Ageing in Place: A Multi-Sensor System for Home-Based Enablement of People with Dementia

Dr Louise Hopper, Rachael Joyce, Dr Eamonn Newman, Prof. Alan Smeaton, & Dr. Kate Irving

Dublin City University (DCU), Ireland
The Dem@Care Project

3 Themes
- Diagnostics
- Enablement
- Safety

3 scenarios
- @Lab (France/Greece)
- @Home (Ireland/Greece)
- @Nursing Home (Sweden/France)

2 loops of care
- Home-based loop
  Between people with dementia and their caregivers
  Sensor-based, context-sensitive, evolving, personalised
  offer encouragement, warnings, alerts
- Clinician loop
  Faithful log of health-related information,
  Summaries, trends, pattern analysis
  Monitor improvement, stasis or warn clinician of deterioration
  Supports care decisions
Data Collection in Five Domains

Person with Dementia

- **SLEEP**
  - Night time sleep, awakenings, bed exits, Difficulty falling asleep, insomnia onset, day-time sleep and napping

- **MOOD**
  - Observed behaviour, physical stress levels, speech analysis, subjective mood reporting

- **PHYSICAL ACTIVITY**
  - Amount of physical activity in the home, outside the home, dedicated exercise, movement speed, distance travelled, activity intensity

- **SOCIAL INTERACTION**
  - Face-to-face social contact, initiated and received phone contact, speech analysis

- **ADL/IADL**
  - Meal/Drink preparation and consumption, daily tasks (e.g. watch tv, listen to music, read, hobbies, chores)
Dem@Home: Aims and Methodology

- **Research Questions**
  - Is the system acceptable in the home, is it non-intrusive, and useful to people with dementia and their families?
  - Can the system optimise the functional status of the person with dementia as operationalised in the 5 domains?
  - How autonomous and independent is the person with dementia and can the deployment of this system support this autonomy?

- **Multiple case study design - person centred using a toolbox approach**
  - Initial assessment of acceptability and usability (n=5 dyads)
  - Lead User participants (n=2 in Dublin; n=3 in Thessaloniki; 7-20 months in duration)
  - Intervention participants (n=5 in Dublin; 3-4 months in duration)
Dem@Home Sensor Toolbox

Dem@Home Care

Sleep
Social
(I)ADL
Activity
Mood

Raw accelerometer data
Activity index
Sleep indicator

2012-08-22 16:53:20 2012-08-22 19:40:00 2012-08-22 22:26:40 2012-08-23 01:13:20 2012-08-23 04:00:00 2012-08-23 06:46:40
The Dem@Home System

- Clinician is able to monitor
  - Sensors recordings
  - Analysis results (e.g. completed activities) from the current or previous dates/periods

- Person with dementia and the carer are able to read messages - prompts - advice that come from
  - The System
  - Clinician
Dublin Case Study: Recruitment Protocol

- Person living at home with early dementia - family caregiver
  - Initial semi-structured functional assessment interview
  - Lead user from October 2013 – involved in co-design process
  - Large longitudinal dataset but some data analysed retrospectively

<table>
<thead>
<tr>
<th>Sleep</th>
<th>PSQI, Epworth Sleepiness Scale, Insomnia Severity Index, Morningness - Eveningsness Questionnaire, Scale of Older Adult’s Routine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Activity</td>
<td>Rapid Assessment of Physical Activity, Physical Activity Scale for the Elderly</td>
</tr>
<tr>
<td>Eating / IADL</td>
<td>Bristol ADL Scale (proxy), Everyday Competence Questionnaire, Mini-Nutritional Assessment</td>
</tr>
<tr>
<td>Mood</td>
<td>Geriatric Depression Scale (GDS)</td>
</tr>
<tr>
<td>Social Interaction</td>
<td>Lubben Social Network Scale, De Jong Loneliness Scale</td>
</tr>
<tr>
<td>Other</td>
<td>Quality of Life (Qol-AD), Carer-Qol, HADS, RSS</td>
</tr>
</tbody>
</table>
Dublin Case Study: Sean and Catriona

