Smart home technologies for health and social care support (Review)

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[Intervention Review]

Smart home technologies for health and social care support

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ABSTRACT

Background

The integration of smart home technology to support health and social care is acquiring an increasing global significance. Provision is framed within the context of a rapidly changing population profile, which is impacting on the number of people requiring health and social care, workforce availability and the funding of healthcare systems.

Objectives

To explore the effectiveness of smart home technologies as an intervention for people with physical disability, cognitive impairment or learning disability, who are living at home, and to consider the impact on the individual's health status and on the financial resources of health care.

Search methods

We searched the following databases for primary studies: (a) the Cochrane Effective Practice and Organisation of Care (EPOC) Group Register, (b) the Cochrane Central Register of Controlled Trials (CENTRAL), (*The Cochrane Library,* issue 1, 2007), and (c) bibliographic databases, including MEDLINE (1966 to March 2007), EMBASE (1980 to March 2007) and CINAHL (1982 to March 2007). We also searched the Database of Abstracts of Reviews of Effectiveness (DARE). We searched the electronic databases using a strategy developed by the EPOC Trials Search Co-ordinator.

Selection criteria

We included randomised controlled trials (RCTs), quasi-experimental studies, controlled before and after studies (CBAs) and interrupted time series analyses (ITS). Participants included adults over the age of 18, living in their home in a community setting. Participants with a physical disability, dementia or a learning disability were included. The included interventions were social alarms, electronic assistive devices, telecare social alert platforms, environmental control systems, automated home environments and 'ubiquitous homes'. Outcome measures included any objective measure that records an impact on a participant's quality of life, healthcare professional workload, economic outcomes, costs to healthcare provider or costs to participant. We included measures of service satisfaction, device satisfaction and healthcare professional attitudes or satisfaction.

Data collection and analysis

One review author completed the search strategy with the support of a life and health sciences librarian. Two review authors independently screened titles and abstracts of results.

Main results

No studies were identified which met the inclusion criteria.

Authors' conclusions

This review highlights the current lack of empirical evidence to support or refute the use of smart home technologies within health and social care, which is significant for practitioners and healthcare consumers.

PLAIN LANGUAGE SUMMARY

The effect of smart home technologies to support people at home

People who are ill (physically or mentally), or who are frail, may find it difficult to meet their everyday personal and social needs at home. Healthcare providers are trying to find ways to support more people at home, but finding home care workers and the money to fund this help is challenging. Advances in technology have created new devices to help support people.

New devices are already starting to be used, such as mobile phones tailored to health care, or electronic sensors that sound alarms in emergency situations. Another new technology is sensors. Sensors can be placed in everyday appliances in the home, like the fridge, cooker or the door, and can send information to healthcare providers. Providers can find out how people are doing in their homes and then make decisions about their care, such as how often to visit the home. Homes with these technologies are called 'smart homes'.

As with many new technologies, smart home technologies are often used without first testing if they are effective. This review aimed to determine what effect any type of smart home technologies have on people. The review produced a significant volume of literature on the use of smart technologies within health care, but there were no studies testing their effectiveness. The effects of smart technologies to support people in their homes are not known. Better quality research is needed.

BACKGROUND

The purpose of health and social care is to deliver targeted services which support individuals who are experiencing impaired functioning as a result of ill health (physical or mental), congenital abnormalities or frailty (often associated with ageing). The delivery of such care provides a means of sustaining people within local communities and preferably within their own home (DOH 2006). Within the Biopsychosocial Model of Disability (a synthesis of the Medical Model (Schwartz Barker 2001) and the Social Model of Disability (Clarke 2001)) an individual's experience of disability and their function is viewed as an outcome of the interactions between health conditions (diseases, disorders and injuries) and the contextual factors influencing performance. These contextual factors are the external environment, where the individual lives, and personal factors such as age, gender and social background (WHO 1998). This concept of health and disability is embedded within the International Classification of Functioning Disability and Health (ICF); a framework produced by the World Health Organization during 2001 (WHO 1998).

