The potential of technology for self-management of long term conditions

The SMART Consortium

www.thesmartconsortium.org
Vision

• “over the next few years we will give 100,000 people with long-term conditions the opportunity to manage their care as 'expert patients'. And during 2008 we will bring forward a patients' prospectus that sets out how we will extend to all 15 million patients with a chronic or long-term condition access to a choice of 'active patient' or 'care at home' options - clinically appropriate to them and supported by the NHS”,

Prime Minister 2008

• Whole System Demonstrators --> SMART-2
Technology Landscape

- HealthSpace, NHS Choices - patient information
- Map of Medicine - evidence based content, treatment pathways
- Health Vault
- Continua Alliance
- Existing platforms
  - doc@HOME, Philips Motiva, Intel Shimmer
HealthSpace

1. Self Care
   I can monitor my condition regularly and load the results for my GP to see. We can discuss them in my next appointment.

2. My Health Information
   I can now review my medical record online in my own time. I can store information and preferences that help clinicians to plan better personalised care for me. I can even do this when I am away from home and need medical care.

3. Better Care
   My clinician can make better decisions because they receive up to date information on my condition before the appointment.

4. My Health Updates
   I get reminders on tests, appointments and screening. Information on my long term conditions is personalised for me.

5. Communicator
   I have secure online interaction with my GP, which also enables me to email a request for repeat prescriptions.

6. Appointments
   I can see available slots and book an appointment with my local GP, Practice Nurse or Hospital at a time convenient for me.

7. Accessibility
   I can access all of the HealthSpace services easily and securely, even if I have special access requirements.

8. Privacy & Security
   My records are secure but now I can see who else has seen my information – this gives me confidence in the service.
Motiva / DOCOBO
Welcome to SMART 2

This is a joint project with partners from Sheffield Hallam University, University of Sheffield, University of Ulster and University of Bath. The project starts on January 1st 2008 and will be completed in December 2011. It is funded by the Engineering and Physical Science Research Council.

The aim of the project is to deepen understanding of the potential for technology in the support of self-management. This will be achieved by creating user-centred designs for technology, resulting in a personalised self-management system, and by carrying out extensive studies with the technology in use.

In the United Kingdom self-management is central to the government’s long term conditions agenda. The research we propose extends existing work by researching some fundamental issues surrounding self-management. These include:

- How can information on changes in chronic conditions be collated and fed back to users in a meaningful and usable way to help them understand their conditions?
- How can information, remote from a therapist, be presented to promote health behaviour change?
- How can a personalised self-management system allow people to adjust life goals to accommodate and aid acceptance of their condition?

Users with three common conditions, chronic pain, stroke and congestive heart failure will be involved in all stages of the project. Currently people with these three conditions have limited access to assistance to help them to make the necessary changes to behaviour in order to accommodate their condition, promote continued recovery and/or prevent deterioration.

**Personal Self Management System (PSMS)**
Policy and Practice

• “there is considerable national and international evidence to show that supporting self care results in health benefits for the people and therefore overall gain for the care system.” Department of Health

• Over 400 studies worldwide report self management can lead to dramatically improved outcomes for patients. British Medical Association

• Expert Patient Programme (1000 participants), 4-6 months after the course (a) GP consultations decreased by 7%, (b) Outpatient visits decreased by 10%, (c) A&E attendances decreased by 16%, (d) Pharmacy visits increased by 18%.
Policy and Practice

• “the evidence supporting the impact of self-management and other chronic disease management initiatives on health service utilisation is more equivocal than policy statements often imply.”

• “Lay-led self-management education programmes may lead to small, short-term improvements in participants' self-efficacy, self-rated health, cognitive symptom management, and frequency of aerobic exercise. There is currently no evidence to suggest that such programmes improve psychological health, symptoms or health-related quality of life, or that they significantly alter healthcare use.” Cochrane review, 2007
Behavioural change

- 20% ready to change, 40% plan to change, 40% in denial/resistance
- Model of behavioural change
- Stage of change will impact on information provided, how presented etc.
- PSMS feedback loops to validate change would be helpful
- Motivational aspects
- Track knowledge absorption, retention and establish stage of readiness => changing intervention
Key Research Questions

• Can the impact of long term conditions be effectively monitored, modelled and analysed using technology?

• Can an assistive technology solutions be identified to deliver self management interventions in key target, high volume, chronic conditions?

• Can technology, remote from a therapist, promote health behaviour change?

• Can technology which situates behaviour change in everyday life improve traditional self-management strategies?
Therapist sets daily goal

Patient receives set goal on home hub or mobile device

Patient successfully achieves goal

Well done! You walked 563 steps.

Notification is sent to therapist

Therapist sets goal

Server

Home hub

Mobile device

Patient gets on with his or her normal day!
Mary has had SMART technology installed in her home to assist with her continued rehabilitation and to help her to regain her independence. This technology includes trainers with sensors embedded in the soles to help her to correct her balance and a bracelet to remind her to relax her left hand.