- Sean (Age 58) and Catriona are married and live with Sean’s mother in their own home outside Dublin. They have two dogs.
- Sean was a carpenter and Catriona works 4 days a week in administration.
- At the start of the study, Sean was just post-diagnosis.
- Sean is active and independent and has comorbid epilepsy, which is being successfully managed pharmaceutically.
- Sean’s mother was not aware of his diagnosis.
Dublin Case Study: Baseline Assessment

<table>
<thead>
<tr>
<th>Domain</th>
<th>Needs</th>
<th>Sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sleep</strong></td>
<td>PSQI score of 6 (sleep pathology) Duration and latency good; disturbance, efficiency, overall quality poor</td>
<td>Gear4 Sleep Clock DTI-2 Actigraphy</td>
</tr>
<tr>
<td><strong>ADL / IADL</strong></td>
<td>General eating, cooking and chores are good, but some tasks may need support (e.g. using the CD Player)</td>
<td>Wearable video Ambient video</td>
</tr>
<tr>
<td><strong>Physical activity</strong></td>
<td>No issues detected, although Sean indicated interest in having support in this area</td>
<td>DTI-2 Actigraphy</td>
</tr>
<tr>
<td><strong>Social Interaction</strong></td>
<td>No issues detected, although both felt there may be a benefit from support in this area</td>
<td>Periodic psychometric measures</td>
</tr>
<tr>
<td><strong>Mood</strong></td>
<td>No issues detected</td>
<td>Periodic psychometric Measures</td>
</tr>
<tr>
<td><strong>Other Measures</strong></td>
<td>Qol-AD (PwD) = 42; Qol-AD (Carer) = 34 Carer-Qol = 5; HADS (A) = 19, (D) = 12; RSS (ED) = 20, (SD) = 15. (NF) = 0</td>
<td>Periodic psychometric Measures</td>
</tr>
</tbody>
</table>
Dublin Case Study: Sleep

- 556 days deployment; 436 days of usable data
- Some disruption in sleep duration and sleep interruptions evident on a day to day basis but very stable patterns over time
- Clear periodicity – higher interruptions on week day mornings
Dublin Case Study: Physical Activity

- 556 days deployment; 330 days of usable data
- Within day variation in activities (more active in the mornings)
- Stress levels generally match activity levels (some exceptions)
Comparisons and Correlations

- Compare any measure with any other (daily, weekly, monthly)
- Interactive labels allow easy highlighting of one data series
- Quick switch off/on functionality

- Correlate any two variables for any length of time (e.g. Moving intensity and sleep interruptions)
- Some improvements required
Dublin Case Study: ADL / IADL

- Most successful data capture was for activities that formed a natural part of PwD’s day
  - Making breakfast, tea, watering plants, feeding birds
  - Capturing specific activities like ‘playing a cd’ were not successful unless they took place with researcher

- Over 130 hours of data; 4.33 were manually annotated to train location, activity, and object algorithms
  - Feed birds (95.98%), Water plant (85.5%), Talk on phone (74.7%), Prepare drug box (49.7%), Breakfast (45.6%), Meal (46.98%), prepare tea (39.1%)

- Manual observation study will be carried out this summer and results will be compared with Dem@Care
Thessaloniki Case Study - Protocol

- Person with MCI living alone at home
  - Co-morbid depression and anxiety
  - Small apartment (living room, bedroom, kitchen, office)
  - Commenced later (February 2014) – real-time intervention support

<table>
<thead>
<tr>
<th>Mental State</th>
<th>Emotion</th>
<th>Functional</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMSE</td>
<td>BDI</td>
<td>Quality of Life</td>
</tr>
<tr>
<td>Verbal Fluency</td>
<td>Beck - Anxiety</td>
<td>IADL</td>
</tr>
<tr>
<td>Trail Making (Part B)</td>
<td>Anxiety Perception</td>
<td>FUCAS</td>
</tr>
<tr>
<td>TEA</td>
<td>Hamilton Test</td>
<td>FRSSD</td>
</tr>
<tr>
<td>RAVLT</td>
<td>GDS</td>
<td>CDR</td>
</tr>
<tr>
<td>ROCFT</td>
<td>NPI</td>
<td></td>
</tr>
<tr>
<td>MOCA</td>
<td>Pittsburgh</td>
<td></td>
</tr>
</tbody>
</table>
## Thessaloniki Case Study: Baseline

