Assistenza e Tecnologie: Favorire il Dialogo tra Domanda e Offerta

Cadute: Prevenzione e Rilevazione

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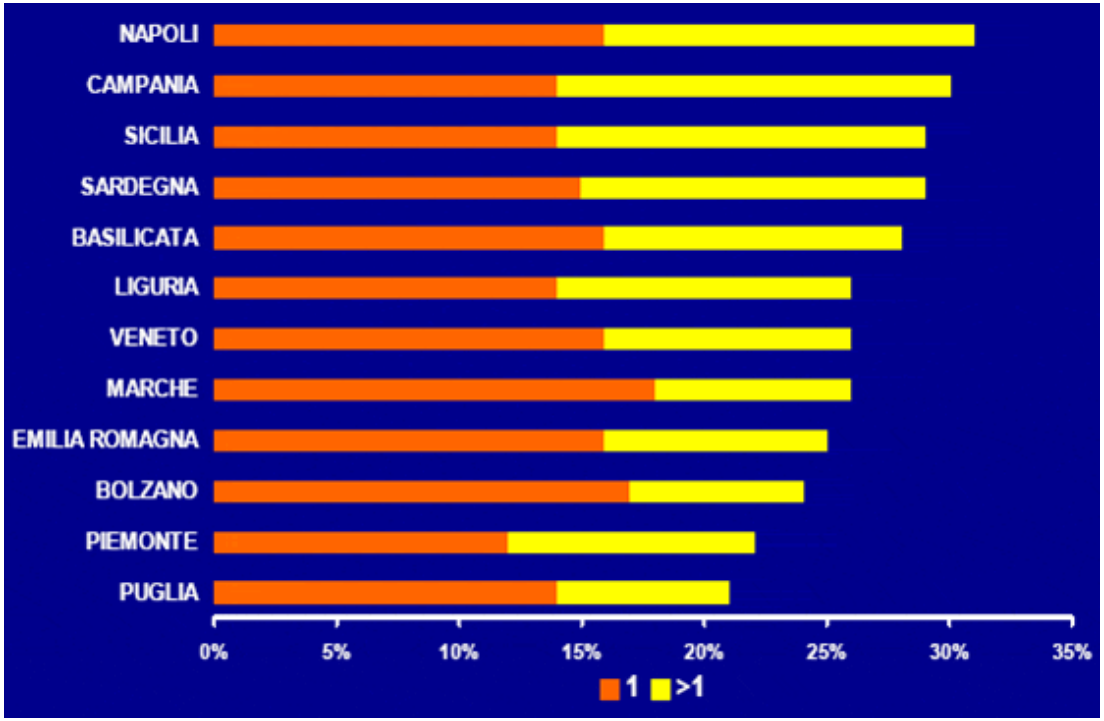
Epidemiologia delle cadute



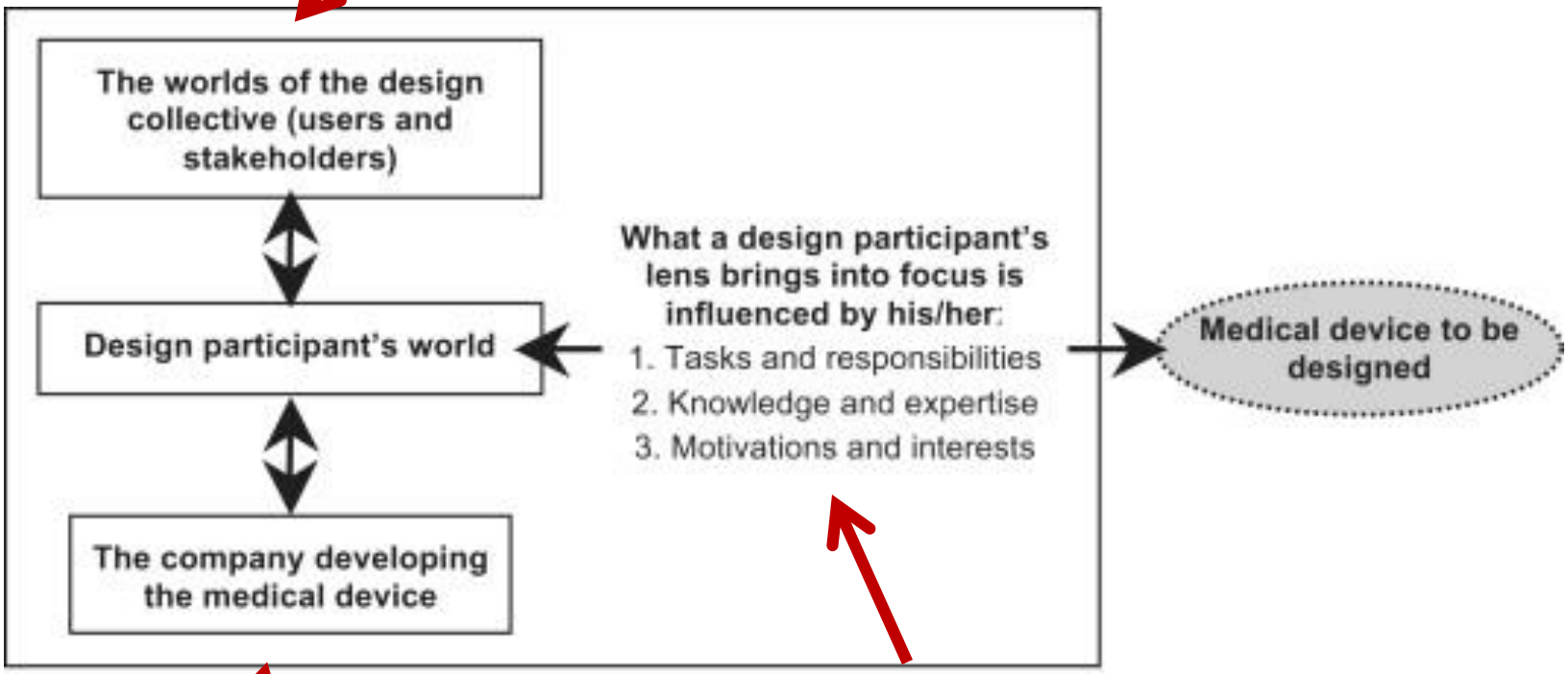
Fonte: Istituto Superiore di Sanità

- Falls are particularly common and burdensome among the elderly. About one third of the older population experiences at least one fall each year (*WHO, 2007*).
- Worldwide, it is estimated that falls are responsible for 35 million disability-adjusted life years (*Murray et al, Lancet ,2012*).

Key gaps

Quali necessità?

Multidimensionalità



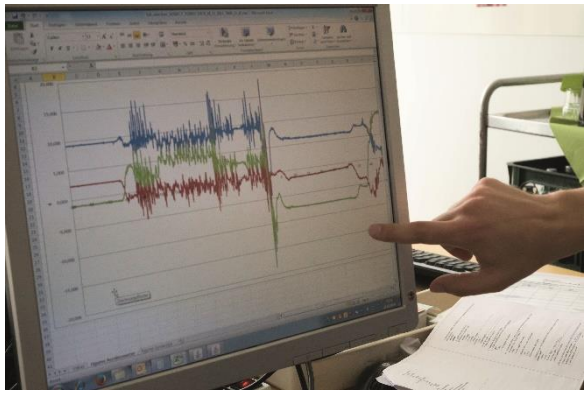
Quale paziente?

Pz a rischio e in grado di interagire con tecnologia

Quale tecnologia?

Assioma

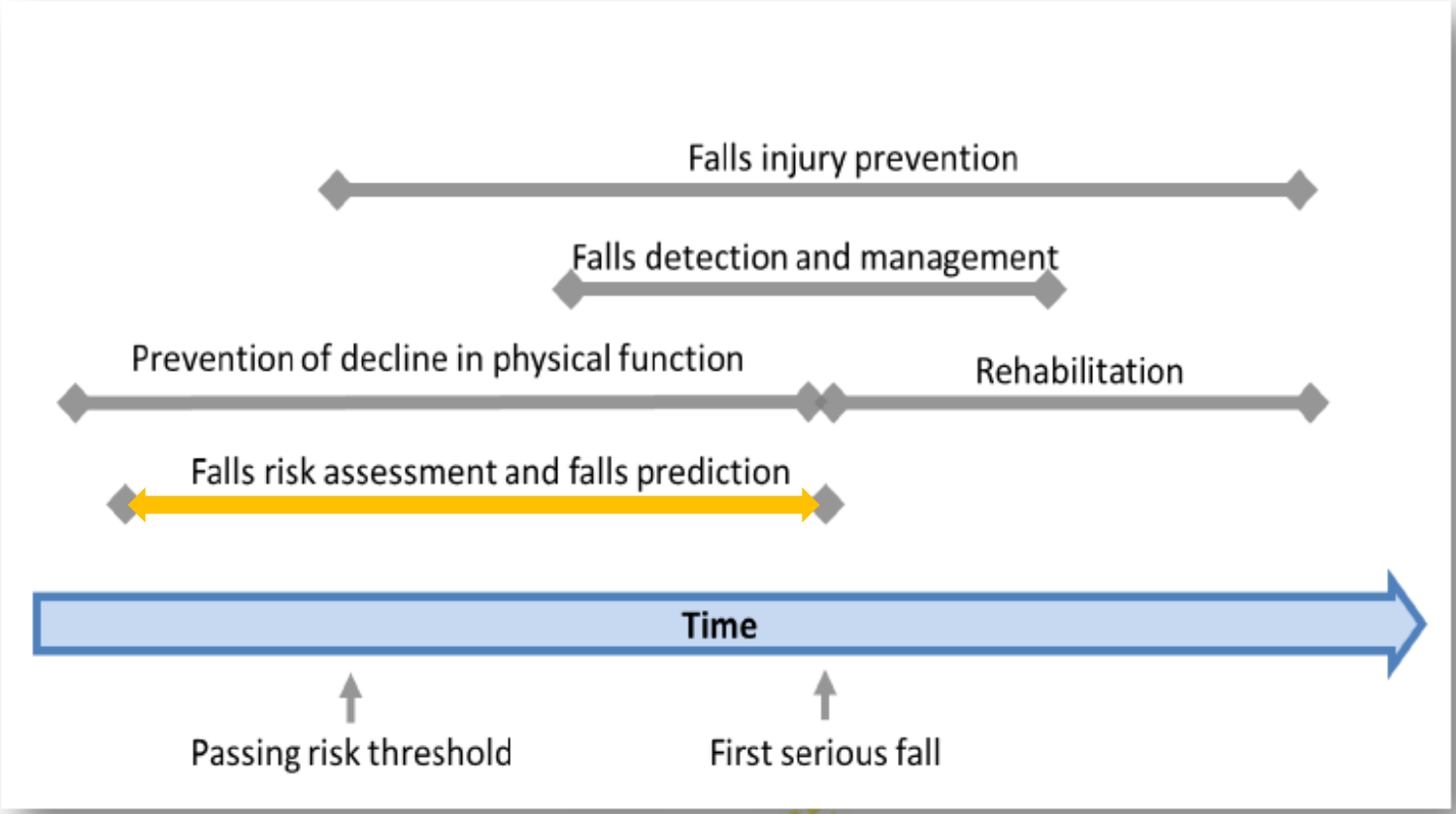
La tecnica, in greco *téchne* e in latino *ars*, è «una disposizione creativa accompagnata da ragione vera [...] intorno a quelle cose che possono essere diversamente da come sono» (Aristotele, *Etica Nicomachea*)



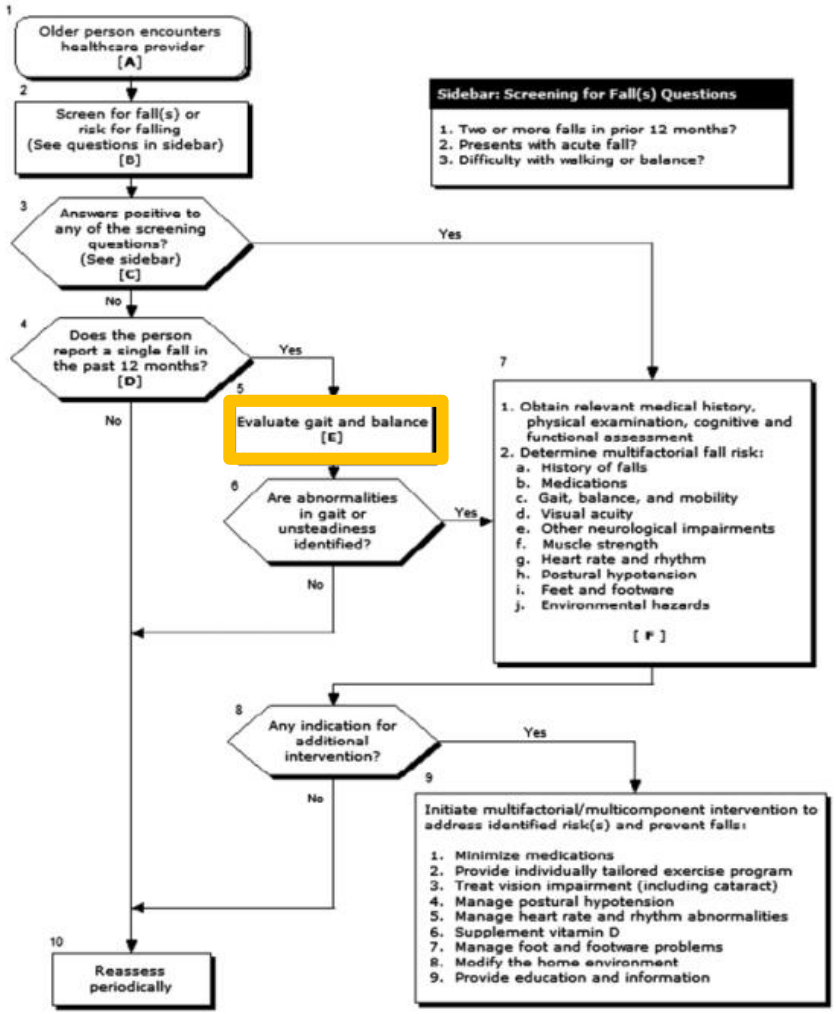
La tecnologia non è parte del problema, ma parte della soluzione

«L'invenzione non è tutto. È necessario che la collettività l'accetti e la propaghi» (Marc Bloch)... «e concorra a determinarne gli esiti» (Angela Spinelli)

Storia clinica: Azioni e reazioni



Le linee-guida (ask & evaluate)



