Home truths:
Insights for designing inclusive smart home technologies for healthcare

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Abstract

The pressing need to reform current forms of healthcare provision has contributed to a vision of the empowered patient who actively self-manages their health and wellbeing. It is widely held that technology will play a central role in achieving this goal, with smart home technologies presenting one promising solution. SPHERE is an interdisciplinary research project that aims to make a contribution to this field by developing a smart home system based on a common platform of non-medical/environmental sensors to address a variety of healthcare needs. Alongside the technical challenges of achieving an integrated multi-sensor platform, it is essential to consider the unique characteristics of the home environment and the variability of its dwellers. This paper describes the early user-centred design work conducted within SPHERE with a view to gaining a contextual understanding of people's healthcare practices and their experiences with technology. The contexts of use were defined as the Self, the Home and the Community, to correspond with possible sensing technologies and solutions to be deployed within SPHERE. This exploratory study used a design ethnography approach, with techniques such as Technology Tours and Cultural Probes. The sample was based on households and comprised, among others, telecare users and households with prior experience of home sensors. Early findings from this study are discussed with a focus on contributing user requirements for meaningful and inclusive domestic healthcare technology.

Keywords: Home healthcare, sensing technology, inclusive design, ethnography, technology tour, cultural probes

1 Introduction

1.1 Houses, homes, households: challenges of designing smart home technology for healthcare

Nowadays people are living longer and, as a result, many live with one or more chronic health conditions. Healthcare services have to cope with a greater number of patients as well as a growing incidence of comorbidity, which is having noticeable social and economic repercussions. Healthcare services are therefore moving from clinical settings into the home; responsibility is increasingly shifting to patients and caregivers, who are envisaged as active participants in the management of their health and care (Greenhalgh et al., 2010). In this context, sensor technology has been embraced as one possible means of supporting people in the self-management of their health conditions (for an overview, see Chan et al., 2008). However, the vision of an informed and empowered patient mentioned by Greenhalgh et al. remains elusive, since research in this field has been primarily driven by the technical push to develop practical and integrated systems.

An often overlooked aspect of smart home technology has been the 'home' component. Homes are complex spaces with physical, personal, and social dimensions, which are constructed by the people who live in them (Harrison & Dourish, 1996). Regarding the design of domestic self-care technology, previous work has investigated acceptance of technology in the home (Grönvall & Kyng, 2012), how people transport and install medical devices in their homes (*ibid*.), the process of finding space for the technology in their home (Axelrod et al., 2009), and incorporating technology into the routines of daily life (Ballegaard et al., 2008).

An additional challenge is presented by the fact that homes often comprise multiple individuals. In fact, it has been observed that current approaches to sensing technologies could already function well in single-person households (Mennicken et al., 2014). It is likely, especially in multi-generational households, that each resident has their own technology profile; in particular, socio-demographic factors, attitudinal variables, and cognitive abilities are known to influence technology use (Czaja et al., 2006). Each person also has their own health and care needs, which changes over time. The combination of these factors means that there is no single solution to suit everyone. However, a sensitive understanding of this diversity is a fundamental first step to developing inclusive systems, which are defined as "accessible to, and usable by, as many people as reasonably possible (...) without the need for special adaptation or specialised design" (BS 7000-6, 2005).

1.2 User-Centred Design in the SPHERE project

Our research is concerned with informing the design of desirable smart home systems for health and wellbeing, and forms part of a larger interdisciplinary project called SPHERE (Sensor Platform for HEalthcare in a Residential Environment). By fusing a range of complimentary non-medical sensors in a generic platform, SPHERE aims to develop new

systems that are clinically effective and have the potential for widespread deployment. The typology of sensors used in SPHERE can be categorised as:

- Indirect, which includes home energy and ambient monitoring;
- Remote, which includes video monitoring;
- On-body, which includes using wearable sensors for personal activity monitoring as well as for energy harvesting and management.

