Involvement of Older People in the Development of Fall Detection Systems: A Scoping Review

Table 1: General aspects of literature involving older people in the development of fall detection systems

Author(s) and year	Country	Design	Type of fall detection system				Fall detection alert (yes / no)	Involved older people			
			Wearable	Placement	Environmental	Placement		Sample size (n)	Mean age in years (range or SD)	Gender: female (n)	Length of test time in day(s) (range)
Abbate et al (2012)	Italy	Exploratory	Sensor / Smartphone (accelerometer)	Waist / belt	N.a.	N.a.	Yes	10	N.s. *[1] (60-82)	4	N.a. *[2]
Ariani et al (2010)	Australia	Exploratory	N.a.	N.a.	Passive infrared sensors (PIRs) and Pressure mats (PMs)	PIR wall mounted and PM in front of doorway of every room; PM on bed, on chair, on the floor in front of toilet seat, shower and sofa.	Yes	10	N.s. (50-70)	5	N.s.
Barralon et al (2013)	Spain	Evaluation	Mobile Telecare device (accelerometer)	Waist	Shower Rug (pressure sensors)	Bathroom	Yes	20	N.s. (55-82)	N.s.	(approx. 7- 90)
Bloch et al (2011)	France	Evaluation	Vigi'Fall® (accelerometer)	Thorax	Infrared sensor	Room (not specified)	Yes	10	83 (7.5)	N.s.	⌀ = 21 (SD 19)
Bourke et al (2008a)	Ireland	Exploratory	Sensor (bi-axial gyroscope)	Trunk	N.a.	N.a.	No	10	77 (70-83)	3	N.s.
Bourke et al (2007)	Ireland	Exploratory	Sensor (tri-axial accelerometer)	Trunk & thigh	N.a.	N.a.	No	10	77 (70-83)	3	N.s.
Bourke et al (2012)	Germany, Ireland, Portugal, Spain, United Kingdom	Exploratory	Sensors (tri-axial accelerometer) & mobile phone	Chest, left under arm, right thigh	N.a.	N.a.	Yes	8	77 (5)	N.s.	N.s.
								6	77 (5)	N.s.	5
								9	69 (14)	4	28
Bourke et al	Ireland	Exploratory	Sensors / mobile	Waist	N.a.	N.a.	No	10	79 (73-	4	3-7

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(2010a)			phone (tri-axial accelerometer)						90)		hours per participant
Bourke et al (2010b)	Ireland	Evaluation	Sensors (tri-axial accelerometer)	Waist (belt)	N.a.	N.a.	No	10	79 (73-90)	4	<8 hours per participant
Bourke et al (2008b)	Ireland	Exploratory	Sensor (tri-axial accelerometer) & mobile phone integrated in a vest	left upper arm or chest	N.a.	N.a.	Yes	10	N.s., elderly	N.s.	24 (8 hours a day, 6 days a week)
Bourke et al (2010c)	Ireland	Evaluation	Sensor (tri-axial accelerometer)	Waist	N.a.	N.a.	No	10	79 (73-90)	4	3-7 hours per participant
Bourke et al (2008c)	Ireland	Exploratory	Sensor (tri-axial accelerometer) integrated in a vest & mobile phone	left upper arm or chest	N.a.	N.a.	Yes	10	N.s., elderly	N.s.	24 (8 hours a day, 6 days a week)
Boyle & Karunanithi (2008)	Australia	Exploratory	PAL Technologies (accelerometer)	Waist (belt)	N.a.	N.a.	No	15	67 (18)	N.s.	⌀=18 (2-81)
Campo et al (2010)	France	Exploratory	N.a.	N.a.	Infrared sensors (motion sensor network)	Placed on ceiling to focus bed and around bed, in bathroom, near chair and table	Yes	1	75 (N.s)	N.s.	N.s.
Che-Chang et al (2007)	Taiwan	Exploratory	Sensor (tri-axial accelerometer)	Waist (belt)	N.a.	N.a.	No	5	N.s., elderly	N.s	N.s
De la Guia	Ireland	Exploratory	Sensor (tri-axial	Trunk	N.a.	N.a.	No	10	77 (70-	3	N.s.