1

- Screening for high risk

2

- Assessment of multiple risk factors for those at high risk

3

- Implementation of a tailored intervention

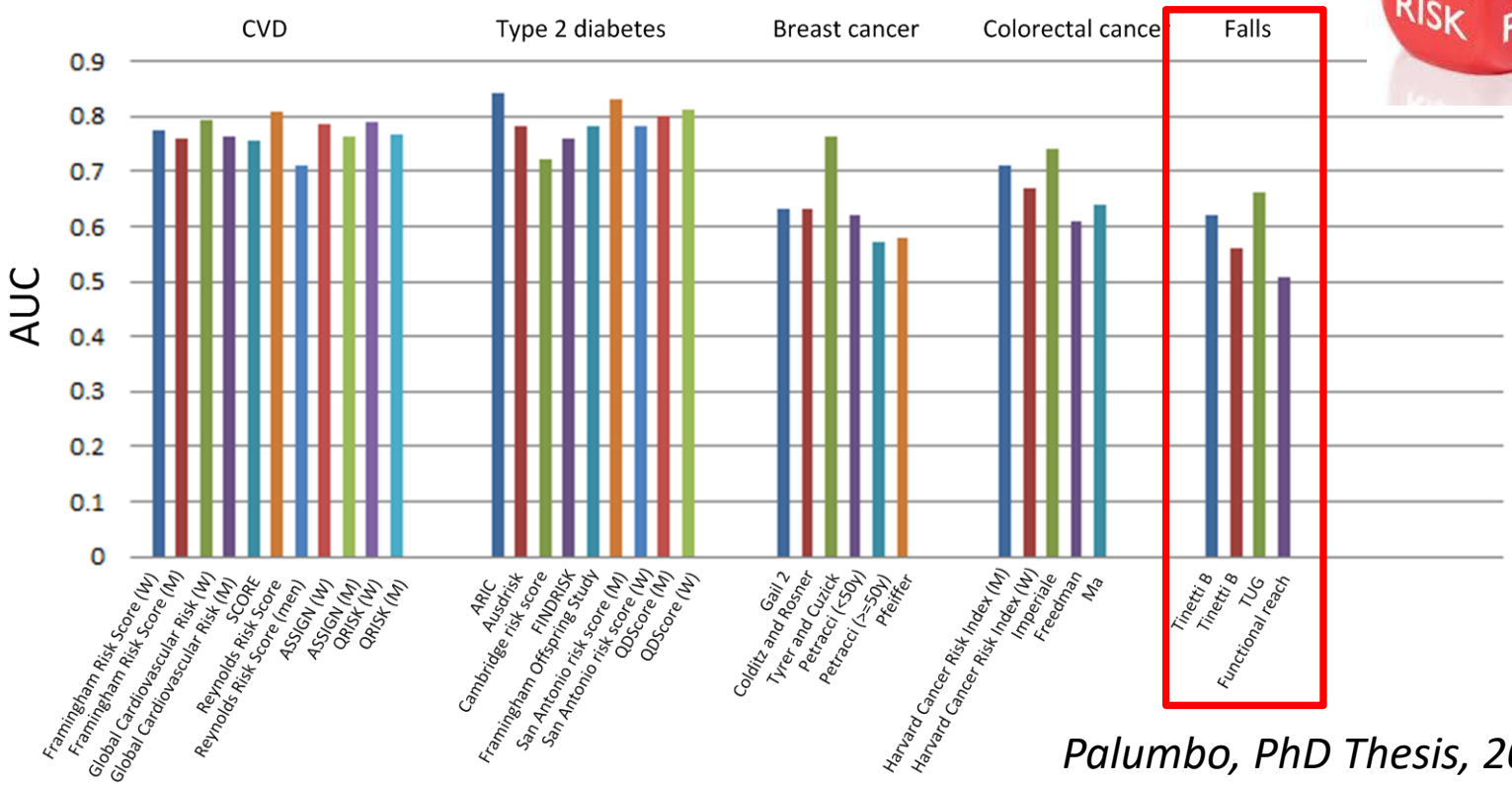
J Am Geriatr Soc. 2011

Prognosi del rischio di caduta?

- Guidelines were tested on older disabled women and in community-dwelling older adults and found to be **suboptimal** with respect to other screening tool and of **moderate clinical utility** (*Muir et al, J Geriatr Phys Ther, 2010*).
- To the best of our knowledge, **no published article reports on the predictive accuracy of current versions of these screening algorithms**.
- Many other **screening tools** have been proposed in the literature but **few of them have been tested outside the derivation cohort**.

- **History of falls** is a strong risk indicator for future falls (*Ganz et al, JAMA, 2007*), although it alone does not suffice for primary prevention.
- **SPPB** is a tool to assess physical performance, commonly included in comprehensive geriatric assessments. Its association with falls and injurious falls is documented (*Veronese et al, Rejuvenation Res. 2014*) but its prognostic performance is not reported.

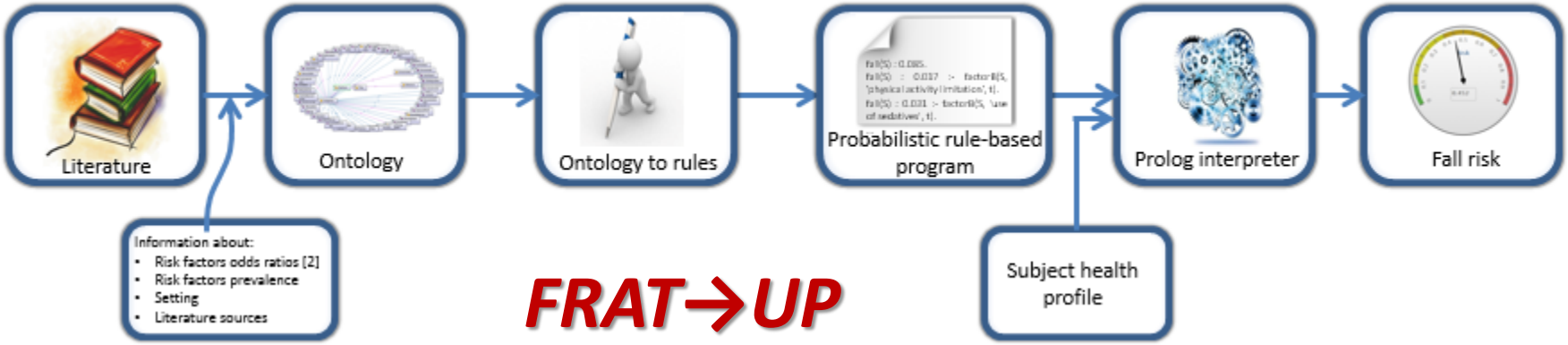
Prognosi del rischio di caduta?



Palumbo, PhD Thesis, 2015

- **TUG** has been judged inadequate in several studies (e.g. *Barry et al, BMC Geriatr. 2014*).
- **Gait speed** is an indicator of health state in geriatric populations. Its prognostic value for future falls has been shown to be equivalent to total time to perform the TUG (*Viccaro et al, J Am Geriatr Soc. 2011*).

A Web-based Fall Risk Assessment Tool



Cattelani et al, J. Med Int Res, 2015

- Assessment tool for evaluating the fall risk within a year
- Aimed to general practitioners and health organizations (per-subject evaluation vs. population wide)
- So far focused on community-dwelling older people
- Based on 26 risk factors available in the literature (*De Andrea et al, Epidemiol, 2010*)
- Exploits available clinical information about the subject
- Freely available as a web-based application at the url **ffrat.farseeingresearch.eu**

Dai fattori di rischio…

Clinical risk factors for falls have been well identified

Epidemiology:
September 2010 - Volume 21 - Issue 5 - pp 658-668
doi: 10.1097/EDE.0b013e3181e89905
Injury: Review Article

Risk Factors for Falls in Community-dwelling Older People: A Systematic Review and Meta-analysis

Deandrea, Silvia[a,b]; Lucenteforte, Ersilia[a,b]; Bravi, Francesca[a,b]; Foschi, Roberto[a]; La Vecchia, Carlo[a,b]; Negri, Eva[a]

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Risk factors for falls in older people in nursing homes and hospitals. A systematic review and meta-analysis

Silvia Deandrea, Francesca Bravi, Federica Turati, Ersilia Lucenteforte, Carlo La Vecchia, Eva Negri

Received: August 7, 2012; Received in revised form: December 5, 2012; Accepted: December 7, 2012; Published Online: January 07, 2013

… ad uno strumento di screening

-Allows the use of statistical prevalence of the risk factor
-Support for dichotomic, scalar and synergy risk factors

Highcharts.com

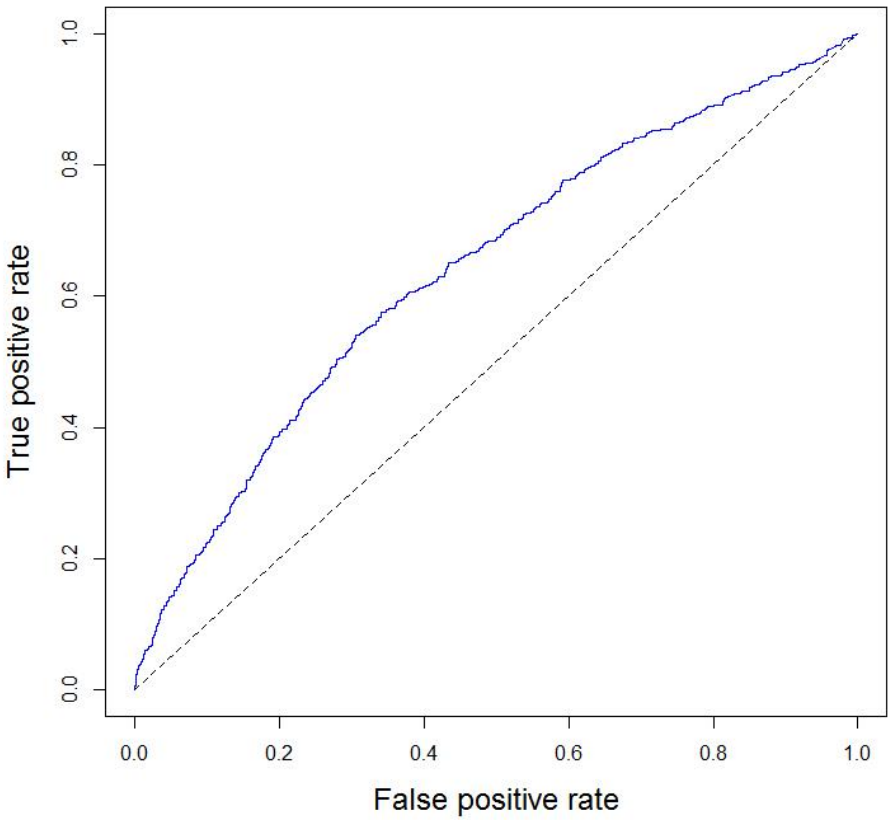
Health profile of the subject:

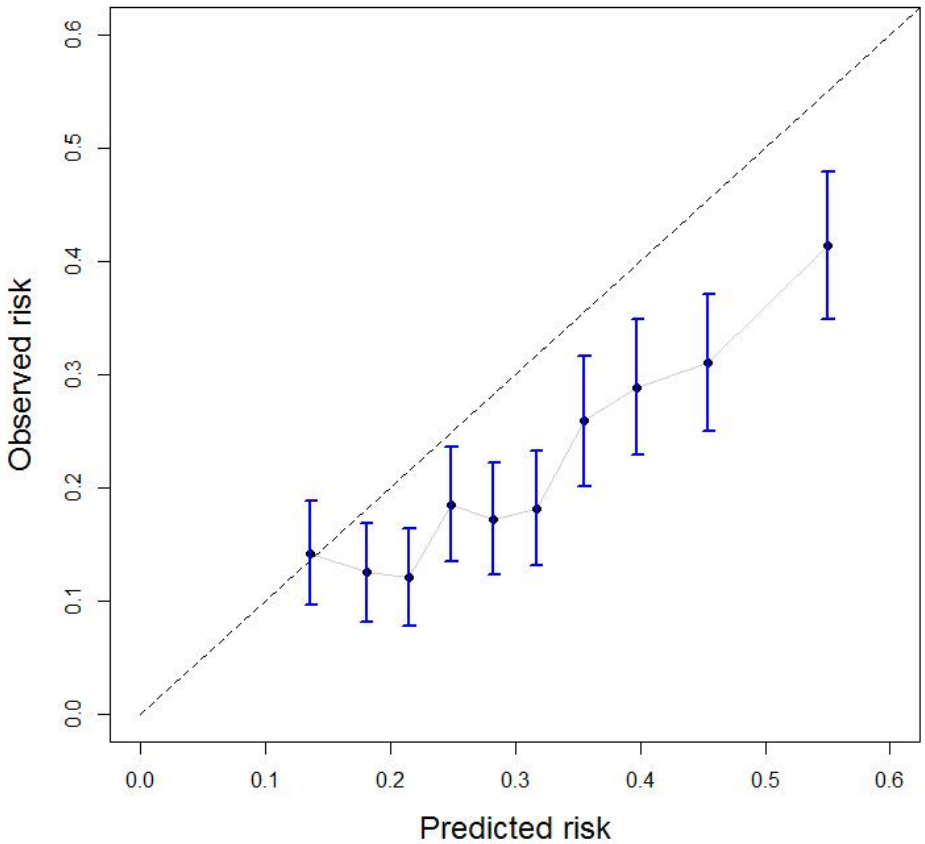
Does the subject use sedatives?	Yes	No	Use prevalence	
Diabetes blood glucose 126?	Yes	No	Use prevalence	
Fear of falling (Deshpande)?	Yes	No	Use prevalence	
Does the subject suffer rheumatic disease?	Yes	No	Use prevalence	
Does the subject suffer Parkinson?	Yes	No	Use prevalence	
Does the subject suffer any pain?	Yes	No	Use prevalence	
Does the subject use antihypertensives?	Yes	No	Use prevalence	
Does the subject use antiepileptics?	Yes	No	Use prevalence	
Is the subject female?	Yes	No	Use prevalence	
Does the subject live alone?	Yes	No	Use prevalence	
Does the subject use a walking aid?	Yes	No	Use prevalence	
Dizziness or unsteadiness last year?	Yes	No	Use prevalence	
Urinary incontinence last year?	Yes	No	Use prevalence	
History of previous strokes?	Yes	No	Use prevalence	
History of previous falls?	Yes	No	Use prevalence	

physical activity level:		Use prevalence
Visual stereognosis:		Use prevalence
Number of ADL disabilities (0-6):	2	Use prevalence
Hearing impairment?:		Use prevalence
Revised Walking Subscore:		Use prevalence
Visual acuity (3 meter):		Use prevalence
Subject's number of IADL:		Use prevalence
MMSE score:		Use prevalence
How does the subject feel:		Use prevalence
CESD:		Use prevalence
Number of drugs used by the subject:		Use prevalence
Contrast sensitivity?:		Use prevalence
Age:	75	Use prevalence

