dependence are still misused as frailty equivalents. Frailty represents one of the paradigms of geriatrics and is accepted together with sarcopenia (loss of mass and muscular function) as one of the "new geriatric syndromes", ahead of the classic giants: immobility, instability, incontinence and cognitive impairment.

In this period of time two schools of thought have been consolidated with very different approaches to frailty. The first theory is based on the frailty phenotype proposed by Lynda Fried [13] and it developed from the longitudinal study of the Cardiovascular Health Study Collaborative Research Group of the United States. In this model we establish the diagnosis of frailty when 3 or more of the following 5 conditions are present: weight loss, decreased strength, lack of energy, sluggishness and low level of physical activity. Pre-frailty is when there is only one or two of the above characteristics.

The etiopathogenesis bases in this model of frailty contemplate sarcopenia as the cornerstone of the process, accompanied by other phenomena such as chronic inflammation, neuroendocrine dysregulation and involving molecular and cellular mechanisms such as oxidative stress, mitochondrial DNA damage and shortening of the telomeres[31, 32]. The gait speed measurement (4 metre walking test), included in the interRAI items and measured by the RADIO system, is the first test to establish the suspected diagnosis of sarcopenia and frailty[33, 34]. Altering this parameter would at least define the pre-frailty state.

The second model used to assess frailty is based on the accumulation of deficits and it is proposed by Kenneth Rockwood[35] and developed by the Canadian Study of Health and Aging (CSHA). This model has a more clinical than pathophysiological perspective. In this approach, unlike that of Fried, frailty is not exclusive to a pre-disability state but rather considers dependence as part of accumulated deficits. The index uses signs, symptoms, disabilities and diseases from different sources including basic and instrumental activities of daily living. This approach dichotomously registers the existence of deficit or lack thereof and establishes a rate on the total number of deficits. For example, if 70 are considered and 35 are present the frailty rate for that person would be 35/70 = 0.5. The concept is that the frailer the patient is, the higher the number of deficits present is. This approach to frailty has also demonstrated its close association with poor health outcomes[36-38].

4.3 Reflections on interpretability and technical requirements for useful clinical information

The coding systems used in the field of functional performance measurement should follow international standards approved for such purposes [39, 40]. Among the clinicometric properties necessary for the development of measurement instruments, besides reliability and validity, is the *interpretability of test results*. Interpretability must be taken into account when considering how performance measurements are translated in a way that can be adopted by computational methods.

There are two aspects related to clinical scales and interpretability. The one is related to how final scores are translated to the degree of severity. Usually, as the final number increases, the degree of dependence or severity of the problem studied increases as well. For example, a value of 8 on

a maximum score of 10 is greater than a value of 1 and translates a higher level of dependence in the performance of that activity.

However, this coding system is not followed universally and creates a problem of interpretability of the tools. The Barthel index[41], for example, interprets a value of 100 as maximum independence while in the WHO approach, in relation to the International Classification of Functioning (ICF), the intervals are totally opposite. The value 0 represents no difficulty and the greater the number the greater the severity of the problem. The functional assessment scales included in the different interRAI tools take this approach into account. The ADL scale of the RUG III[42, 43] case-mix groups included in the instrument has a range of values between 4 and 18, with the value 4 being equivalent to functional independence and 18 maximum functional dependence.

Another complexity in interpreting clinical scales is the grading of the level of dependence itself. For example, interRAI ADL self-performance items are assessed based on the level of dependence for the accomplishment of the functional activity and the level of support received (independent= 0, independent, setup help only =1, supervision = 2, minor help = 3, significant help = 4, maximum help = 5, total dependence = 6).

Naturally, given RADIO's target group the minimum detectable and useful change is the non-performance of the activity independently. This means that the RADIO output is forced to adopt a dichotomous code of an activity as 0 for independent and 1 non-independent. The change is clinically significant and therefore useful from a clinical point of view.

In this sense, the proposal that we make as a technical requirement for the RADIO project to have clinical usefulness, is to assume the dichotomous option (independent versus not independent) for coding performance in ADLs. This approach is very similar to that used in the origin of the Katz index[44-47] (one of the international functional assessment standards) by modifying from three independent, intermediate and dependent states to the two independent - dependent states.

4.4 Performance and Capacity

In parallel to the how frailty is defined, what is measured for its assessment, and the dichotomous decision between independence and not, one should consider and discriminate between the concepts of *performance and capacity*. InterRAI items should be scored in both categories: Performance and Capacity. ***Performance*** measures what the person actually did within each IADL category in the last 3 days. ***Capacity*** is based on the person's presumed ability to carry out the activity. This requires speculation by the assessor.

Because of lack of skills or experience, a person may not perform some activities, but would be capable of doing so with the proper training or opportunity. Therefore, it is important to distinguish between non-performance that is due to impairment of capability (caused by health problems) and non-performance that is due to other factors (not related to the person's health). For example, some males may never have learned to cook, and some females may never have handled financial matters.

The International Classification of Functioning Disability and Health (ICF), provides us with a common language and framework for the description of health states and domains related to it. The ICF allows us to describe the function and body structure and its "potential functioning" in relation to a standard environment (capacity) and "actual functioning" in the current environment (performance). The capability construct considers the highest level of "probable" functioning at any given time in an adjusted environment[48].

It becomes clear from the above that RADIO system can only record performance. It will never value capacity because as previously defined capacity requires an inference by the subject or a

proxy regarding "potential functioning" (not actual) in a standard environment. The procedure for registering this information, as detailed in the inteRAI user manuals, is done at the time of admission by clinical personnel, which will simultaneously record capacity and performance.