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Solaz et al (2010)			accelerometer)						83)		
Demiris et al (2004)	USA	Qualitative descriptive	Fall detection technologies amongst other health technologies				N.a.	15	N.s. (65<)	8	N.a.
Fourty et al (2009)	France, Spain	Exploratory	Portable system (bi-axial accelerometer)	N.s.	N.a.	N.a.	Yes	9	76 (N.s)	6	N.s.
Marquis-Faulkes & al (2005)	UK	Qualitative descriptive	N.a.	N.a.	Camera	Ceiling-mounted	Yes	31	N.s. (65<)	N.s. clearly	N.a.
Gietzelt et al (2012)	Germany	Evaluation	Sensor (tri-axial accelerometer)	Chest	Camera	Wall-mounted	No	3	87 (81-92)	1	60 - Approx. 10h / day
Godfrey et al (2011)	UK, Ireland,	Exploratory	Sensor (tri-axial accelerometer)	Chest	N.a.	N.a.	No	10	77 (70-83)	3	N.s.
Goevercin et al (2010)	Germany	Qualitative descriptive	N.a.	N.a.	surveillance camera type, motion detector, fish-eye type camera, in-wall camera	Room: wall or in-wall mounted	No	22	70 (50-85)	16	N.a.
Holzinger et al (2010)	Germany, Austria, Switzerland	Evaluation	Watch (accerometer)	Wrist	N.a.	N.a.	Yes	N.s. clearly	N.s. (55<)	N.s.	N.a.
Horton (2008)	UK	Observational	pendant alarm or fall detector	Neck or worn on body (N.s.)	Bed occupancy sensor	Under mattress	Yes	35	78 (65<)	22	Weeks: 15 (4)
Huang et al (2012)	Taiwan	Exploratory	Sensor (tri-axial accelerometer)	Wrist	N.a.	N.a.	No	3	80 (11)	N.s.	N.s.
Jantaraprim et al (2012)	Thailand	Exploratory	Sensor (tri-axial accelerometer)	Trunk	N.a.	N.a.	No	14	68 (4)	7	N.s.

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Kangas et al (2012)	Finland, Sweden	Exploratory	Sensor (3D accelerometer)	Waist	N.a.	N.a.	No	16	88 (5)	13	N.s. (60-180)
Kangas et al (2009)	Finland, Sweden	Exploratory	Sensor (tri-axial accelerometer)	Waist	N.a.	N.a.	No	21	83 (9)	10	N.s.
Kerdegari et al (2012)	Malaysia	Exploratory	Sensor (accelerometer)	Waist	N.a.	N.a.	No	1	65 (N.s)	N.s.	N.s.
Lai et al (2010)	South Korea	Exploratory	Sensors (accelerometer)	Neck, waist, both wrists, both thighs	N.a.	N.a.	No	1	N.s., elderly	N.s.	N.s.
Lai et al (2011)	Taiwan	Exploratory	Sensors (tri-axial accelerometer)	Both hands, trunk, both feet	N.a.	N.a.	No	16	N.s., elderly	N.s.	N.s.
Lindemann et al (2005)	Germany	Exploratory	Sensors (accelerometer)	Head (hearing aid housing)	N.a.	N.a.	No	1	83 (N.s)	1	N.s.
Shinmoto et al (2013)	Australia, USA	Exploratory	Sensor (accelerometer)	Sternum	N.a.	N.a.	No	14	N.s. (66-86)	N.s.	N.s.
Liu & Lockhart (2013)	USA	Exploratory	Inertial measurement unit & sensor (tri-axial accelerometer	Thigh / trunk	N.a.	N.a.	No	10	75 (6)	N.s.	N.s.
Londei et al (2009)	Canada	Mixed Method	N.a.	N.a.	Intelligent videomonitoring system (IVS)	Room(s) at home (N.s.)	Yes	25	79 (65-87)	19	N.s.
McKenna et al (2006)	UK	Qualitative descriptive	N.a.	N.a.	Vision-based monitoring	N.a.	Yes	N.s. clearly	N.s (65<)	N.s.	N.a.
Yu et al (2013)	China	Exploratory	N.a.	N.a.	Camera	Room, wall-mounted close to ceiling	No	1	N.s., old person	N.s.	N.s.
Narasimhan (2012)	USA	Exploratory	Sensors (tri-axial accelerometer)	Torso	N.a.	N.a.	No	15	74 (63 – 91)	5	N.s.
Parker et al (2008)	Austria, UK, Ireland	Descriptive	Fall detection technologies amongst other health technologies				N.a.	97	76 (57-94)	65	N.a.