Run the assessment! | Generate a report (.pdf)

Validation on the InChianti DB (N=977)

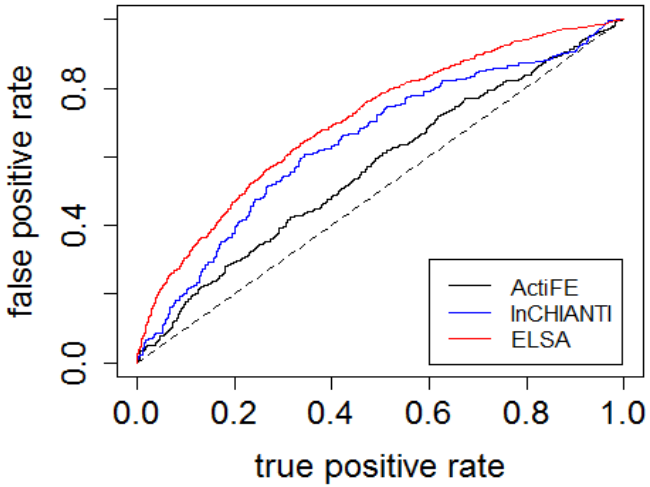


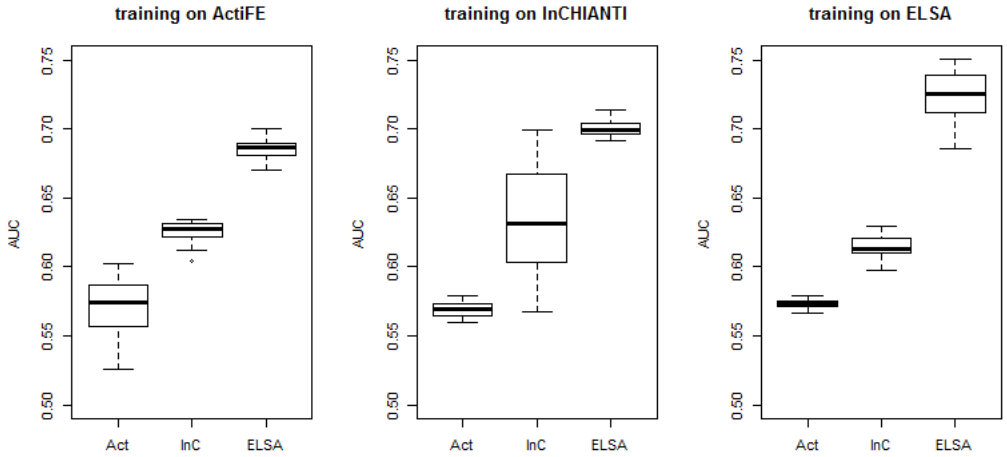


AUC = 0.642 (95% CI 0.614-0.669)

Cattelani et al, J Med Int Res, 2015

Validation on other DBs

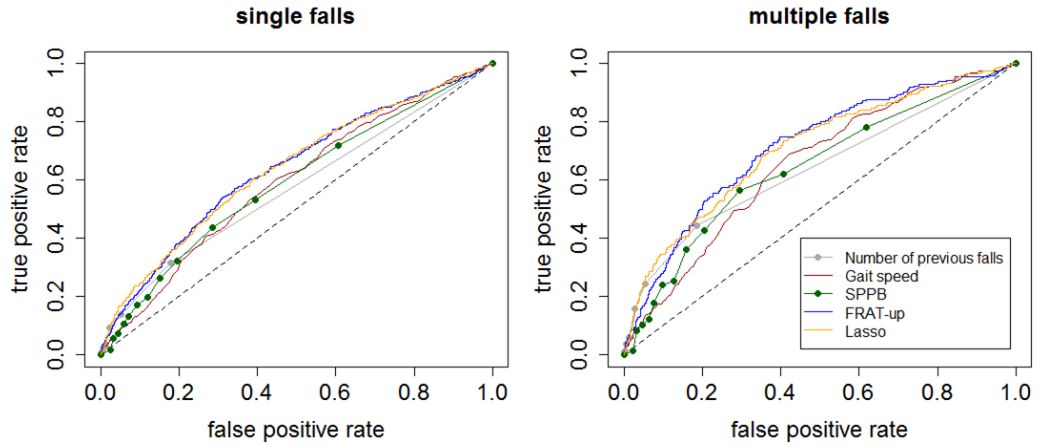




	AUC (95% CI)		
	ActiFE	**ELSA**	**InCHIANTI**
FRAT-up	0.565 (0.533-0.594)	0.706 (0.688-0.724)	0.637 (0.593-0.678)
Models fitted on ActiFE (HA)	**0.570 (0.527-0.600)**	0.686 (0.674-0.697)	0.625 (0.608-0.634)
Models fitted on ELSA (HE)	0.573 (0.567-0.579)	**0.724 (0.693-0.748)**	0.614 (0.600-0.627)
Models fitted on InCHIANTI (HI)	0.569 (0.560-0.578)	0.700 (0.692-0.712)	**0.635 (0.580-0.694)**
Models trained on non-harmonized datasets (and tested on same dataset)	NHA 0.581 (0.547-0.628)	NHE 0.716 (0.695-0.742)	NHI 0.629 (0.580-0.680)

Palumbo et al. 2015, in preparation

Clinical risk factors: can we do better?



	Single falls		Multiple falls	
	AUC (95% C.I.)	p value Risk indicator vs FRAT-up / Risk indicator vs Lasso	AUC (95% C.I.)	p value Risk indicator vs FRAT-up / Risk indicator vs Lasso
Number of previous falls	0.574 (0.551-0.597)	** / **	0.640 (0.603-0.678)	** / **
Gait speed	0.594 (0.566-0.622)	** / **	0.653 (0.615-0.692)	** / *
SPPB	0.590 (0.563-0.618)	** / **	0.645 (0.604-0.686)	** / **
FRAT-up	0.638 (0.610-0.666)	– / 0.92	0.713 (0.675-0.752)	– / 0.62
Lasso	0.639 (0.611-0.667)	0.92 / –	0.708 (0.669-0.747)	0.62 / –

Palumbo et al., PLOS One, in press

La copertura dei fattori di rischio è multidimensionale

AGS/BGS	FRAT-up	Data-driven model (variables available for selection)	Data-driven model (variables most frequently selected)
Relevant medical history, physical examination, cognitive and functional assessment	Diabetes MMSE Self-perceived health status	Widely covered	Self-perceived health status, CESD, familiarity to diabetes,
History of falls	Yes	Yes	Yes
Medications	number of medications, sedatives, anti-hypertensives, antiepileptics,	Domain accurately covered.	Number of medications, drug for dementia, anti-hypertensives, antidepressants
Gait, balance, and mobility	Gait problems assessed via the Revised walking sub-score, walking aid use	Gait speed in different tests, FICSIT, SPPB, etc.	Gait speed, cautious attitude while walking
Visual acuity	Visual acuity, contrast sensitivity, visual stereognosis	Visual acuity, contrast sensitivity, visual stereognosis	
Other neurological impairment	Parkinson's disease	Parkinson's disease, subclinical/non overt neurological signs	
Muscle strength	No	Grip strength, lower limb muscle strength	
Heart rate and rhythm	No	Yes	
Postural hypotension	No	No (There is information about blood pressure before and after standing up but not explicity the difference…)	
Feet and footware	No	Information about shoes	
Environmental hazards	No	No	No

Esistono altre possibilità per una valutazione multidimensionale?

Instrumented Functional Tests

Timed Up and Go

Balance

Repeated Chair Standing

Gait

Sensor-based multidimensional assessment

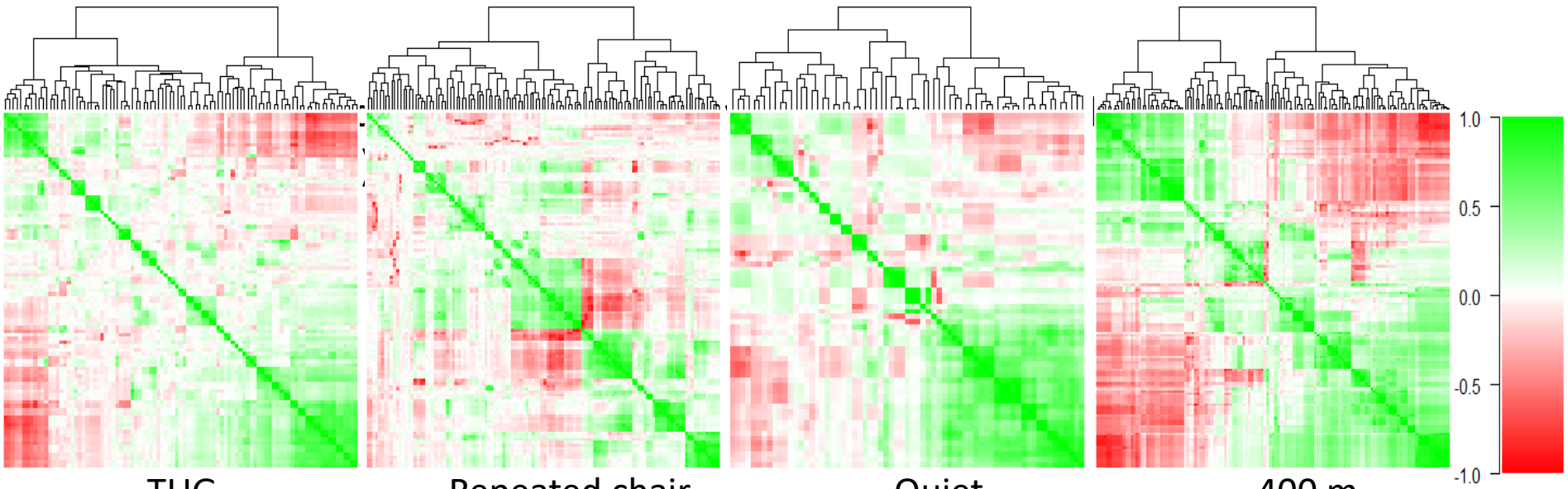
Stato dell'arte

Authors	Journal	N	N of fallers
Marschollek et al.	*Methods Inf Med* 2011 *BMC Med Inform Decis Mak* 2011	46	19
Paterson et al.	*Gait Posture* 2011	97	54
Schwesig et al.	*Clin Rehabil* 2013	171	40 (17 cases)
Doi et al.	*J Neuroeng Rehabil* 2013	73	16
Weiss et al.	*Neurorehabil Neural Repair* 2013	71	12
Weiss et al.	*Plos One* 2014	67	14 ← Parkinson's Disease
Schwenk et al.	*Gerontology* 2014	77	28 ← Dementia
Van Schooten et al.	*J Gerontol A Biol Sci Med Sci* 2015	169	59
Rispens et al.	*JMIR Res Protoc* 2015	202	70

Only studies with falls assessed prospectively are included

Limiti dello stato dell'arte

- Very few studies have made used of information about falls collected **prospectively**
- **Datasets are relatively small**
- **Lack of validation** of previous results impedes the assessment of the robustness of the results obtained so far.



TUG	Repeated chair standing	Quiet standing	400 m walk
95 x 95	120 x 120	67 x 67	133 x 133

Coni et al, IEEE-EMBS, 2015

Risultati preliminari sull'InChianti

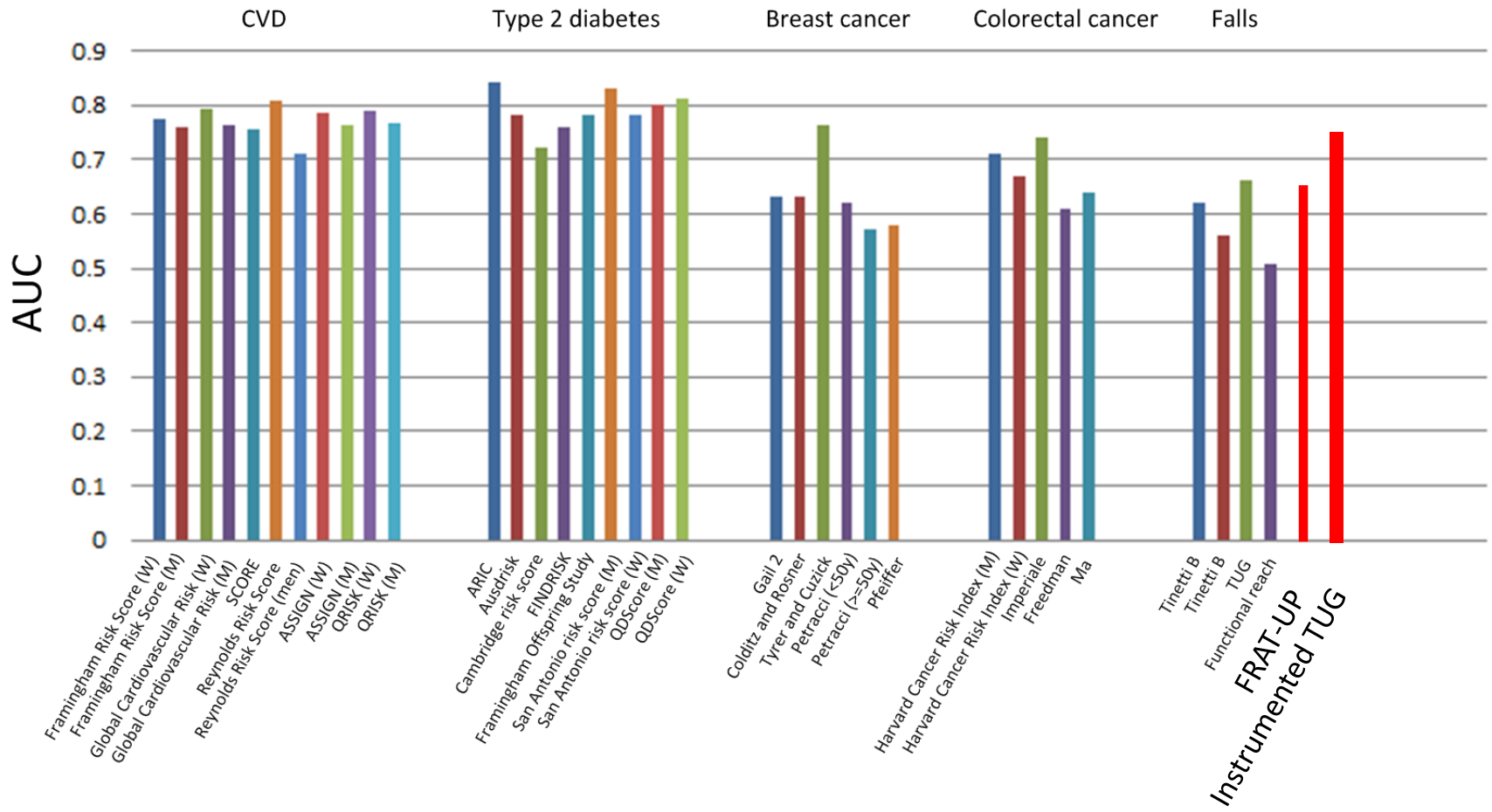
Sensor-based assessment only

- Factor analysis on data from **TUG**
  - *global performance*
  - *smoothness of sit to walk transition (StW)*
  - *lateral weight shift control during the turn to sit transition (TtS)*
  - *lateral weight shift control during StW*
  - *forward weight shifting control during StW*
  - *smoothness of TtS*

- Confounders: age, gender, MMSE, BMI, SPPB, CES-D, #Drugs
- Logit multiple regression model
- All factors are associated with falls at **6 months** with **AUC=0.74** (p=0,01)
- All factors are associated with falls at **12 months** with **AUC=0.7327** (p=0,01)
- Single factor, *Smoothness of StW* is associated with falls at **12 months** with **AUC=0.708** (p=0,01)

Colpo et al, Proc. GSA, 2015
Colpo et al, Proc SIGG, 2015

Prognostic tools: we can do better!