The bracelet also connects with sensors placed in each room in the house. Activity data from the sensors is processed by a computer within the existing TV.
Case 3: Mary – ‘stroke’

Patient's story
- "You can't give up, you've got to prepare to change your ways of doing things and you cannot afford to dwell on it."

Clinical needs
- Poor control of upper limb, reduced proprioception, neglect

Patient's life goal
- Improving dressing

Therapy intervention
- Restorative and adaptive, Education, Neuro-developmental Techniques ➔ Weight-bearing exercises on wrist and hand using sensory feedback

Technology
- Furniture sensors, clothing sensors
Evidence base - Search Strategy Terms - ‘chronic pain’

- Search terms were produced with guidance from previous systematic reviews (e.g. Murray, Burns, See Tai & Nazareth, 2005) and by dissecting the main components of the research questions.

- Databases PubMed, PsycInfo, MedLine, and EMBase were searched.

<table>
<thead>
<tr>
<th>Overhead Term</th>
<th>Search Terms</th>
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<tbody>
<tr>
<td>Technology</td>
<td>“distance” OR “remote” OR “internet” OR “on-line” OR “online” OR “technology” OR “telemedicine” OR “telecare” OR “e health” OR “e-health” OR “ehealth” OR “computer” OR “multimedia” OR “interactive” OR “software” OR “cd-rom” OR “medical informatics”</td>
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<tr>
<td>Behaviour</td>
<td>“behaviour” OR “behavior” OR “behavioural” OR “behavioral”</td>
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<tr>
<td>Change</td>
<td>“change” OR “changes”</td>
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<tr>
<td>Therapy</td>
<td>“therapy” OR “outcome” OR “treatment” OR “program” OR “programme” OR “intervention” OR “assistance”</td>
</tr>
<tr>
<td>Health Condition</td>
<td>“health” OR “illness” OR “disease” OR “condition” OR “pain”</td>
</tr>
</tbody>
</table>
Levels of Agreement

- There was 91% agreement between initial ratings
- Articles with discrepant ratings were discussed and agree upon by both researchers
- Two categories of articles with 100% agreement were then compiled:
  - Definite articles
  - Articles dependent on research question

<table>
<thead>
<tr>
<th>Level of Agreement Between Researchers</th>
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</thead>
<tbody>
<tr>
<td>Level of Agreement</td>
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<tr>
<td>---------------------</td>
</tr>
<tr>
<td>Number of Articles</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Second Filtering of Discrepant Ratings - Both Researchers in Agreement</th>
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<tbody>
<tr>
<td>Definite Articles</td>
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<tr>
<td>Dependent on Question</td>
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<tr>
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<td>---------------------------</td>
</tr>
<tr>
<td>Monitor Daily Activities</td>
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<tr>
<td>Breathlessness</td>
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<td>Blood Pressure</td>
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<tr>
<td>Sleep Patterns</td>
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<td>Fatigue</td>
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<tr>
<td>Vital Signs</td>
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<tr>
<td>Weight</td>
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<tr>
<td>Function &amp; Balance</td>
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<tr>
<td>Upper Limb Position</td>
</tr>
<tr>
<td>GPS</td>
</tr>
<tr>
<td>Questions</td>
</tr>
<tr>
<td>Uptime/Downtime Measurements</td>
</tr>
<tr>
<td>Lower Limb Position</td>
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<tr>
<td>Gait</td>
</tr>
</tbody>
</table>
Example Sensors

**Bed Sensor**
- In-bed sensor with 4 levels of sensitivity
- Up to 6 monitored periods per day
- Integral 169.48125 & 433.92 MHz transmitters
- 1 year battery life
- Out of bed sensor or bed in bed sensor
- Interface dimensions: 35x85x170 mm (HxWxD)
- Interface weight: 220 grams

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Proposed Use in Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall Detector</td>
<td>Fall detectors</td>
</tr>
<tr>
<td>Flood Detector</td>
<td>Useful if we wish to determine if someone is doing the dishes or measuring water flow</td>
</tr>
<tr>
<td>PIR</td>
<td>Will be useful to detect movements in different areas of the room</td>
</tr>
<tr>
<td>Bed Occupancy Mats</td>
<td>Useful to detect if someone is sitting on a chair or standing in a specific position.</td>
</tr>
<tr>
<td>Pill Dispenser</td>
<td>Used to manage the dispensing of medication</td>
</tr>
<tr>
<td>Client Wandering Keypad</td>
<td>Detects if a user has left the house</td>
</tr>
<tr>
<td>Door Contacts</td>
<td>Useful to detect the opening of cupboards, doors, fridge, etc.</td>
</tr>
<tr>
<td>Panic Button</td>
<td>Useful to generate warning message</td>
</tr>
<tr>
<td>Sayphone 21</td>
<td>Home based hub system</td>
</tr>
<tr>
<td>Personal Pendant</td>
<td>See panic button</td>
</tr>
<tr>
<td>Personal panic button</td>
<td>As above</td>
</tr>
<tr>
<td>Remote controlled Mains</td>
<td>Can be used to turn on and off equipment in the environment</td>
</tr>
</tbody>
</table>
Accelerometers

MTi-G (Xsense):
• real-time computed GPS-enhanced attitude/heading and inertial enhanced position/velocity data
• GPS integration overcomes typical IMU/AHRS challenges
• high update rate (100 Hz)
• individually calibrated for temperature, 3D misalignment and sensor cross-sensitivity

Philips wireless accelerometers
(smart target)
Smart Environment
PSMS - Conceptual Design

Application Layer

Service Layer
- Healthcare Professional
  - Life Goals
- Stationary Device
- Mobile Device

Sensor Platform Layer
- Pain
- Stroke
- CHF

Physical Layer
- Sensor
- Sensor
- Sensor
- Sensor
- Sensor
- Sensor
- Sensor
- Sensor
- Sensor

MySQL Database / Server
What feedback?