Globally, changes in the demographic profile of the world population suggest an increase in the number of people living into old age, and a corresponding decrease in the numbers within the economically active age range. The world population is predicted to rise to nine billion by the middle of this century. A complication within this is a shift in the structure of the population profile, including a quadrupling of the population aged 60 years and over by the year 2050 (Bloom 2004). This will be the first time in history that the number of older persons (those over 60 years) will exceed the young (under age 15) (WHO 1998). Potential associated repercussions are a higher demand for health and social care, due to the forecast increase in the prevalence of chronic illness and increase in the age of mortality, in tandem with a decrease in the workforce available to contribute towards funding and providing the care.

In 2006 the World Health Organization reported in the World Health Report that globally many healthcare systems are weak, unresponsive and inequitable - even unsafe (WHO 2006). For communities and nations a healthcare system is a labour-intensive sector and workforce issues are widely regarded as central to the successful organisation and management of health and social care.

The changing population profile will invariably put pressure on an already challenged service. A major challenge to governments will be how to provide both the future financial funding of sustainable services; fit for purpose and meeting the demands of populations, and manage the challenges of decreased workforce availability to contribute to the healthcare system (WHO 2002).

Description of the methods being investigated

Electronic Assistive Technology (EAT) refers to a broad range of devices, for example, environmental control systems to enable a physically disabled person to have more control over the home environment, or a social alarm which a frail elderly person can use to summon help if, for example, they have fallen (Doughty 2003). All electronic assistive technologies use information and communication technology (ICT) as a core component, generating dynamic, often intelligent devices capable of invoking a response following an action by a user. In addition, integration of a networked ICT infrastructure facilitates device communication, widening functional capability and capacity.

Currently the rapid developments within the domain of ICT have spawned the emergence of devices and communication networks that are commercially competitive and offer functionality and specifications which are applicable within health and social care scenarios. The emerging applications are diverse, as evidenced by the wide range of solutions available. However, ambiguity exists around how academics, service providers and service users categorise the integration and use of electronic assistive technology. Sometimes a descriptor of the created environment is used, for example, a 'smart home', though this is not a homogenous term and on comparison the technologies within studies may vary quite dramatically. Others report in terms of a service descriptor and define, for example, 'telecare' or 'telehealthcare' to support a particular population of disabled people.

Aldrich 2003 has proposed five hierarchical classes of 'smart homes', which have been adopted to guide the inclusion of studies in this review. The classification is outlined below.

1. Homes which contain intelligent objects: environments with generally stand-alone appliances and objects, which function in an intelligent manner. For example, an environmental control system that is set up to facilitate access via the front door, or facilitate the opening and closing of windows.
2. Homes which contain intelligent objects, which are enabled via wire or wireless networking to exchange information with each other.
3. The 'connected home' or 'ubiquitous home', which has both internal and external networks allowing interactive and remote control of systems, as well as access to services and information from both within and beyond the home. In this environment the tenant is not always required to connect proactively with the technology, which is discreetly positioned in the home environment and may unobtrusively gather information in relation to the tenant. This generates data relating to the general activity of the tenant which can be used to inform the care process and alter the environmental context that the tenant experiences.
4. The 'learning home' builds on the preceding level and data on patterns of activity, such as water use or movement within particular rooms, are discreetly gathered and recorded. The accumulated data are used to anticipate users' needs and then control the technology accordingly.
5. The 'attentive home' has the technical capability to record activity patterns, and the location of people and objects is constantly registered. This information is used to control technology in anticipation of the occupant's needs.

Why it is important to do this review

Technology is increasingly being integrated into health and social care as an intervention and to date a systematic literature review on the effectiveness of smart home technologies had not been completed.

OBJECTIVES

- To determine the effects of smart home technology interventions on an individual's health status.
- To establish the effects of smart home technology interventions on healthcare resources (including clinician time and hospital admission).
- To explore whether the sophistication of smart home technologies is related to their effects.