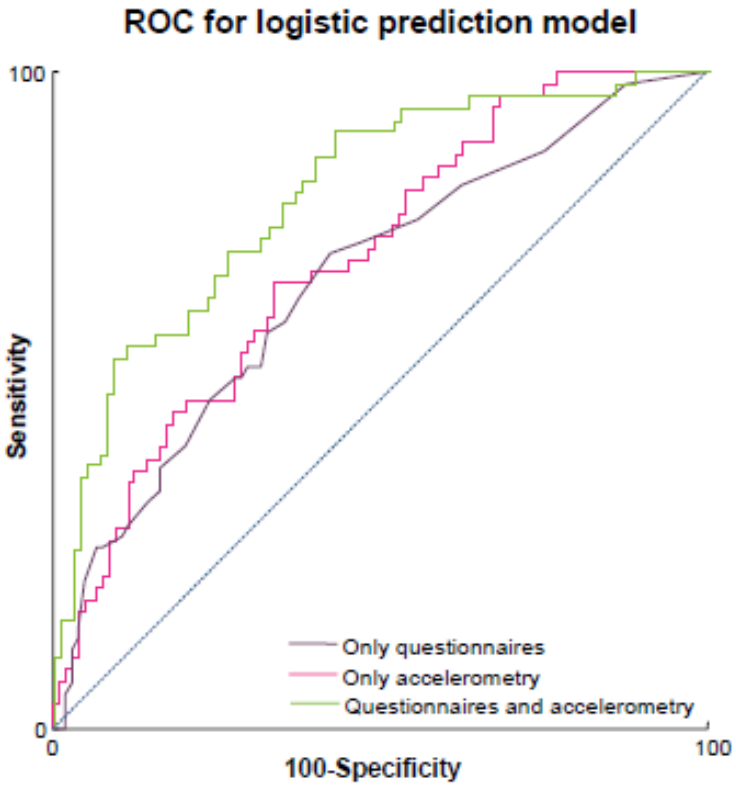


What's next?

Model 1: Fall prediction with median values

Added value of accelerometry

- 6-month history of falls
- local divergence exponent AP
- intensity VT
- number of strides
- geriatric depression scale
- smoothness ML
- sample entropy VT
- intensity VT x number of strides
- smoothness ML x number of strides



- AUC 0.82*

Gait features computed from long-term recordings of PA

(van Schooten et al., J. Gerontol 2015)

Future applications

Integration with diagnostic tests

1. FRAT-up as a first-level assessment of the risk per-subject
2. If appropriate, second level assessment: "Timed Up-and-GO" test with a commercial smartphone
   - Diagnostic test executed in a controlled environment
   - Farseeing app developed on purpose
3. Third level assessment: activity day life monitoring with commercial smartphone
   - One week observation
   - Farseeing app developed on purpose

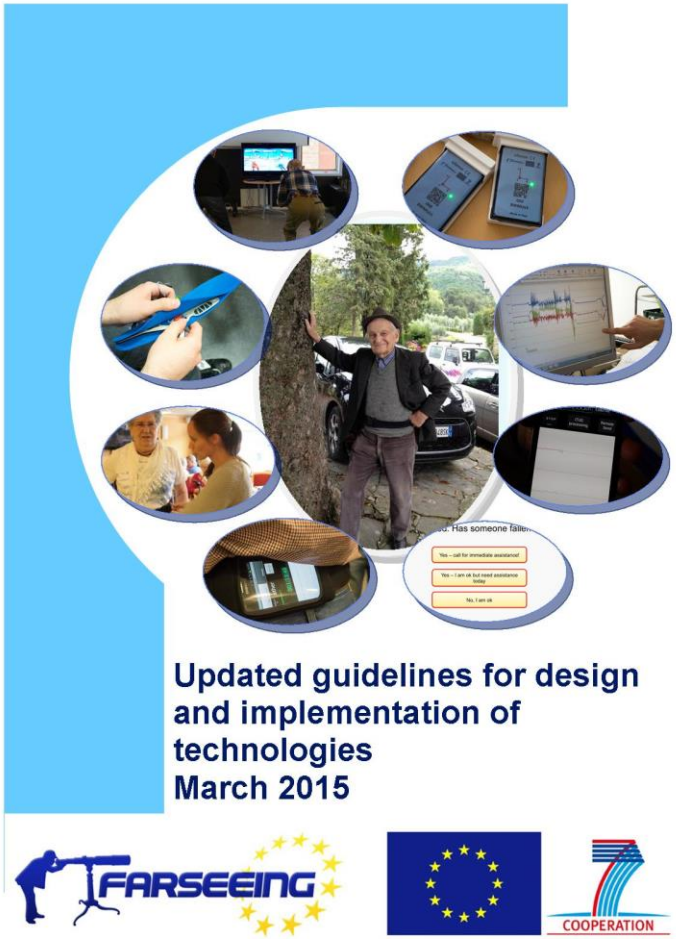
Accuracy & Precision

Invasiveness

Prototype available at:
http://ffrat.farseeingresearch.eu/bruxelles/

Conclusioni

- Le tecnologie ICT sono «amiche» dell'anziano e di chi lo studia/assiste
- Possono aiutarci a conoscere meglio, anche in luoghi impensati e per tempi molto lunghi, il processo dell'invecchiamento
- Possono aiutarci a mettere a punto nuovi strumenti di screening per identificare precocemente alcuni dei fattori di rischio associati al declino della mobilità



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Koen Milisen (*Professor Geriatric Nursing*)
Jacqui Close (Professor & *Consultant Geriatrician*)
Lindy Clemson (*Professor in Ageing and Occupational Therapy*)
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Tele-healthcare Satisfaction Questionnaire Wearable Technology (TSQ-WT) v1.0

Area		Statement	Mean	SD
BENEFIT	1	I can benefit from this technology	3.75	0.83
	2	The effort of using this technology/method is worthwhile for me	4.20	0.88
	3	I am confident I'm getting the most out of this technology/method	3.73	0.79
	4	This Technology/method is helping me to achieve my goals	2.69	1.13
	5	I would recommend this technology/method to other people in my situation	4.32	1.01
USABILITY	1*	The use of this technology/method requires effort	4.57	1.06
	2	The technology/method is reliable according to my estimation and experience so far.	3.95	0.83
	3	This technology/method is easy to use	4.83	0.45
	4	I feel safe when using this technology/method	3.94	1.09
	5	I feel good while using this technology/method	4.11	0.97
SELF CONCEPT	1	The use of this technology/method is an interesting challenge for me	2.96	0.85
	2*	This technology/method reminds me of losing my independence	4.76	0.71
	3*	The use of this technology/method is making me feel older than I am	4.70	0.79
	4*	I (would) feel embarrassed using this technology/method visible around others	4.82	0.75
	5	I like to use technological products or systems like this technology/method	3.36	1.43

Tele-healthcare Satisfaction Questionnaire Wearable Technology (TSQ-WT) 2/2

Area		Statement	Mean	SD
PRIVACY AND LOSS OF CONTROL	1*	I feel there is too much supervision by this technology/method	4.69	0.81
	2*	I use this technology/method by request of others (e.g. physician, therapist, relatives)	2.53	0.99
	3	I am sure that my personal data are stored or processed in an appropriate way	4.63	0.62
	4*	The use of this technology/method may have unpredictable negative consequences for me	4.68	0.71
	5*	This technology/method forces me to disclose personal facts that I prefer to keep to myself	4.67	0.75
QUALITY OF LIFE	1	Using this technology/method improves my physical well-being	2.33	1.20
	2*	This technology/method evokes unpleasant feelings	4.57	0.98
	3	This technology/method enhances my social contacts	2.32	1.32
	4	This technology/method helps me to maintain or increase my independence (e.g. with regard to mobility, communication, medication)	2.82	1.15
	5	The use of this technology/method has a positive effect on me	3.18	1.16
WEARING COMFORT	1	Wearing this device (parts of the device) is comfortable	3.87	1.41
	2	I am pleased with the size of the device (parts of the device)	4.36	1.05
	3	I would wish another look and design of the device (parts of the device)	1.86	1.21
	4	I am pleased with the weight of the device (parts of the device)	4.61	1.11
	5*	The body-worn parts of the device are difficult to adjust (fix, fasten)	4.42	1.25

Database structure

Real-world fall meta-database

subject characteristics

- age
- gender
- disease
- functional status
- …

fall characteristics

- date & time
- fall direction
- verification
- outcome
- …

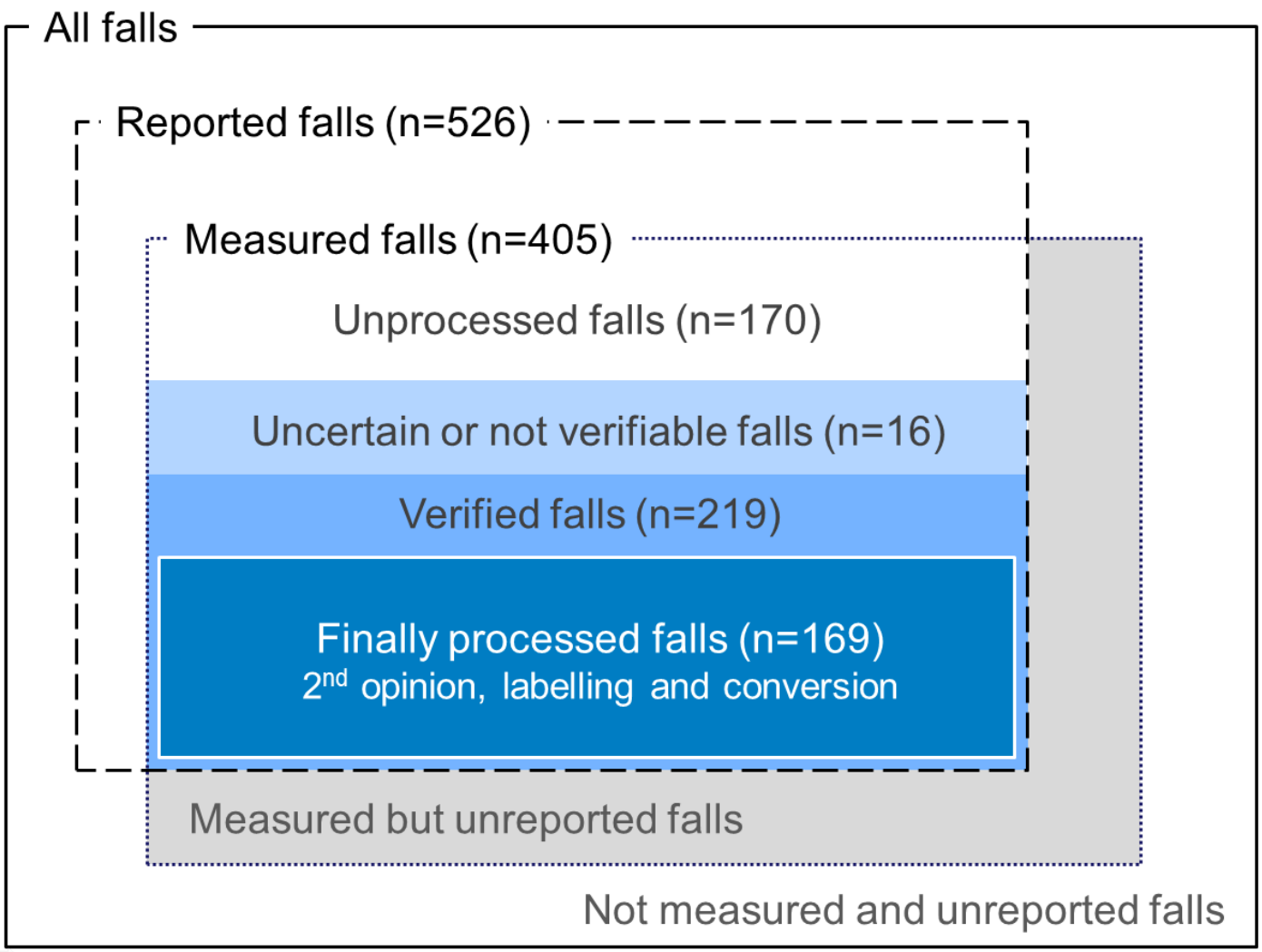
technical characteristics

- type of sensor
- sample rate
- sensor site
- duration
- …
-

Fall signals

- accelerometer
- gyroscope
- magnetometer

Database status



Fall verification process

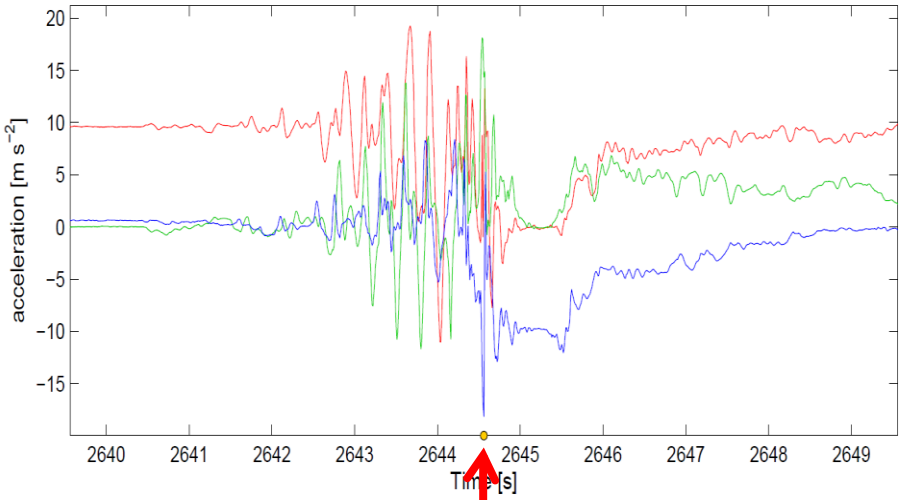
<u>Fall Report</u>
Fall no.: 18194920-02

Date: 19.06.2014
Time: 08:40:00

“While walking initiation, subject turned 90° and fell directly on the buttock.”