4.5 Discussion on clinical implications and functional obtrusiveness

It becomes clear from the previous sections that there are several considerations to be taken into account when defining what an 'accurate measurement is' for a majority of items used to assess (pre-) frailty. It becomes very challenging to eliminate functional obtrusiveness of an ICT system that is dedicated to assess frailty. These considerations along with the need of supporting elderly to live independently push towards exploring ways to assess frailty timely, with accuracy and in a universally accepted way.

RADIO target group are people with high functionality in ADLs, whether in the community or in institutions. It is in this group that early diagnosis would have greater profitability since it should allow us to design effective and specific interventions. This imposes the need to reflect on the concept of pre-clinical functional impairment, sometimes named pre-frailty state.

It is in this field of the highly functional or pre-frail elderly where the development/ calibration /refinement of measurement tools is proposed and where new studies are currently concentrated. We should not forget that most functional assessment scales were developed in long-stay units and in highly dependent elderly patients. These traditional disability instruments, when applied to relatively well-functioning elderly adults, do not discriminate sufficiently (ceiling effect) and underestimate disability in the early stages of development. One of the reasons they do not discriminate well is because most use variables with an ordinal scale that do not respond to change.

Fíeo et al[49] discusses a methodology in the calibration of these tools called IRT "Item Response Theory" that can increase the interpretability of the ADL -iADL scales. IRT models can increase the interpretability of the ADL-IADL scales in many ways: by confirming an underlying one-dimensional continuum of disability, by establishing the measurement of the interval level or hierarchies of articles and by increasing the accuracy of the scale.

In RADIO, in addition to dichotomously recognising ADLs we complement event detection with the performance time of ADLs. The measurement of speed in the performance of some ADLs will allow us to have potentially useful variables for assessing pre-frailty in the future study.

An interesting point, for our technical requirements and medical evaluation of the RADIO project is the work of Avlund[50] who attempted to compare fatigue with speed reduction using an interval scale conversion for speed but abandoned this approach because of the great heterogeneity between the existing age groups.

In reference to assessing capacity and performance, the absence of information about capacity cannot be considered as another aspect of functional obtrusiveness. From a medical point of view knowing capacity helps arranging changes in the environment or providing technical aids to improve performance., but not assessing capacity does not constitute functional obtrusiveness.

On the other hand, it can be explored in the future if the systematic observations about performance provided by the RADIO system (as opposed to sporadic assessments conducted by clinical staff) can be used to make inferences about capacity as well. Appropriate decision making models could decide if and when trends in long-term performance data indicate changes in capacity (at least of the interRAI items observed).

The importance of this approach for the RADIO project is that we could develop a frailty index based on “accumulated deficits” detected by the RADIO solution. In this case, data are collected in a dichotomus way (dependent vs independent or present versus absent) over a determined number of potential deficits derived from performance results in basic and instrumental activities of daily living, an index adapted from frailty.

5 SUMMARY

In *D2.6 Balancing between medical requirements and obtrusiveness I* we made an in depth analysis of Hensel's dimensions of obtrusiveness regarding interRAI LTCF items set as the medical requirements for the project RADIO system (D2.2 *Early Detection methods and relevant system requirements II).* In this report we started by complementing this analysis adding obtrusiveness consideration regarding instrumental activities of daily life (iADLs) as required in D2.3 (*Early Detection methods and relevant system requirements III*). Moreover, we also discussed about potential obtrusiveness of active actuations from the perspective of both the primary users of RADIO and the caregivers (secondary users).

The major requirement for the RADIO system is to provide sound medical information relevant to patient healthcare while at the same time using the technology that is unobtrusive. In Table 2 we commented on type of information needed for clinically sound decisions and obtrusiveness. One of major potential utilities of the technology was having an accurate way of performing a somehow "equivalent to healthcare professional's assessment" of human activity patterns. Functional assessment is a very time consuming exercise in every day practice and any ergonomic improvement in this area is more than welcome.

Instrumental activities of daily life have very high importance in daily practice because any impairment on them could be regarded as predictor of further deterioration and an indicator of the severity of the illness. Instrumental activities prelude basic activities' loss as the Guttman effect exists between advanced, instrumental and basic activities of daily life.

These three dimensions follow similar hierarchical structure of difficulty regarding obtrusiveness when using the robotic platform; mainly due to outdoors and privacy considerations. However, obtrusiveness is also related to potential detriment of human interaction. A reflection on "personal relationships cost" versus "independence" needs to be balanced in the field of caring for the elderly.

Obtrusiveness related to active actuations was considered both in term of primary and secondary RADIO users. Privacy and function are the main considerations related to primary users while the routine, sustainability dimension, function and usability dimensions of obtrusiveness can impact secondary user's life.

In this report, we further analyzed functional obtrusiveness. We first revisited monitoring of mood behavior items. Given the accuracy of the state of art methods for monitoring mood, it was decided that no monitoring of these items will be included in the RADIO system.

We then went on by discussing several considerations to be taken when defining what an 'accurate measurement is' for a majority of items used to assess functional activities of daily living. Although it is very challenging to eliminate functional obtrusiveness of ICT systems assessing frailty, at the same time systematic observations obtained by such system can offer new opportunities for assessing frailty timely, with accuracy and in a universally accepted way, and thus supporting elderly to live independently.

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