METHODS

Criteria for considering studies for this review

Types of studies

Randomised controlled trials (RCTs), quasi-experimental studies, controlled before and after studies (CBAs) and interrupted time series analyses (ITS), where there is a clearly defined point in time when the intervention occurred and at least three data points before and three after the intervention. Studies published in all languages were to be included.

Types of participants

Adults over the age of 18, living in their home in a community setting. We included studies that included participants with a physical disability, dementia or a learning disability.

Types of interventions

We included studies of the following interventions: social alarms, electronic assistive devices, telecare social alert platforms, environmental control systems, automated home environments and 'ubiquitous' homes. We excluded studies if they solely evaluated telemedicine applications (Wooton 2008). Therefore, we excluded the development of an acute sector service traditionally carried out in the hospital but now offered to a citizen at home with a healthcare professional based at the hospital (e.g. development of a telecardiology service (Scalvini 2007) or remote facility to monitor patients (Terschuren 2007)).

We planned the following comparisons:

1. use of a smart home technology compared to no intervention;
2. use of a smart home technology compared to a single non-technology intervention (e.g. provision of care staff);
3. use of a smart home technology compared to a multifaceted, non-technology intervention (e.g. moving to a purpose-built housing scheme with no technology).

Types of outcome measures

Any objective measure that records an impact on a participant's quality of life, and measures of health or social care requirements, for example:

- quality of life measures;
- health-related quality of life measures;
- prevention of admission to institutional care, i.e. residential/nursing home;
- healthcare professional workload;
- economic outcomes (a) costs to healthcare provider; b) costs to participant;
- measures of service satisfaction;
- measures of device satisfaction;
- healthcare professionals' attitudes or satisfaction (we would have included these in this review but would have excluded studies reporting only these outcomes with no objective measure of patient outcomes or professional performance).

Search methods for identification of studies

We applied the methods recommended by the Cochrane Effective Practice and Organisation of Care (EPOC 2007) Group and the Trials Search Co-ordinator assisted in the development of the search strategy.

We searched the following databases for primary studies:

(a) the Cochrane EPOC Group Register (and the database of studies awaiting assessment) (see Specialised Register under Group Details);

(b) the Cochrane Central Register of Controlled Trials (CENTRAL) (*the Cochrane Library*, issue 1, 2007);

(c) bibliographic databases, including MEDLINE (1966 to March 2007), EMBASE (1980 to March 2007) and CINAHL (1982 to March 2007).

We also searched the Database of Abstracts of Reviews of Effectiveness (DARE).

Other sources

We also:

a) handsearched those high-yield journals and conference proceedings which have not already been handsearched on behalf of the Cochrane Collaboration;

b) screened reference lists of all papers and relevant reviews identified;

c) contacted authors of relevant papers regarding any further published or unpublished work;

d) contacted authors of other reviews in the field of effective professional practice regarding relevant studies that they may be aware of;

e) searched the ISI Web of Science for papers that cited studies included in the review.

We applied no language restriction to the search.

Data collection and analysis

Data collection

One review author executed the search strategy with the support of a life and health sciences librarian.

Selection of studies

Two review authors independently screened titles and abstracts for inclusion. SM reviewed all titles and abstracts. In addition, we randomly divided the full number of retrieved titles and abstracts among the co-authors for screening. Any disagreement was to be resolved by discussion between the review authors and arbitrator(s) as required. We retrieved full text copies of all relevant papers, and also those where it was not possible to determine eligibility from the title or abstract.

Data extraction and management

Once the relevant studies were identified for possible inclusion, two review authors independently considered the data regarding inclusion criteria (design, participants, interventions and outcomes), quality criteria and results according to the Cochrane

Handbook (Cochrane 2008). We proposed that data extraction should be undertaken independently by SM and checked by GK. In addition, the group had planned to explore the effects of increasing sophistication of the intervention according to Aldrich's five hierarchical classes (Aldrich 2003).