Reported fall direction: Backwards

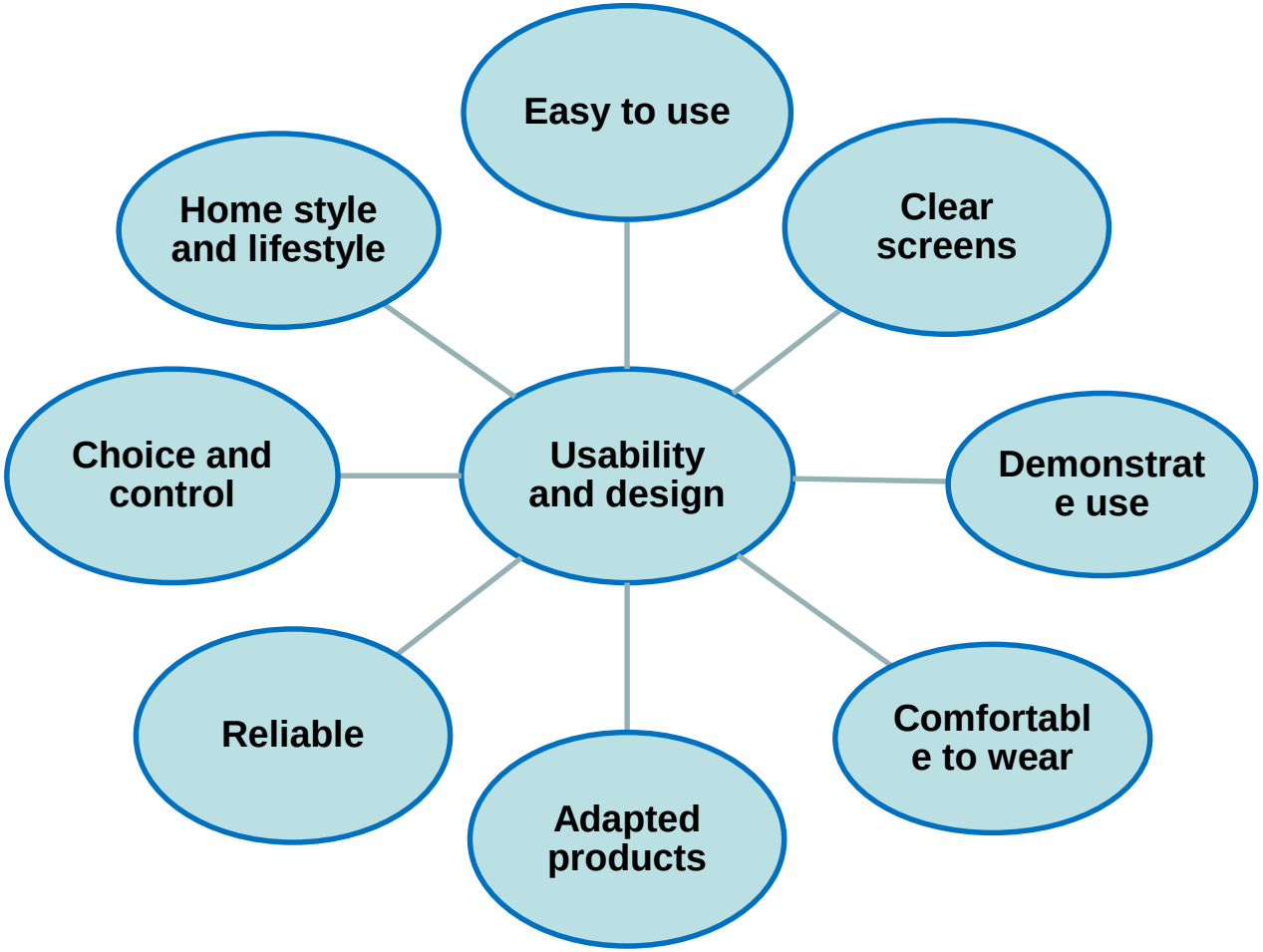
Sensor: Samsung Galaxy S3
Location: L5



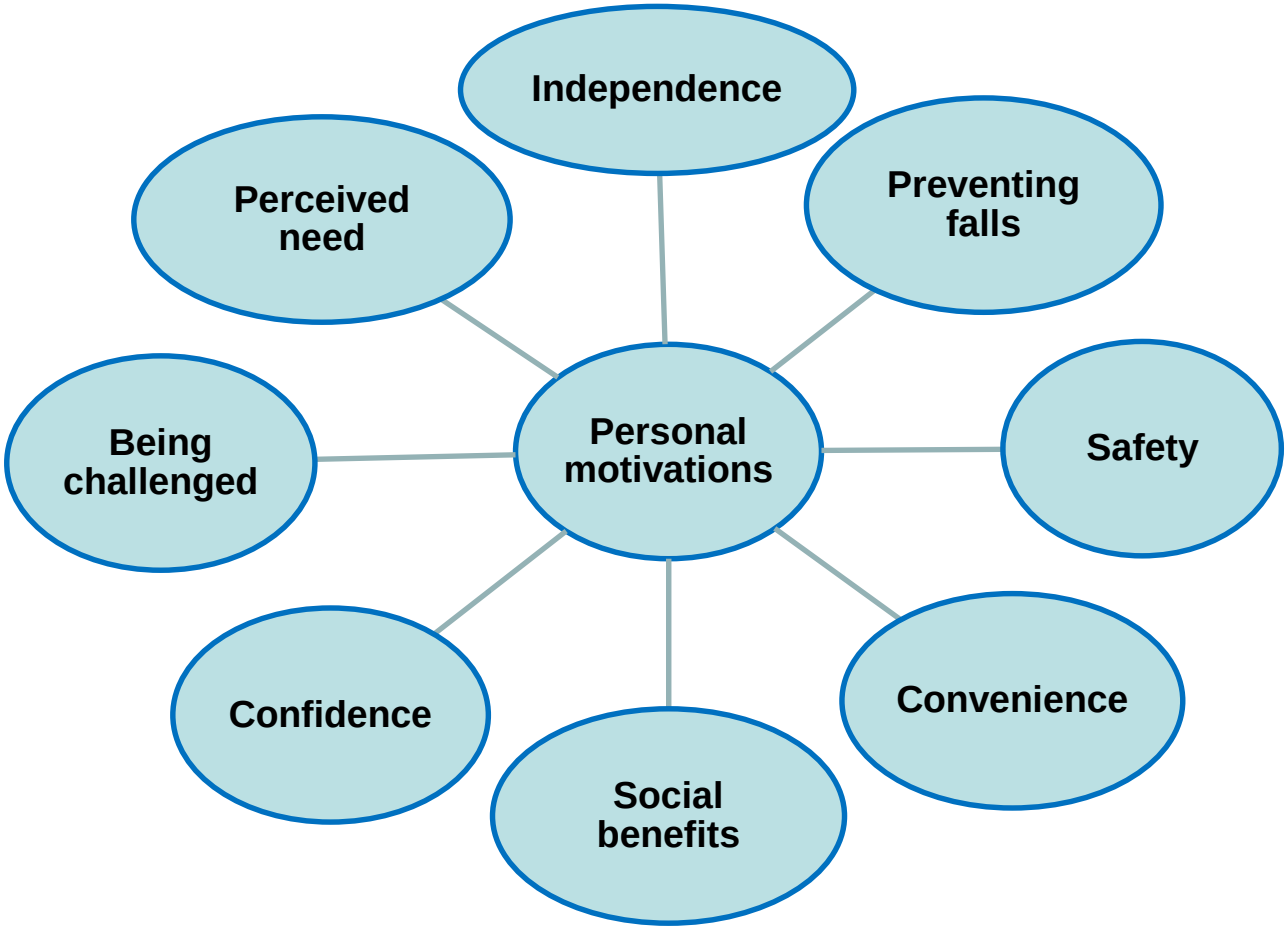
Acceptance of ICT

- Systematic review of users' perceptions of technologies (Hawley-Hague et al. 2014 - IJMI).
- Stakeholder consultation – older adults' acceptance and implementation opportunities.
- Usability testing - waist-worn smartphones.
- Usability testing - Exergames – DDR, The Mole (SilverFit) and Light Race.
- Usability testing – smart home touchscreen.
- User feedback – Fall Alarm Trial and Focus Groups

Themes (1)


Easy to use
Home style and lifestyle
Clear screens
Choice and control
Usability and design
Demonstrate use
Reliable
Adapted products
Comfortable to wear

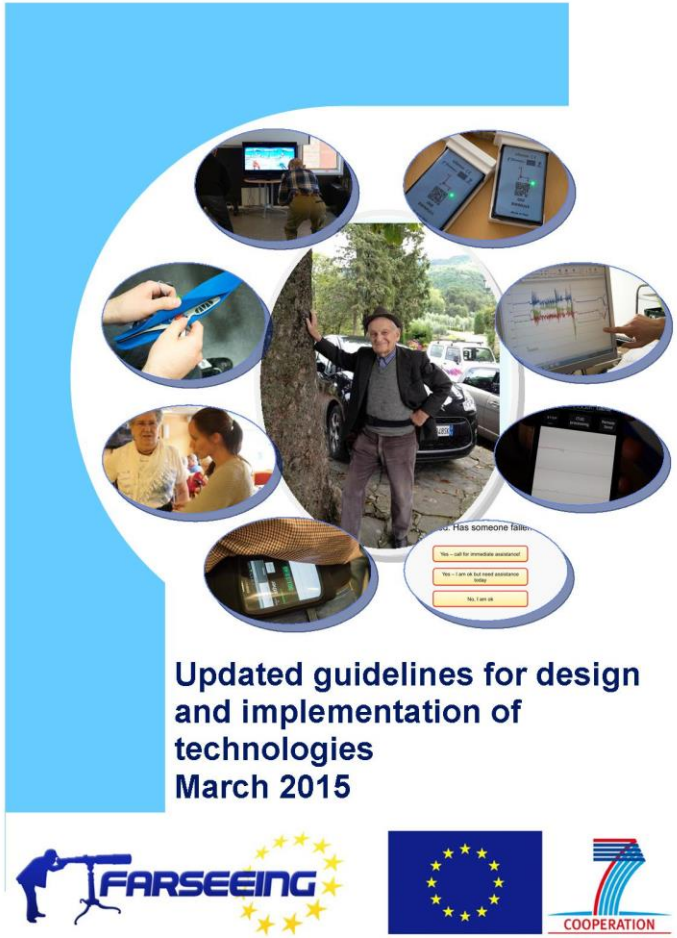
Themes (2)


Independence
Preventing falls
Perceived need
Being challenged
Personal motivations
Safety
Confidence
Convenience
Social benefits

Themes (3)


Promoting new technologies
Affordable
Direct appeal
Appeal to curious
Existing networks
Positive focus
Local relevance
Local champions
Demonstrate acceptance
Sound research
Commercial events

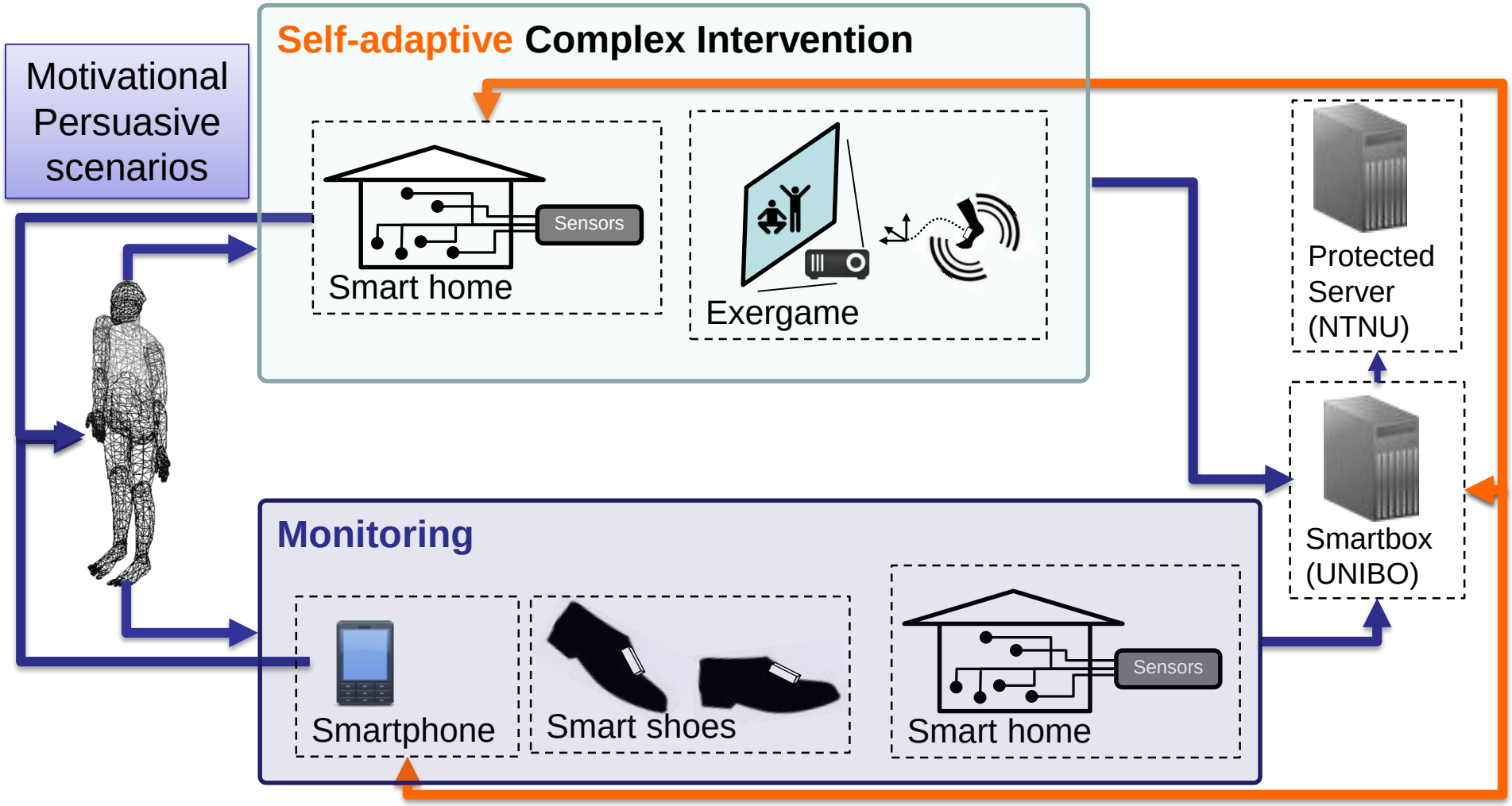
The Guidelines



farseeingresearch.eu

- Be transparent
- Give the choice
- Have a feedback
- Set Personal goals
- Not be boring (Self-adaptive interventions)