The SPHERE project does not target specific age groups or health conditions, but rather it intends to develop a generic but customisable system to support clinical diagnoses and self-management of wellbeing. This vision is in line with the platform-oriented approach described by Hardisty et al. (2011), who propose that technology is the basis around which a range of capabilities and services can be integrated. This approach has the potential to support inclusive design solutions, provided it is informed by the needs of a range of people. To achieve this, we conducted an ethnography study to understand the context of use of domestic healthcare technologies, in accordance with the first phase of the user-centred design process (ISO 9241-210, 2010).

2 Methodology

2.1 Research design, setting and participants

This qualitative study constituted the first phase of user-centred design activity within the SPHERE project. The aim was to gain a broad contextual understanding of people's healthcare practices and experiences with technology, with a focus on exploring the diverse characteristics of envisaged users. Three contexts of use were defined for this study, which were the Self, the Home, and the Community (Figure 1). The research design followed a design ethnography approach (Bell, 2001) and was therefore conducted mainly in participants' homes.

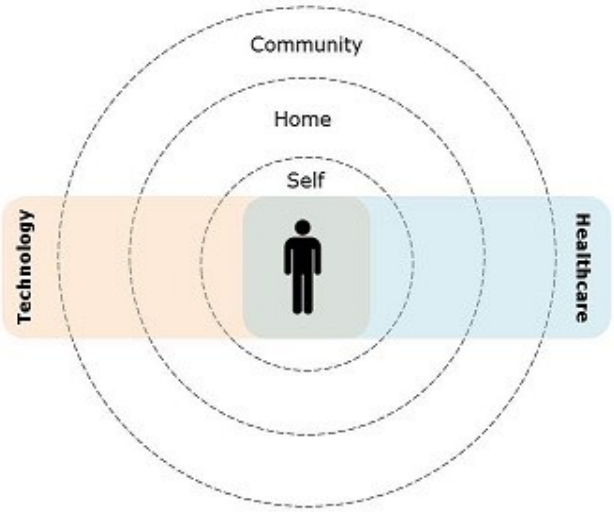

Figure 1: Contexts of use

We intended the study sample to include people with different personal characteristics, while aiming for a balanced gender representation. The sample for this study was based on households and the only exclusion criterion was inability to give informed consent. Participants were recruited through project partners at Bristol Careline (Bristol City Council) and the Knowle West Media Centre, as well as through SPHERE public engagement activities. The sample consisted of 15 households that included telecare users and households with experience of home sensors, among others. The study was reviewed and approved by the University of Bristol's Faculty of Engineering Human Research and Ethics Committee.

2.2 Data collection

Data were elicited through a combination of traditional ethnographic methods and participatory techniques. Data collection comprised three phases, which were:

- Ethnographic interviews in participants' homes, which were conducted in one or more home visits. These semi-structured interviews focused on three main areas – the home, technology, and health – and the interrelationships between them. The researcher encouraged participants to talk about experiences that were meaningful to them. Where possible, participants were asked to show the researcher around their home and talk about the technology present in each room. This technique is known as Technology Tour (Baillie & Benyon, 2001) and is used to facilitate conversations about people's experiences of domestic technology as they walk around each room. For the researcher, this walking tour of the home also provided an opportunity to understand how technology was embedded in the fabric of the home but also in people's daily lives.
- Cultural probes, with follow-up interview to discuss the materials produced. Participants were given a probe pack, which contained three elements that allowed them to self-document relevant experiences. The design of these elements was informed by themes that emerged from the ethnographic interviews and that we felt were interesting to explore further. These included a body map (Map of Me), to facilitate conversations about health and technology in relation to the context of the Self; a diary activity in the form of a daily timeline (Map of My Day) that allowed participants to record what they had done during the day, what technology they had used, and how their experiences could be improved; a digital camera with the several photo elicitation prompts, as well as blank cards for participants to create their own meaningful prompts. The diary and camera activities did not focus on a single context, but could be used by participants to reflect on aspects on the Self, the Home and the Community.
- A focus group discussion of the SPHERE technology, which was conducted in a two-bedroom residential property in Bristol that was fully instrumented with the first version of the sensor platform. This gave participants an opportunity to give their initial thoughts on the SPHERE technology, as well as raise any issues that they felt were important to consider in future iterations of the system.