What information should the carer see?

Automatic or therapist?

What services and how many?

Which sensors and how many?
Information Pathways

Therapist and Patient enter life goals

Patient enters own life goals

System assigns life goals based on profile matching

System Interaction

User Interaction

IF Day == Sunday AND patientLocation != Outside THEN sendFeedback

MySQL Database/Server

Sensor Platform Layer

Stroke

Physical Layer

Smart Shoe

Upper-limb Bracelet

Mobile Device

PIR Sensor

Application Layer

Feedback

Audio – Visual – Sensory

Service Layer

Healthcare Professional Life Goals

Stationary Device

Mobile Device

MySQL Database Server

Sensor Platform

Yes

No

It’s Sunday, wouldn’t you like to go to church?

Stationary Device

Mobile Device

PIR Sensor

Attend Church

User Profile

Life Goal Library

Enters Details

User Interaction

Service Layer

Healthcare Professional Life Goals

Stationary Device

Mobile Device

MySQL Database Server

Sensor Platform

Yes

No

It’s Sunday, wouldn’t you like to go to church?
Design prototypes
CHOOSE ACTIVITY GOALS...

walk

garden

hoover

cycle

stairs

back to SETTING MODE press 10
Decision Support System

• Objectives
  - Support decision making in justification of life goal/care plan

• Tasks
  - Mining patterns/associates from a large dataset of patient activity sensor data/vital sign/self reports (datasets required)
  - Making suggestions to users
Information Flow of Decision Support System

1. Identify Value
   - Life Goal: pain/stroke/CHF
2. Justify
3. Over a period of time
   - Monitoring
   - Self Report
4. Define
   - Vital Signs
   - Activity
   - Monitoring
   - Self Report
5. Real time
   - Reminder/Feedback
6. Real time
7. Decision Support System
   - Users
Decision Support - activity

• Investigating basic framework for Decision Support
  - Techniques for data analysis, feature selection, data mining and data classification.

• Study 1: investigating Pain data:
  - Three stages: pre-treatment, treatment, follow-up
  - Current work is investigating the data patterns associated with these three stages

• Study 2: analysing activity data
  - Activity recognition

![Graph showing acceleration over time](image)
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• Advisory Group: Peter Lansley, William Maton-Howarth, Paul Gee, Chris Clark, Louise Tillman, Nigel Barnes, Julia MacLeod, Peter Moore
Extra Slides
1. Is technology effective at achieving behaviour change?

2. What technology has been employed to change behaviour?
   - Are specific features of technology associated with specific behavioural outcomes?
   - Is the technology transferable to a range of conditions or limited to specific conditions?

3. Is technology more successful, less successful, or of equal success in comparison with traditional/non-technological techniques?
   - Pros
   - Cons

4. What variables mediate the effectiveness of technology?
   - Features of technology: e.g. training requirement, difficulty of use
   - Location of use: Clinic or home based
   - Features of the individual: e.g. demographic info, beliefs, experience
   - Additional Support
# Potential Data to be Collected

<table>
<thead>
<tr>
<th>Pain (Accommodative)</th>
<th>Stroke (Restorative)</th>
<th>CHF (Preventative)</th>
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<tr>
<td>pain measurement</td>
<td>activity diary reporting relating to specific life goals</td>
<td>breathlessness</td>
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<td>activity diary reporting</td>
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<tr>
<td>timing of activities of daily living</td>
<td>gross motor activity</td>
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<td>wrist sensor for upper limb activity</td>
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<td>{monitor};</td>
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<td></td>
<td>heart rate</td>
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</table>
Electronic Healthcare Professionals

Advice & feedback

Electronic Health Record

Life Plan & Goals

Client Profile

Client

Healthcare Professionals

Single Assessment Process

LMS Medical WWS Client specific monitoring

Expert management system

Carers

SYSTEM STRUCTURE
Touch Screen Devices for Data Entry

**HTC P3300**
- 130 g
- Touch screen (finger/stylus)
- Few buttons
- Mobile phone (GSM)
- GPRS/WLAN
- Built-in GPS (SiRF III)
- Windows Mobile 5.0 PocketPC

**iiyama ProLite T1730SR-B**
- 17
- Touch Screen
- 17 LCD Panel
- 5 ms
- 800:1 CR
- USB and Serial
- DVI and VGA
- 2 x 1w Speakers
- Black