Self adaptive intervention

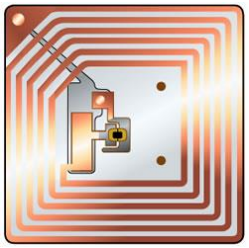


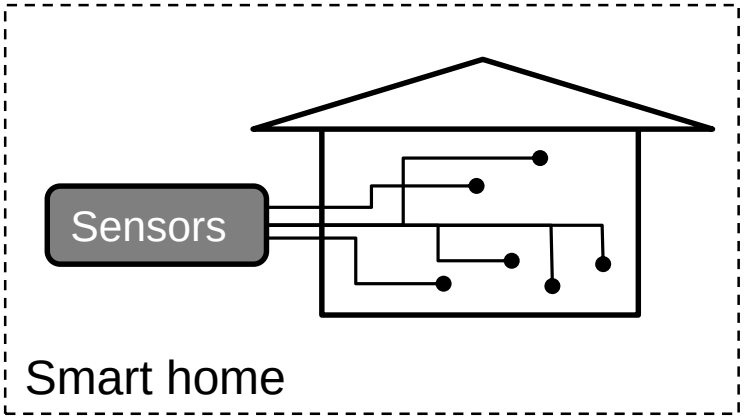
Smart home

- Technology
  - 10” touch screen user interface

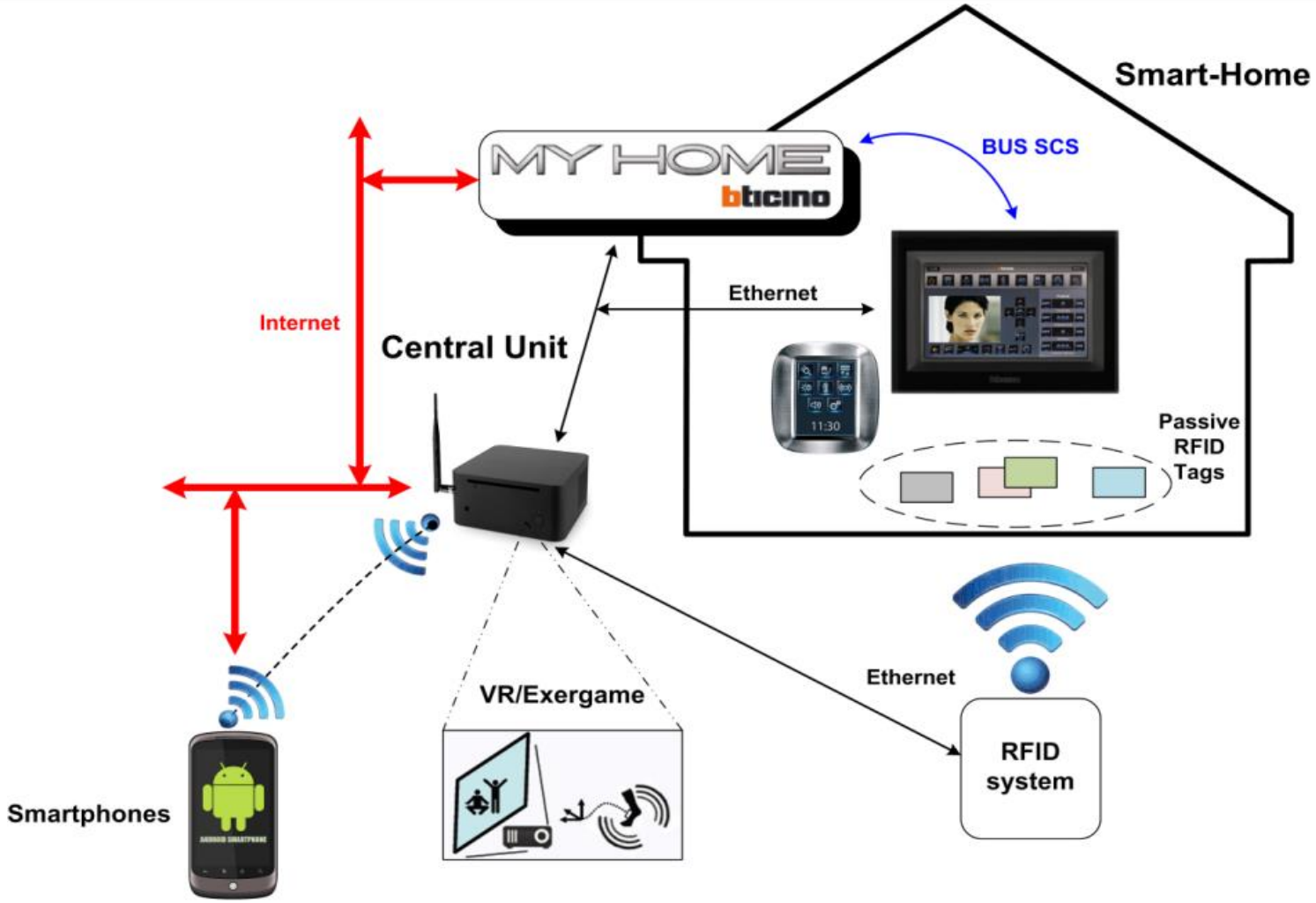
  - Sensors and switches
    - PIR detector, Gas, temperature, RFID, Push-button switches

- Measurement features
  - Scenarios
  - Interaction with all the peripherals sensors and interfaces
  - Indoor localization
  - Indoor/outdoor time
  - Gait speed



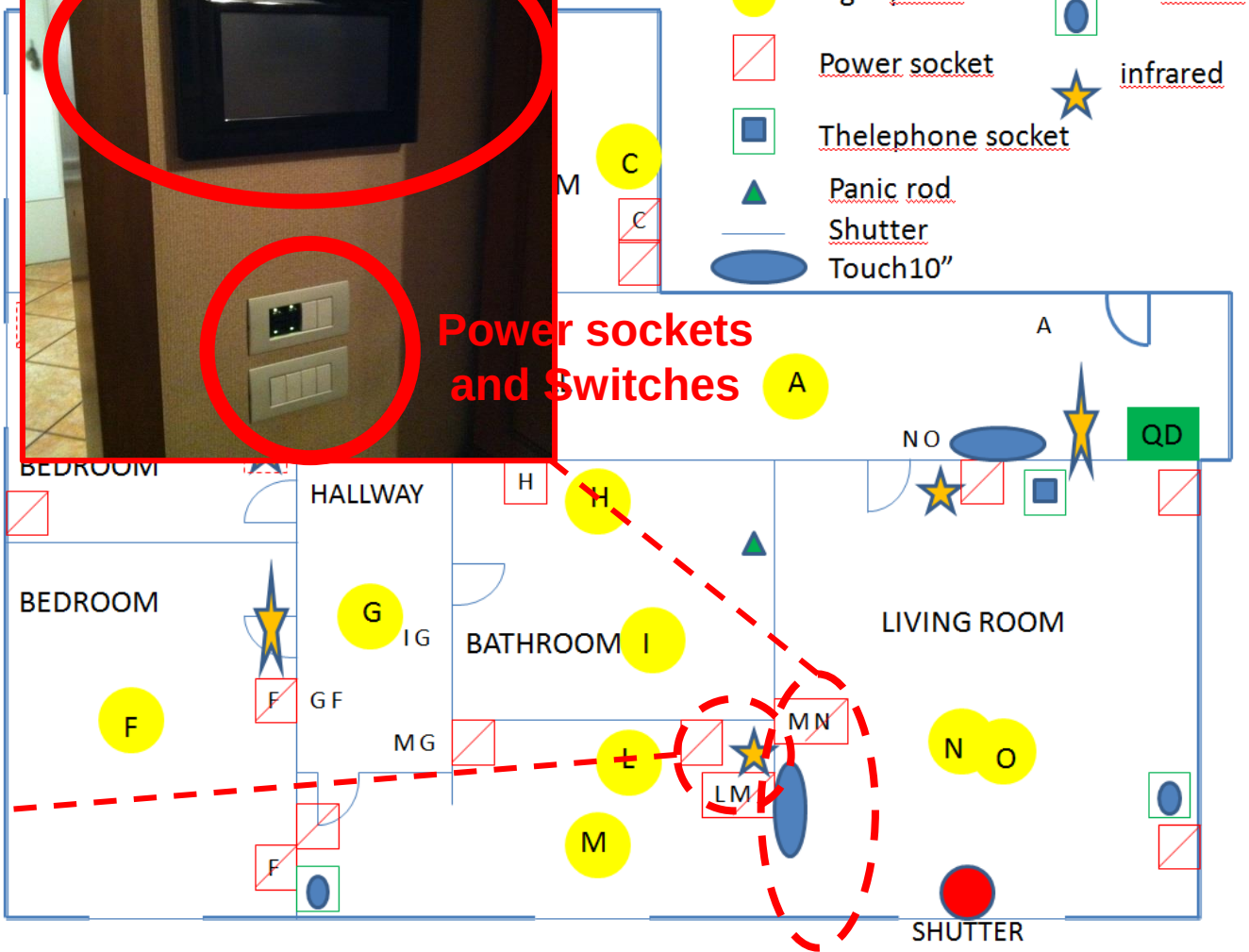


Smartbox


Smart-Home
MY HOME
bticino
BUS SCS
Ethernet
Internet
Central Unit
Passive
RFID
Tags
Ethernet
VR/Exergame
RFID
system
Smartphones

Smarthome Installation

Movement Sensor plus a power socket



Self-adaptive intervention

- 5 Scenarios

Walking

Exercices

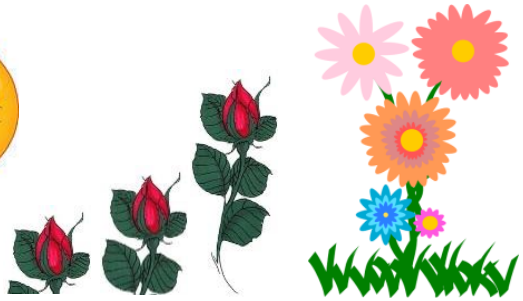
Self-test (velocity)

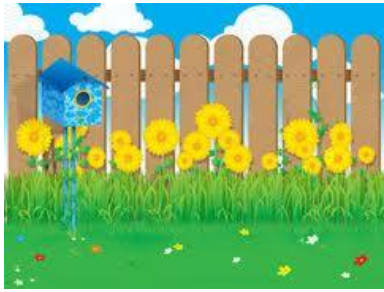
Exergame

Fall

Motivation and feedbacks

- Motivational and persuasive strategy





- Feedback messages are delivered in the form of a growing garden

- Smartphone reminder

- VR exergame - Silverfit

Assistenza e Tecnologie: Favorire il Dialogo tra Domanda e Offerta

Cadute: Prevenzione e Rilevazione

Graziano Onder
Centro Medicina Invecchiamento
Università Cattolica Sacro Cuore
Roma

60° CONGRESSO NAZIONALE
NAPOLI
25-28 Novembre 2015

Falls and technology

Monitoring

- motion sensors, body-worn sensors, pressure sensors, video monitoring and sound recognition

Prevention

- exergames, Wii-fit, Kinect

Quale finalità?

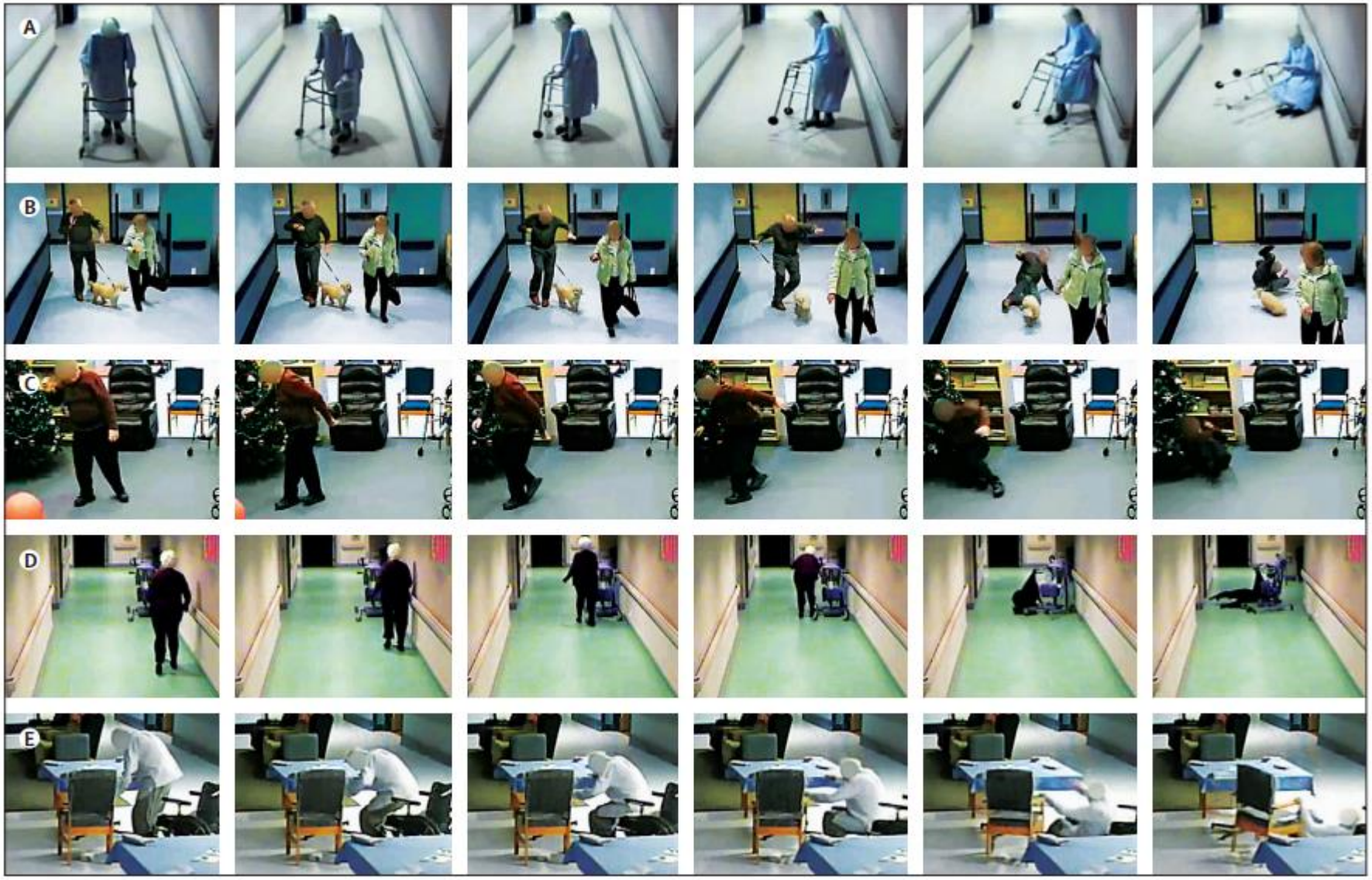
- Ricerca?