The authors of Jutai 2000 and Hopps 2006 were contacted directly by Suzanne Martin and the studies were discussed prior to exclusion.

Reasons for exclusion are also set out in the table 'Characteristics of excluded studies'.

RESULTS

Description of studies

See: Characteristics of excluded studies.

The initial search generated 2380 citations. We retrieved a total of 62 full papers. From these, 14 papers were excluded as they were literature reviews of telemedicine (Barlow 2007; Bensink 2006; Brignall 2007; Demiris 2005; Garcia-Lizana 2007; Hailey 2002; Hankansson 2000; Mair 2000; Martinez 2006; Whitten 2000; Whitten 2002; Whitten 2007; Williams 2001) or telehealth (Jennett 2003). From the remaining 48 studies, 44 were excluded as they were either discussion papers, editorials, reported on telemedicine applications or did not meet the pre-defined inclusion criteria.

Two review authors then independently considered the remaining four papers for inclusion (Hopps 2006; Jutai 2000; Sixsmith 2000; Vincent 2006), and assessed them further for study design and methodological quality. This was required, as on first reading the studies appeared to meet the eligibility criteria. Guidance was also provided by a UK based EPOC editor. Following consideration, it was agreed that none of the studies met the inclusion criteria of the review.

Excluded studies

We inspected the following studies in detail prior to exclusion, as on the surface they appeared to meet the eligibility criteria. We excluded two studies on the basis that the methodological design was not in keeping with the eligibility criteria for inclusion within this review:

Sixsmith 2000 describes the evaluation of an intelligent home monitoring system applying a multi-method research approach involving qualitative and quantitative techniques;

Jutai 2000 reports on a study to investigate the impact of electronic aids to daily living for young adults with progressive neuromuscular conditions. This was a site-control after study design.

We excluded Hopps 2006 as it reported on a telemedicine application, although this was described by the author as a telehealth intervention. We excluded Vincent 2006 as it could not be confirmed from the published paper as an ITS study, presenting as an uncontrolled study, and all efforts to contact the author failed.

Risk of bias in included studies

No studies met the inclusion criteria for this review.

Effects of interventions

No studies met the inclusion criteria for this review.

DISCUSSION

Summary of main results

Smart home technologies within health and social care include a wide range of information and communication technology (ICT) enabled electronic assistive devices. These devices may operate in a stand-alone intelligent capacity to access, operate and control household appliances. In other scenarios, multiple device integration creates a home environment that is technology-enriched, thereby facilitating and supporting the delivery of a range of health and social care services. The purpose of the technology is to enhance functional independence and the quality of life achieved by either directly enabling service users, informing service providers, or both.

An interesting finding from this review is the lack of national and international consensus on terminology, classification or taxonomy of devices, products or service models. Some of the literature reporting on telehealth or telecare is, in effect, describing a telemedicine application. To debate the difference between the two would be helpful for both researchers and clinicians and assist with the reporting and seeking of evidence.

The World Health Organization has stated that the adoption of ICT in the healthcare sector often occurs without comprehensive evaluation of the health impact or a true understanding of the added value of ICT to health services (WHO 2005). This would appear to be the situation globally as national governments promote the implementation of technology-enriched health and social care services by a fusion of policy, investment and operational service change across the developed world.

Quality of the evidence

This review considered a substantial amount of published literature and did not find any studies that met the inclusion criteria. Current available published studies lack the application of robust empirical methodologies to validate smart home technologies as an effective intervention to support health and social care.

Agreements and disagreements with other studies or review

This review has similar findings to other reviews that have explored different aspects of technology within health care. Barlow 2007 found that less than 1% of literature retrieved could be included in a literature review on the use of telecare for frail elderly people with long term conditions. Similarly, Demiris 2005 classified only 4.7% of the telemedicine literature as a clinical trial. Another similarity with systematic literature reviews of telemedicine is that many authors find that good quality evidence is lacking; often methodological detail is under-reported to such a degree that the deficiencies limit the generalisability of findings (Bensink 2006; Brignall 2007; Garcia-Lizana 2007; Hailey 2002; Mair 2000; Whitten 2000; Whitten 2002; Whitten 2007; Williams 2001).