3 Findings

The final sample comprised four households with experience of telecare, four households with prior experience of sensor systems, and seven other households. Regarding occupancy, five households had only one occupant, eight households had two occupants (five were couples, two were single parent and child, and one was a house share), and the remaining two had three and four occupants (two parents and children). All residents of the 15 households were invited but not required to take part in the study; the study thus comprised a total of 19 participants. Eight men and 11 women participated in this study, with ages ranging from 19 to 77 (median age: 51). Participants included healthy people, as well as people with diagnosed health conditions such as chronic pain and cancer. In terms of level of education, participants ranged from having no formal qualifications to having a Master's degree. In this sample, eight people were retired, seven people were employed full-time, one person was employed part-time, and three people were unemployed. Four participants reported being informal carers for an older relative, living elsewhere. Table 1 provides an overview of participants' age, health conditions, and care duties.

Table 1. Summary of participant characteristics

House type	Pseudonyms	Age	Notes about own health and/or care duties
Telecare	Jerry	66	Terminal cancer and previous heart attack
Telecare	Brian Josie	55 50	Both participants are informal carers for Brian's mother, who has late stage Alzheimer's
Telecare	Linda	65	High blood pressure, learning disability
Telecare	Brenda	65	Previous heart attack
Sensors	Dave	51	Dyslexia
Sensors	Claire	41	Migraines, asthma
Sensors	Laura	40	Chronic pain, history of mental health problems
Sensors	Sally Jake	44 19	No chronic health conditions Chronic pain
Other	Julie	49	Informal carer to her father, who was recently diagnosed with vascular dementia
Other	Mike	74	Undiagnosed chronic pain, multiple strokes
Other	Lisa	35	Undiagnosed chronic pain
Other	Lloyd Rose	75 74	Arthritis High blood pressure, hearing problems
Other	Kim	30	No chronic health conditions
Other	Fred	32	Recurring back pain, from a previous injury
Other	George Margaret	77 69	Both participants have occasional age-related pains, but no chronic health conditions

The households that took part in the study had varying amounts of technology. In terms of consumer electronics, the television was the single common technology across the households. Variability was most notable regarding information and communication technologies (ICT), which ranged from one participant who had no computer or similar device to participants who owned multiple computers.

This study produced a large amount of rich qualitative data, which highlighted the diversity of healthcare needs and experiences with technology. These data included interview transcripts, field notes, photographs and other visual materials. Data analysis is currently underway, using thematic analysis and design-oriented techniques. Our methodology was effective in exploring the complex and sometimes sensitive topics surrounding health and care in domestic settings. We found the participants chose to share information in different ways, supporting the need for a mixed methods approach to investigating people's real life experiences. For instance, in the interview some participants stated they did not have particular healthcare needs but they subsequently shared multiple examples of health conditions on their body maps. Figure 2 shows some examples of completed body maps, with yellow stickers indicating health conditions and blue stickers indicating technology that participants wear or carry with them. Among other things, this discrepancy between the interviews and body maps allowed us to consider the importance of self-perception of health as a factor that could affect the adoption of healthcare technologies.