	Frequency*		Participants falling due to this cause†		Number of falls per participant†	
	Number	Percentage of falls captured	Estimated proportion, % (SE)	95% CI	Estimated count, n (SE)	95% CI
Incorrect transfer or shift of bodyweight	93	41%	51·2% (4·5)	42·5–59·8	0·72 (0·078)	0·59–0·90
Trip or stumble	48	21%	26·0% (3·9)	19·1–34·3	0·35 (0·054)	0·26–0·47
Hit or bump	25	11%	17·3% (3·4)	11·7–25·0	0·19 (0·040)	0·13–0·28
Loss of support with external object	25	11%	18·9% (3·5)	13·0–26·7	0·20 (0·041)	0·13–0·30
Collapse or loss of consciousness	24	11%	16·5% (3·3)	11·0–24·1	0·17 (0·039)	0·11–0·27
Slip	6	3%	4·7% (1·9)	2·1–10·2	0·047 (0·020)	0·021–0·11
Could not tell	6	3%	..	..	..	..

In descending order of frequency. *Of 227 total falls captured. †Of 215 falls analysed, after exclusion of cases for which the faller could not be identified (six), and cases for which the team could not identify the cause of the fall (six).

Table 2: **Estimated proportion of participants falling at least once, and average number of falls per participant, attributable to various causes of falling**

Robinovitch et al. Lancet 2013



Robinovitch et al. Lancet 2013

Quale finalità?

- Ricerca?
- Clinica?

Quale finalità?

- Ricerca?
- Clinica?
    - **Quale paziente?**

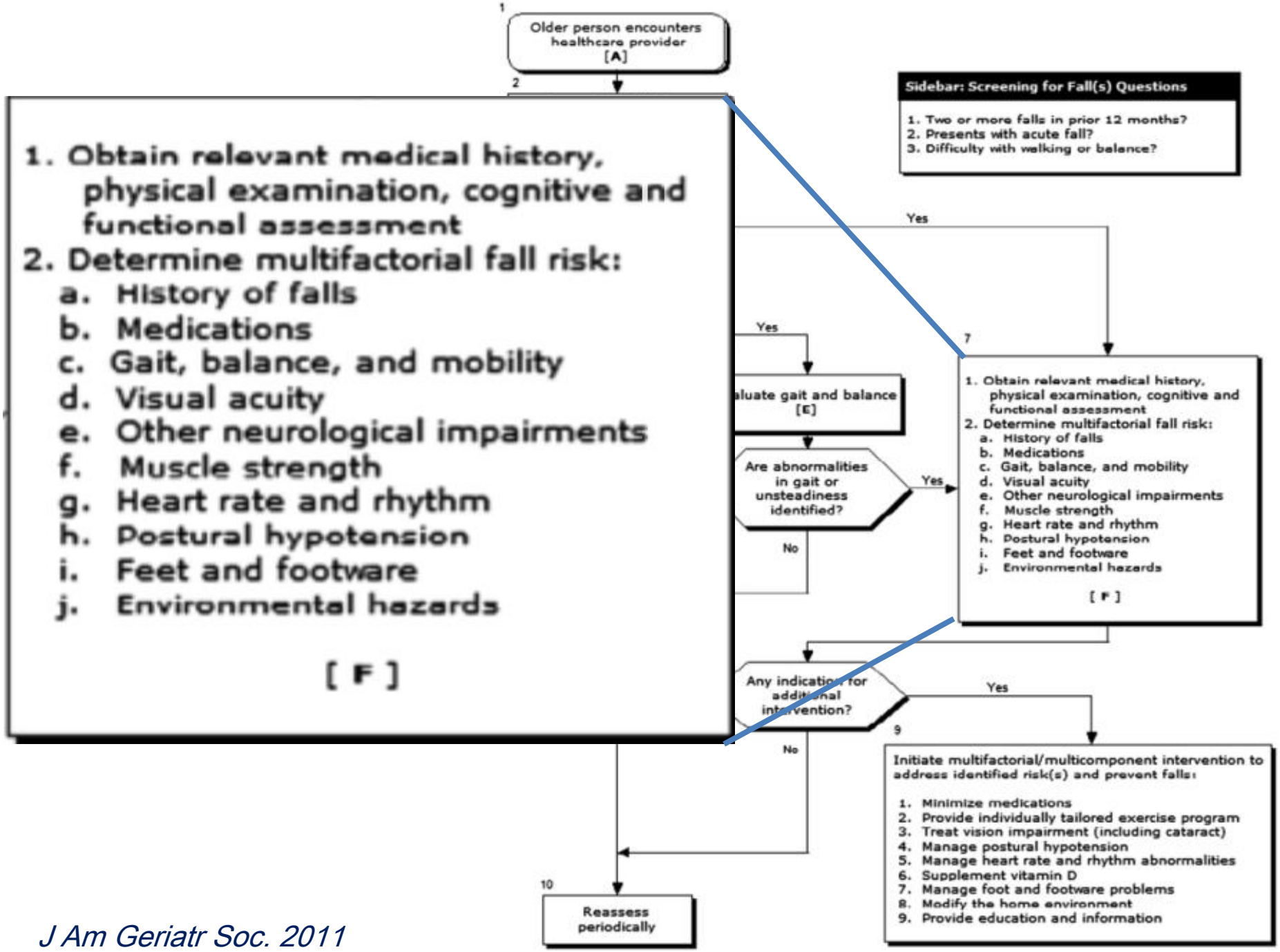
Quale paziente?

- Identificare il paziente a rischio

Who is at risk of recurrent falls in "The adventures of Tintin"?

Characteristic	Multiple Regression Models[a] Incidence Rate Ratio (95% Confidence Interval)	P-Value
Age		
Children	Reference	
Young adults	0.57 (0.44–0.74)	<.001
Middle-aged adults	1.44 (1.04–2.00)	.03
Older adults	0.32 (0.27–0.39)	<.001
Female	0.11 (0.10–0.13)	<.001
Characters		
Tintin	21.74 (21.10–22.40)	<.001
Captain Haddock	4.25 (3.91–4.61)	<.001
Nestor	0.52 (0.49–0.54)	<.001
Thomson and Thompson	2.76 (2.61–2.91)	<.001
Calculus	2.71 (2.56–2.87)	<.001
Castafiore	0.95 (0.78–1.14)	.56
Minor characters[d]	Reference	

Beauchet et al. J Am Geriatr Soc. 2014



J Am Geriatr Soc. 2011

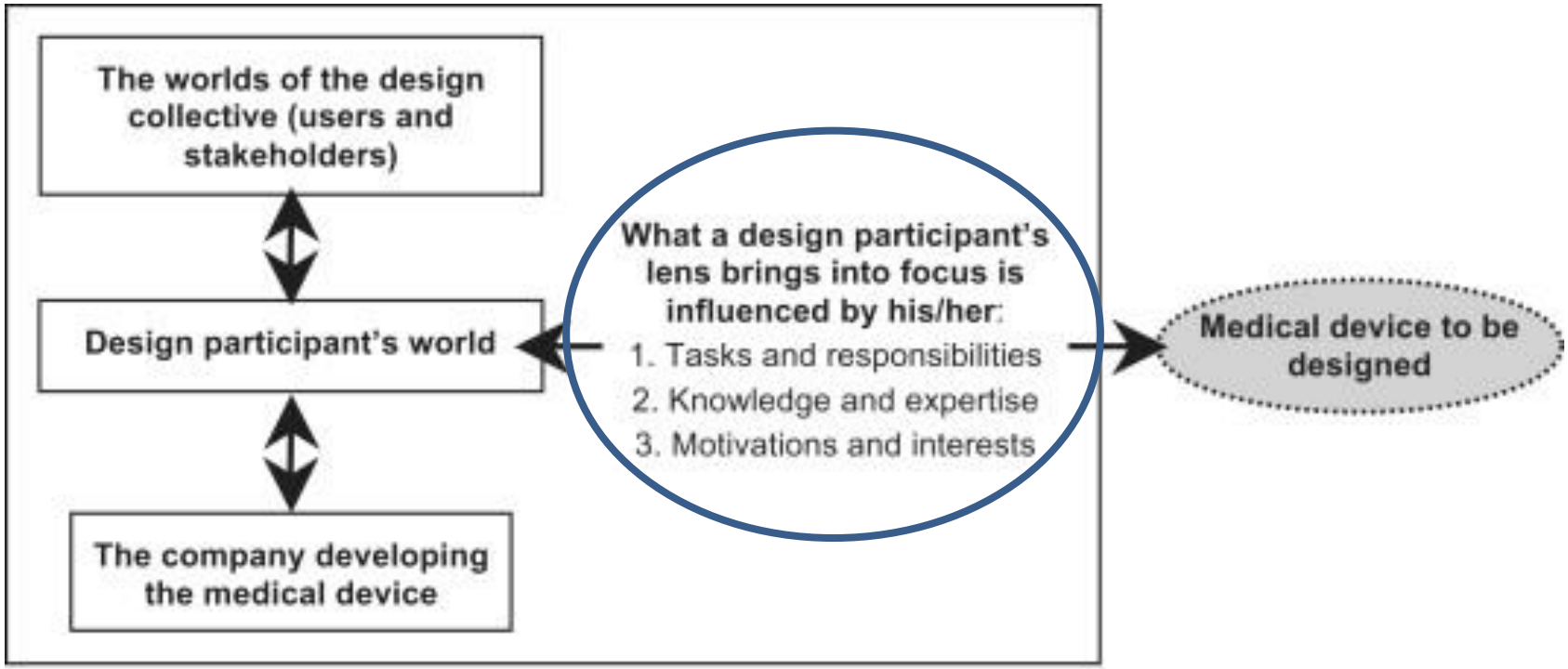
Sensors vs. experts – A comparison of sensor-based fall risk assessment vs. conventional assessment

model name	+ likelihood ratios value	95% confidence interval
STRATIFY score	**1.07**	**0.71-1.61**
Timed Up&Go test	1.15	0.83-1.59
Team Assessment	**1.25**	**0.63-2.49**
model CONV	2.64	1.07-6.5
model SENSOR	**2.61**	**0.94-7.26**

Marschollek et al. BMC Med Inform Decis Mak. 2011

Quale paziente?

- Identificare il paziente a rischio
- Identificare chi può utilizzare e trarre beneficio dalla tecnologia (*impactability*)



Lehoux et al. Design Stud. 2011

Older adults

- Older adults' attitudes towards fall detectors and smart home technology are generally positive;
- Privacy concerns and intrusiveness of technology were perceived as less important to participants than their perception of health needs;
- Unfriendly and age-inappropriate design of the interface may be one of the deciding factors in not using the technology.

Pietrzak et al. Inform Prim Care. 2014

Key Stats About Baby Boomers

(%)

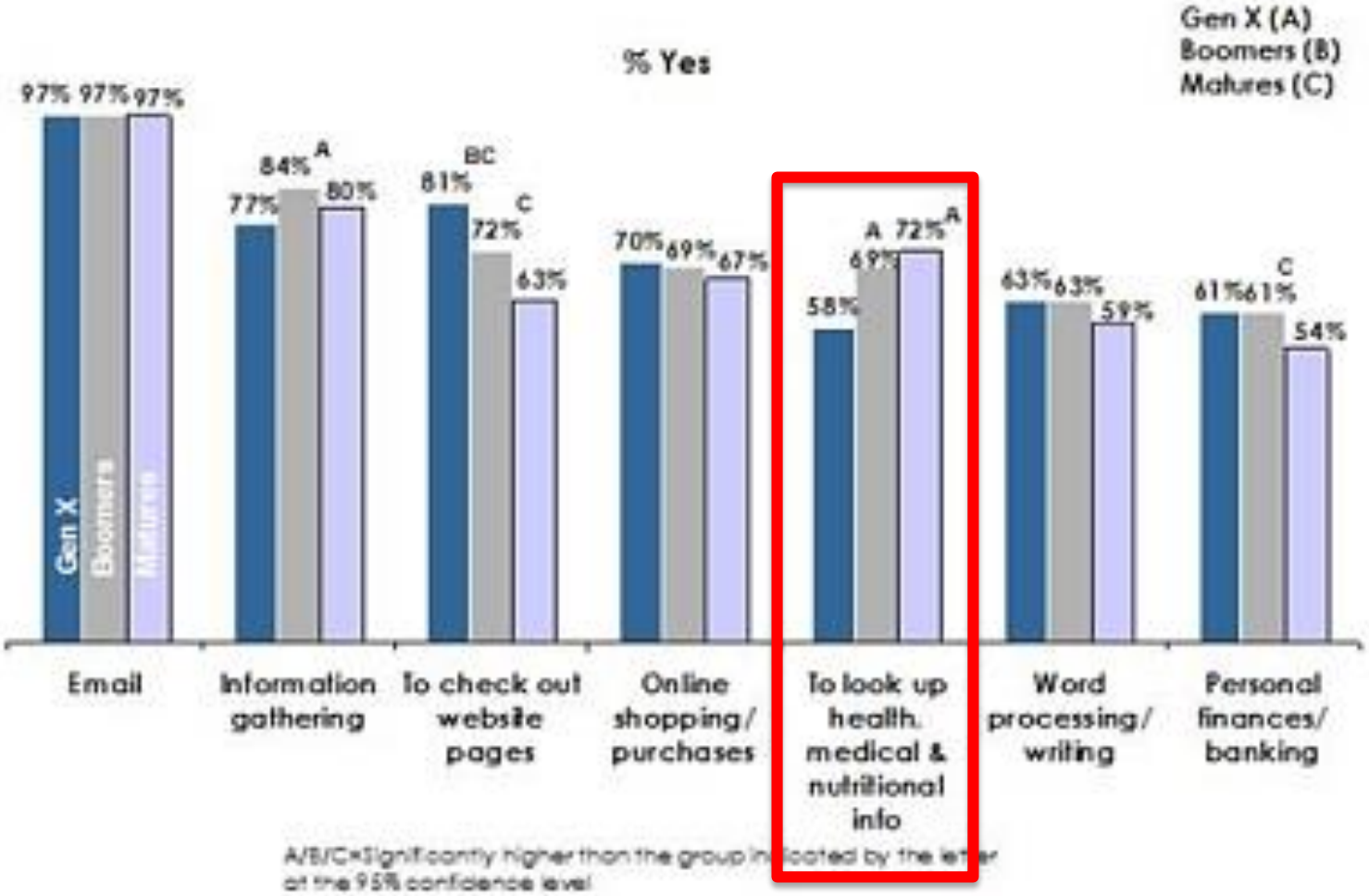
August 2012

44%	of US population
70%	of US disposable income
49%	of total CPG sales
40%	of customers paying for wireless
41%	of customers purchasing Apple computers

MC MARKETINGCHARTS.COM

Source: Nielsen/BoomAgers

Use Computer For…



Quale finalità?