This intervention is complex, with substantial inherent heterogeneity, and impacts not only on service users but also on the service provider and the organisational processes. Opportunity exists to investigate all of these aspects of the intervention. The UK Medical Research Council has produced a framework for the development and evaluation of RCTs for complex interventions to improve health (MRC 2000), which may prove useful.

2) International consistency in describing and reporting on technology-enabled interventions (telemedicine, telecare, telehealth as examples) could enhance the design, delivery, implementation and dissemination of research projects and enhance the quality and accessibility of the evidence base available for practitioners.

3) The adoption of any assistive technology into everyday activity is complex, yet integration of ICT into the pattern of daily routine must be assured if the full potential of the device is to be realised. Research to date, however, demonstrates that with all assistive technologies there is a high abandonment rate (Galvin 1996; Scherer 1996). Research into this aspect of the adoption and utilisation of ICT within the social context is essential to enhance understanding of integration into service and inform technology design and development.

AUTHORS' CONCLUSIONS

Implications for practice

This review does not provide sufficient evidence to support or refute the integration of smart home technologies into health and social care.

Implications for research

1) There is a dearth of well-designed studies despite the substantial amount of literature emerging from the literature search.

ACKNOWLEDGEMENTS

Laura Mills, Health Sciences Librarian, University of Ulster at Jordanstown, Northern Ireland.

Kay Ballantine, Health Sciences Librarian, University of Ulster at Coleraine, Northern Ireland.

Martin Eccles, Professor of Clinical Effectiveness and the William Leech Professor of Primary Care Research, Institute of Health and Society, Newcastle University, England.

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* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Hopps 2006	Methodology and design. The intervention described is a telemedicine application aiming to provide nursing contacts beyond those available under traditional home care
Jutai 2000	Methodology and design. This study investigates the impact of electronic aids to daily living for young adults with progressive neuromuscular conditions. This was a site-control after study design
Sixsmith 2000	Methodology and design. This study describes the evaluation of an intelligent home monitoring system, applying a multi-method research approach involving qualitative and quantitative techniques
Vincent 2006	Methodology and design. This study was uncontrolled and was not an interrupted time series analysis (ITS)

DATA AND ANALYSES

This review has no analyses.

WHAT'S NEW

Last assessed as up-to-date: 30 March 2007.

Date	Event	Description
12 November 2008	Amended	Minor changes

HISTORY

Protocol first published: Issue 1, 2007

Review first published: Issue 4, 2008

Date	Event	Description
31 July 2008	Amended	Converted to new review format.
29 July 2008	New citation required and conclusions have changed	Substantive amendment

CONTRIBUTIONS OF AUTHORS

Suzanne Martin conceived and co-ordinated the review. Funding was secured by Suzanne Martin in collaboration with Christopher Nugent. All authors contributed to the data collection for the review, i.e. Suzanne Martin, Greg Kelly, George Kernohan, Bernadette McCreight and Christopher Nugent. Suzanne Martin undertook data management. All authors contributed toward the writing of the review.

DECLARATIONS OF INTEREST

There are no conflicts of interest with this review and no industrial funding was received.

SOURCES OF SUPPORT

Internal sources

- University of Ulster, UK.

External sources

- Research and Development Office, Central Services Agency, UK.

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

No changes were made to the protocol to enable the completion of this review. The following methods from the protocol could not be implemented in the current review because no studies met the inclusion criteria:

a) data abstraction;

b) assessment of methodological quality;

c) reporting;

d) analysis of data;

e) exploration of heterogeneity.

INDEX TERMS

Medical Subject Headings (MeSH)

*Disabled Persons; *Electronics, Medical; *Home Care Services; Monitoring, Ambulatory [*instrumentation; methods]

MeSH check words

Humans