<table>
<thead>
<tr>
<th>Domain</th>
<th>Needs</th>
<th>Sensors</th>
</tr>
</thead>
</table>
| **Sleep**       | Difficulties with sleep – intermediate and general insomnia, palpitations and anxiety. Also frequent and long bathroom visits. | Sleep sensor (Aura)  
Actigraphy (Up24)  
Presence sensors (bathroom) |
| **ADL / IADL**  | Low levels of ADL (e.g. person doesn’t vacuum, iron, wash clothes)  
Also monitor: cooking, washing dishes, eating, refrigerator usage, phone | Ambient video (kitchen)  
Presence sensor (kitchen)  
Plug and motion sensors (various)  
Water sensor (flower pot) |
| **Physical activity** | Low levels of physical activity - correlated with time watching TV. Also some gait and stability problems | Actigraphy (Up24)  
Plug sensor on TV  
Motion sensor (TV remote)  
Ambient video |
| **Social Interaction** | Almost no social interaction reported | Door sensor  
Intervention required |
| **Mood**        | Low mood reported                                                     | Receiving intervention                                                 |
Thessaloniki Case Study: Interventions

- Suggested interventions (e.g.)
  - Physical activity at home via Smart TV every two days
  - Ballroom dance therapy twice a week
  - Psychotherapy
  - Perform a schedule of simple daily living activities: cooking, bathing, washing dishes, potting flowers, maintain social life – build motivation to participate in everyday life
  - Relaxation exercises and anxiety management techniques

- Dem@Home and associated sensors
  - Monitor compliance
    - Activities according to weekly schedule
    - Gait improvement from physical activity/dancing
  - Enable ongoing evaluation
    - Sleep, physical activity and ADLs
    - Alter intervention is desired results not being met
Thessaloniki Case Study: Physical Activity

- ADL intervention – scheduled daily activities
- Increased levels of moving intensity found
Improvements in sleep before and after
Dem@Home: Key Strengths

- **Objective measurement**
  - Provides a different approach to the clinical assessment of a person’s cognitive, functional, and emotional status in a familiar environment
  - Supports ongoing monitoring of improvement, stasis, or decline

- **Individualisation of interventions and treatment plans**
  - Gives immediate results about everyday activities
  - Improvements for person with MCI/dementia based on feedback and monitoring
    - *Sleep quality*: Less TV watching lead to more sleep
    - *Daily routine*: Active participants in ADLs

- Support the person with dementia with online reminders, checklists, prompts, directed practice
Dem@Home: Key Challenges

- Recruitment difficulties unless combined with an intervention
  - Comfort with technology and ethical concerns
  - What happens when the researcher/clinician leaves?

- Initial anxiety regarding sensor use (in some cases)
  - Importance of adequate training and researcher/clinician support
  - Need to balance the idea of co-design with the difficulties introducing an incomplete system with a person with dementia

- The suitability of deploying sensors with someone in the later stages of dementia – when is too late?

- Ethical issues
  - Informed consent and third party consent
  - Privacy – sensor privacy options forgotten, safety nets needed
  - Surveillance – risk of continuous monitoring
Conclusions

- Value of objective ongoing assessment
  - Analysis of sensor level data shows promising results although the real value of the Dem@Home system is the ability to:
    - Triangulate data from various sensors measuring varied domains
    - Identify improvement, stasis, and/or deterioration over time

- Supports that enable Dem@Home use
  - Easy to use sensors, data transfer, and automated feedback
    - Caregiver is still required as primary source of support
    - Clinician needs to make the effort to ensure that people understand how ICT can and may not help, and that informed consent is given
  - Importance of well-supported training periods
  - Importance of personal interaction with the clinician (or researcher)
  - Perceived benefits must be stronger than the perceived effort to use the technology
Dem@Home – For Further Information...

DCU Dublin
louise.hopper@dcu.ie

CERTH Thessaloniki
akarakos@iti.gr
Thank you for your attention

For further information:

www.demcare.eu
louise.hopper@dcu.ie
akarakos@iti.gr

Funding Acknowledgement:

Dem@Care Consortium partners