- Ricerca?
- Clinica?
    - Quale paziente?
    - **Quali necessità?**

Necessità?

Direct interventions customized to the identified risk factors, coupled with an appropriate exercise program should follow the **multifactorial fall risk assessment**. [A]

A strategy to reduce the risk of falls should include **multifactorial assessment of known fall risk factors and management of the risk factors identified.** [A]

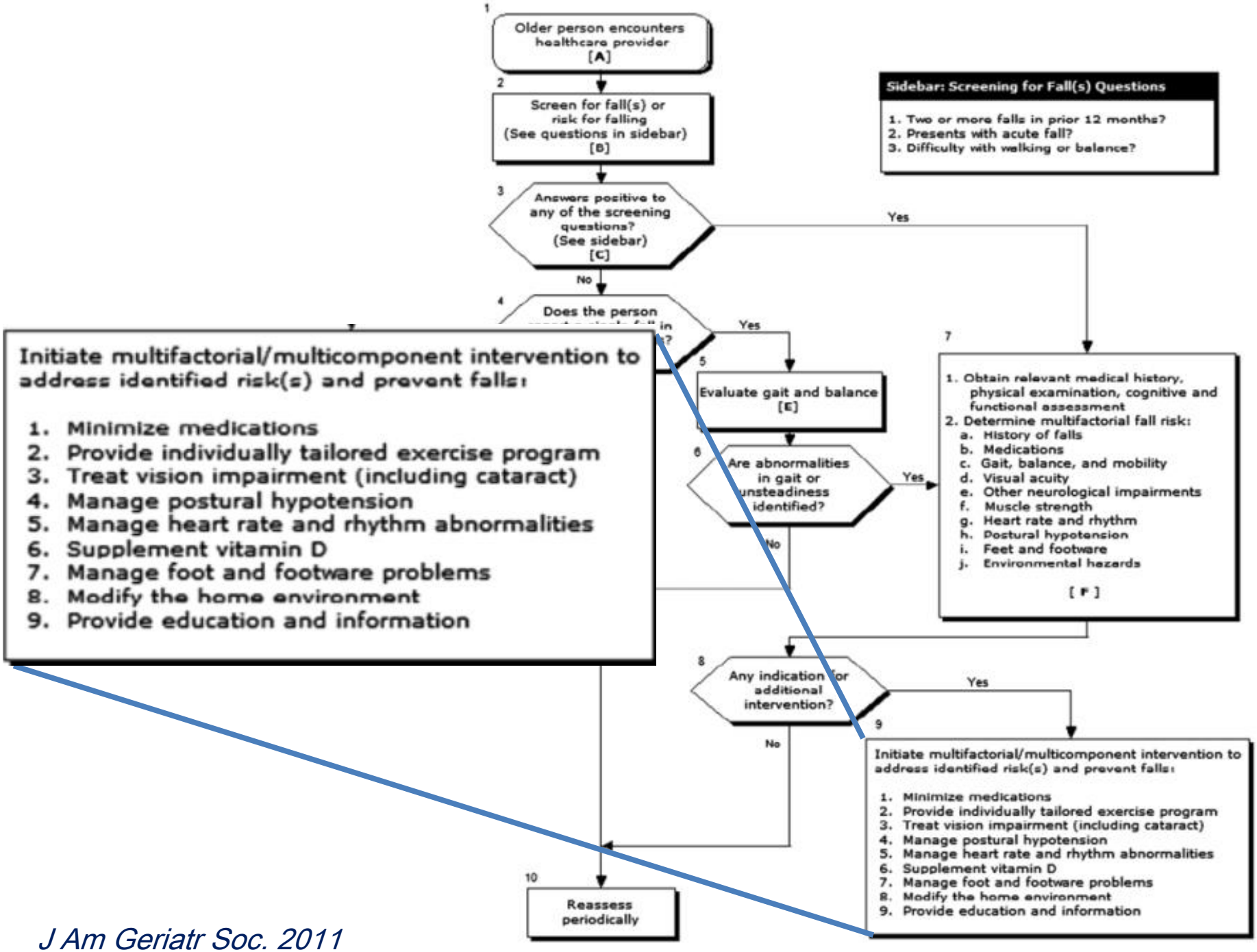
J Am Geriatr Soc. 2011

Necessità?

Multicomponent Interventions

…Staff training and feedback, environmental adaptations, balance and gait training, strength training, training in the use of appropriate assistive devices, and decrease in psychotropic medications are interventions that have frequently been included in multicomponent intervention and multifactorial trials in this setting.

J Am Geriatr Soc. 2011



J Am Geriatr Soc. 2011

Quale finalità?

- Ricerca?
- Clinica?
  - Quale paziente?
  - Quali necessità?
  - **Perchè non ci sono soluzioni adottabili nella pratica clinica?**

Perché al momento non sono state trovate soluzioni adottabili nella pratica clinica?

Nelle linee guida AGS/BGS (2011) il termine technology/ICT/IT non è mai presente

Perché al momento non sono state trovate soluzioni adottabili nella pratica clinica?

Nelle linee guida AGS/BGS (2011) il termine technology/ICT/IT non è mai presente

- **Il problema è multidimensionale**

Perché al momento non sono state trovate soluzioni adottabili nella pratica clinica?

Nelle linee guida AGS/BGS (2011) il termine technology/ICT/IT non è mai presente

- Il problema è multidimensionale
- **Può la tecnologia dare risposte su molteplici dimensioni?**

Perché al momento non sono state trovate soluzioni adottabili nella pratica clinica?

Nelle linee guida AGS/BGS (2011) il termine technology/ICT/IT non è mai presente

- Il problema è multidimensionale
- Può la tecnologia dare risposte su molteplici dimensioni?
- **Costi?**

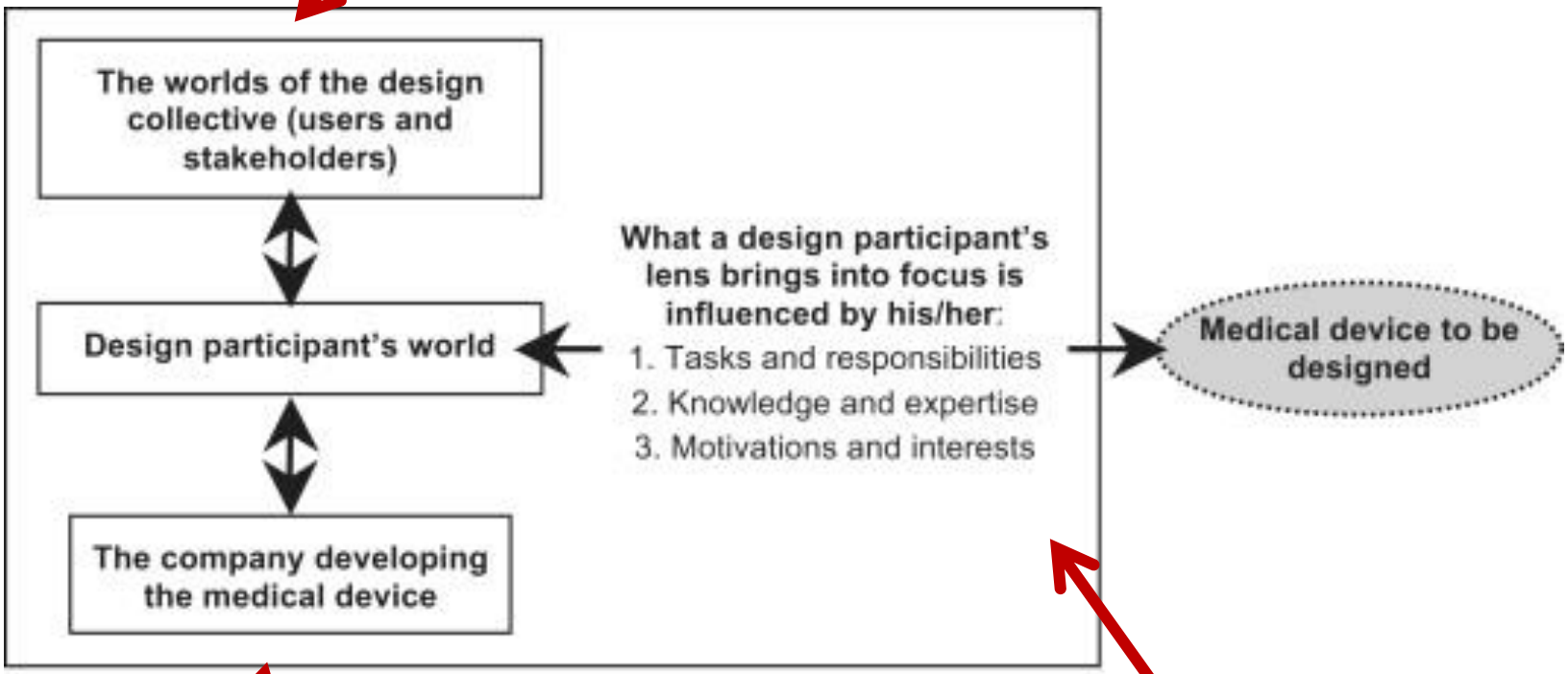
Perché al momento non sono state trovate soluzioni adottabili nella pratica clinica?

Nelle linee guida AGS/BGS (2011) il termine technology/ICT/IT non è mai presente

- Il problema è multidimensionale
- Può la tecnologia dare risposte su molteplici dimensioni?
- Costi?
- **Studi clinici?**

Conclusioni

Quali necessità?



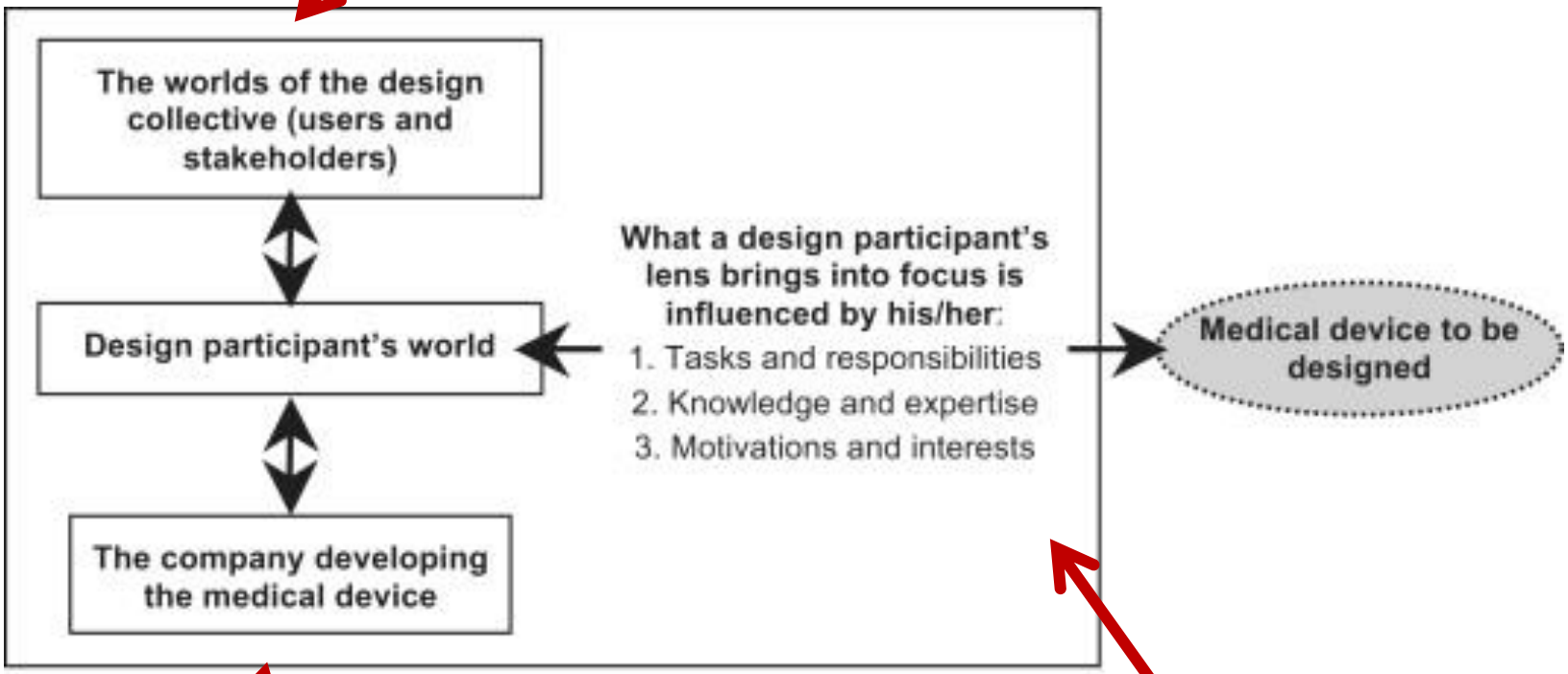
Quale paziente?

Quale tecnologia?

Conclusioni

Quali necessità?

Multidimensionalità



Quale tecnologia?

Quale paziente?

Pz a rischio e in grado di interagire con tecnologia

Grazie per l'attenzione!