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Quagliarella et al (2008a)	Italy	Exploratory	Sensor (single-axis accelerometer)	N.s.	N.a.	N.a.	Yes	10	76 (3)	5	N.s.
Quagliarella et al. (2008b)	Italy	Exploratory	Device (triaxial transducer, data-logger SARI)	Waist	N.a.	N.a.	Yes	10	76 (3)	5	N.s.
Rantz et al (2013)	USA	Exploratory	N.a.	N.a.	Sensor system: pulse-Doppler range control radar (General Electric®), Microsoft Kinect®, two web cameras	Radar: Next front door, Kinect: above front door; Cameras, N.s.	Yes	15	57 (23-67)	8	
								17 (after one year n=11)	88 (67-98)	10	1.5 years
Sixsmith & Johnson (2004)	UK	Exploratory	N.a.	N.a.	Infrared array technology	Wall-mounted close to ceiling	Yes	28	N.s. (65-82)	N.s.	N.a.
Soaz et al (2012)	Germany	Exploratory	Actibelt® (3D accelerometer)	Waist	N.a.	N.a.	No	5	70 (N.s)	5	N.s. clearly
Stone & Skubic (2014)	USA	Evaluation	N.a.	N.a.	Microsoft Kinect® (depth imaging sensor)	Wall-mounted close to ceiling	No	16	N.s. (67-97)	9	One year
Tamrat et al (2012)	USA, India	Exploratory	Sensors (tri-axial accelerometer)	Each wrist, each hip, neck	N.a.	N.a.	No	12	79 (66-91)	64 %	6 or 12 (non-consecutive), 4.8h/ day (SD

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											3.2)
van de Ven et al (2008a)	Ireland	Exploratory	Sensor (tri-axial accelerometer) & mobile phone	chest	N.a.	N.a.	Yes	N.s.	N.s., elderly	N.s.	<8 hours per day for four weeks
van de Ven et al (2008b)	Ireland	Exploratory	Sensor (tri-axial accelerometer) & mobile phone	Chest or under left arm	N.a.	N.a.	Yes	N.s.	N.s., elderly	N.s.	<8 hours per day for four weeks
Wang et al (2014)	China, Korea, UK	Exploratory	Sensor (accelerometer) & mobile phone	Chest	N.a.	N.a.	Yes	N.s.	N.s. (50-70)	N.s.	Two weeks
Wu & Xue (2010)	USA	Exploratory	Sensor (tri-axial accelerometer)	Waist	N.a.	N.a.	No	14	N.s. (72-91)	N.s.	40-60 minutes
Wu & Xue (2008)	USA	Feasibility	Sensor (tri-axial accelerometer and triaxial angular rate sensor)	Waist	N.a.	N.a.	No	14	N.s. (72-91)	N.s.	N.s.
Zhang et al (2006)	China	Exploratory	Sensor (tri-axial accelerometer)	Waist	N.a.	N.a.	No	12	N.s. (10-70)	4	N.s.
John et al (2008)	UK	Exploratory	PreventFall Monitor (accelerometers)	Waist	N.a.	N.a.	No	5	N.s. (71-84)	2	263 (total)

*[1]Not stated; *[2]Not applicable