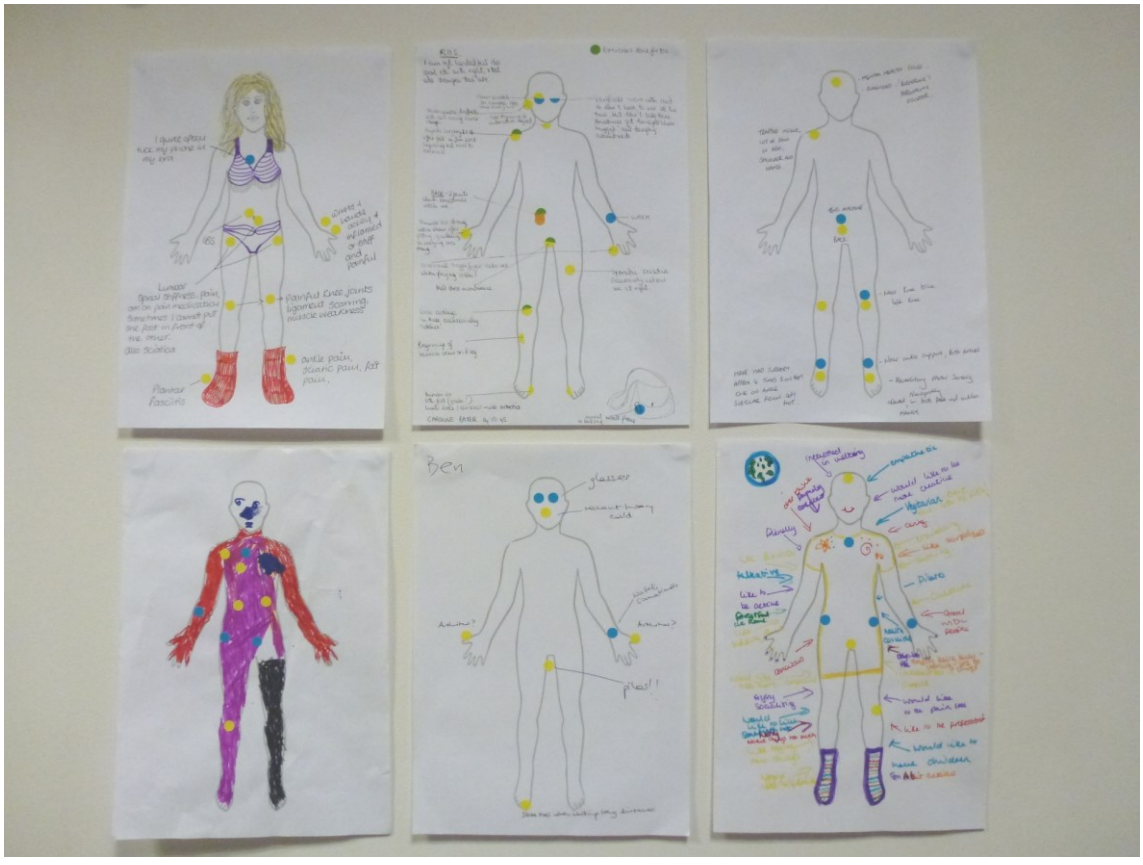

Figure 2: Examples of completed body maps

For the cultural probes, participants were given the freedom to express themselves through any medium (e.g. words, drawings, photos) and to share as much or as little information as they wished. This open-ended approach was intended to allow participants to share the feelings and experiences that were meaningful to them. Even though most participants reported enjoying the cultural probes as an opportunity to reflect on their behaviours, only three participants completed all elements of the probe kits. The photo activity produced mixed results, in particular because some participants were not comfortable using a digital camera. In some instances, participants wrote down examples on each of the prompt cards. For others, this was a very engaging task; for example, Lisa took at least one photo for each of the ten photo elicitation prompts and added her own categories. Examples of these photos are given in Figure 3.

Figure 3: Examples of photos taken by Lisa

The diary activity also produced diverse results, as illustrated in Figure 4. Some participants completed all three sheets they were given, to show different examples such as days of the week versus weekends, or days spent at home versus days spent out. Laura (top example in Figure 3) annotated her timelines with stickers to represent “technology running in the background” (the heating) and her health routines throughout the day. Lloyd (bottom example in Figure 3) was also keen to represent the heating and light working throughout the day, but he only completed one sheet because he felt that his days were mostly the same.

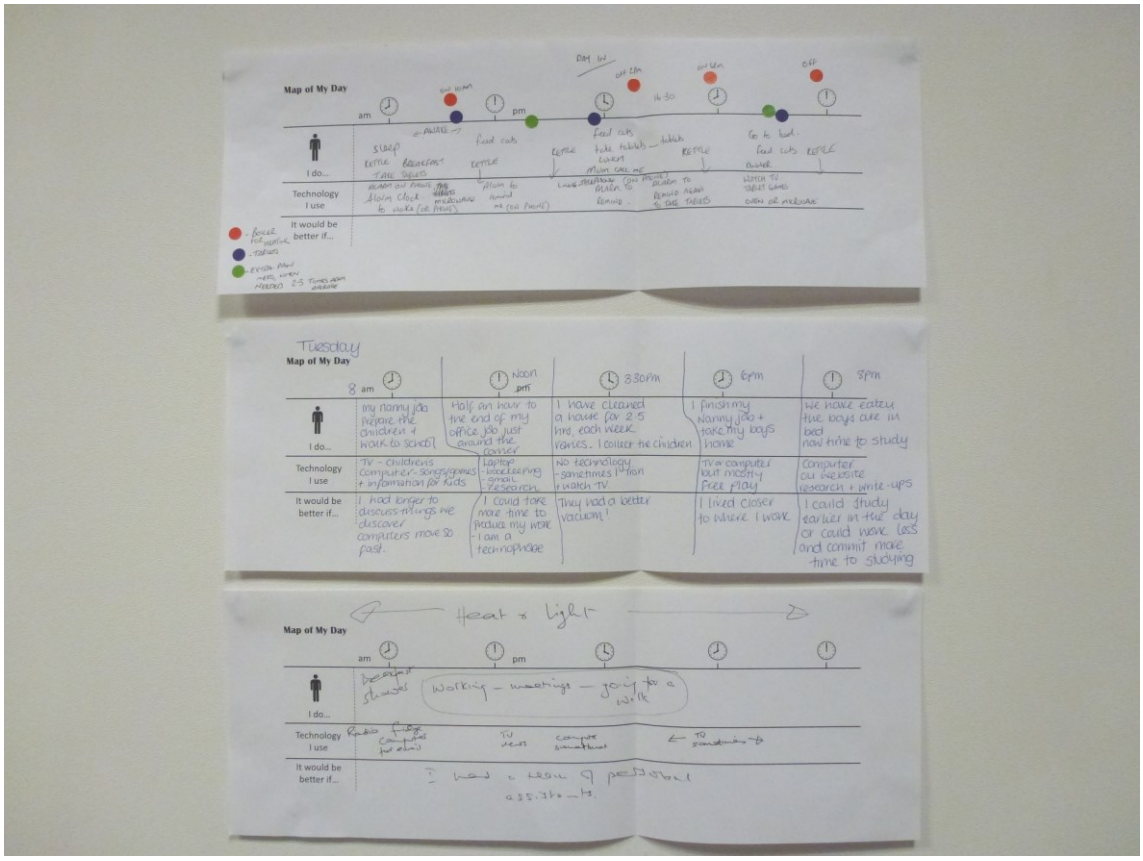

Figure 4: Examples of a completed diary activity for three different participants

4 Conclusion and next steps

Even at this preliminary stage, our research has underlined the importance of understanding the diversity of contexts of use for designing smart home technologies for health and care purposes. People's abilities and needs are dynamic, so it is fundamental that healthcare technology has the flexibility to remain meaningful throughout these life changes. Moreover, homes are imbued with physical, personal and social meaning that must be considered when developing any domestic system. This study generated a large amount of rich data, which requires deeper analysis. This process is ongoing and findings will be reported in future work by the authors. In particular, we are interested in developing design tools that can be used to share these diverse user data with other stakeholders within SPHERE and in similar interdisciplinary research projects.

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