Technologies for Ageing in Place to Support Home Monitoring of Patients with Chronic Diseases

Alexandra Queirós[1], Luís Pereira[2], Ana Dias[3] and Nelson Pacheco Rocha[4]
[1]Health Sciences School, University of Aveiro, Campo Universitário de Santiago, 3810-193 Aveiro, Portugal
[2]Medtronic Portugal, Torres de Lisboa, Rua Tomás da Fonseca, Torre E - 11º andar, 1600-209 Lisboa, Portugal
[3]Department of Economicas, Management, Industrial Engineering and Tourism, University of Aveiro, Campo Universitário de Santiago, 3810-193 Aveiro, Portugal
[4]Department of Medical Sciences, University of Aveiro, Campo Universitário de Santiago, 3810-193 Aveiro, Portugal

Keywords: Technologies for Ageing in Place, Home Monitoring, Chronic Diseases, Older Adults.

Abstract: Objectives - This study aims to identify: i) the most relevant chronic diseases in terms of the use of technologies for ageing in place to support home monitoring; and ii) types, outcomes and impacts of technologies for ageing in place being used to support home monitoring. Methods - A systematic review of reviews and meta-analysis was performed based on a search of the literature. Results - A total of 35 reviews and meta-analysis across 4 chronic diseases, diabetes, congestive heart failure, chronic obstructive pulmonary disease, and hypertension, were retrieved. These studies compare home monitoring supported by different technologies with usual care. Conclusion - Home monitoring has positive effects in various health related outcomes, but further research is required to allow its incorporation in the clinical practice.

1 BACKGROUND

The active ageing concept refers not only to the ability to be physically active or have an occupation, but also to be able to participate in social, economic, cultural, civil or spiritual matters (Kickbusch and Nutbeam, 1998; World Health Organization, 2002). Therefore, the older adults, even when having some kind of pathology or disability, should continue to contribute actively in social terms, together with their family, friends and community (Kickbusch and Nutbeam, 1998). In this context, information technologies have a key role in the promotion of human functioning and in the mitigation of limitations, particularly the ones resulting from the natural ageing process (Queirós, 2013; 2015).

Technological solutions emerge as potentially cost-effective to meet the needs of citizens and to promote the services reorganization (Genet et al., 2011), which are the aims of concepts such as Medicine 2.0 (Eysenbach, 2008), connected health (Kvedar, Coye, and Everett, 2014), or holistic health (Mori et al., 2013; Koch, 2013). In particular, technologies for ageing in place (Connelly, Mokhtari and Falk, 2014) can overcome multiple impairments, including declines in cognitive and functional abilities (Teixeira et al., 2013; Cruz et al., 2013; 2014) and, consequently, can allow older adults to live safely, independently, autonomously, and comfortably, without being required to leave their own residences, but with the necessary support services to their changing needs (Pastalan, 1990).

The present study is part of a medium term project that aims to systematize current evidence of technologies for ageing in place. Particularly, a systematic review of reviews and meta-anaysis was perform to identify technologies being used to support home monitoring of patients with chronic diseases, not specifically designed for older adults, but that can be used by this population, and to analyse how these tecnologies impact health related outcomes.

There are several reviews of reviews related to home care of patients with chronic diseases (Househ, 2014; McBain, Shipley and Newman, 2015; Kitsiou, Paré and Jaana, 2015; Slev, 2016). However, these reviews focus on specific technologies (e.g. short message services (Househ, 2014), or specific pathologies (e.g. congestive heart failure (Kitsiou, Paré and Jaana, 2015)). Therefore, the broad analysis of the study reported in the present article is useful to inform: i) the practitioners

QueirÃşs A., Pereira L., Dias A. and Pacheco Rocha N.
Technologies for Ageing in Place to Support Home Monitoring of Patients with Chronic Diseases.
DOI: 10.5220/0006140000660076
In *Proceedings of the 10th International Joint Conference on Biomedical Engineering Systems and Technologies (BIOSTEC 2017)*, pages 66-76
ISBN: 978-989-758-213-4

about the available home monitoring solutions; and ii) the researchers about home monitoring issues that are being object of research.

2 METHODS

Considered the aforementioned objective, the systematic review of reviews and meta-analysis reported in the present article was informed by the following research questions:

- What are the most relevant chronic diseases in terms of the use of technologies for ageing in place to support home monitoring?
- What are the types, outcomes and impacts of technologies for ageing in place being used to support home monitoring?

In order to determine the most appropriate search strategy, an initial scoping study was conducted. The outcomes of this process were discussed with various researchers and captured in a review protocol with explicit descriptions of the methods to be used and the steps to be taken.

The resources considered to be searched were two general databases (i.e. Web of Science and Scopus) and two specific databases (i.e. PubMed, a medical sciences database, and IEEE Explorer, a technological database).

The list of keywords for the systematic review was created through three steps:

- First, health related and technological terms were selected for a draft search strategy based on the terminology that the authors were familiar due to their background readings. A preliminary search with the identified keywords was tested by two authors.
- Afterwards, the two authors carried out a hand search of the table of contents of three relevant journals: Journal of Telemedicine and Telecare, Telemedicine and Ehealth and Journal of Medical Internet Research.
- Finally, new keywords were introduced in order to gather articles of the mentioned journals that were not retrieved in the previous queries.

The queries that resulted from these successive refinements intended to include: i) all the reviews where any of the keywords 'telecare', 'telehealth', 'telemedicine', 'homecare', 'telemonitoring', 'home monitoring', 'remote monitoring´, ehealth´, 'telerehabilitation', 'mobile health', 'mhealth' or 'assisted living' were presented in the title or abstract; and ii) all the reviews where any the keywords 'technology-based', 'information technology', 'information and communication', 'internet-based', 'web-based', 'on-line', 'smartphones', 'mobile apps', 'mobile phone', 'monitoring devices' or 'consumer health information' were presented in the title or abstract together with any of the keywords 'healthcare', 'health care', 'patient', 'chronic disease', 'older' or 'elderly'.

The search was limited to articles in English, but conducted in any country, and performed on 30 of April of 2016, to include reviews published during the preceding 10 years.

2.1 Inclusion and Exclusion Criteria

The study reported in the present article included reviews and meta-analysis related to technological solutions that can be used to support home monitoring of older adults living with a chronic disease. Chronic disease is defined as an illness that is prolonged in duration, has a non-self-limited nature, is rarely cured completely and is associated with persistent and recurring health problems (Thrall, 2005; Australian Institute of Health and Welfare, 2006).

Since the scientific literature presents a large number of articles that report studies related to home monitoring, it was planned to include systematic reviews or meta-analysis only.

The authors excluded all the articles not published in English or that report systematic reviews of reviews. Furthermore, the authors also excluded all the reviews and meta-analysis reporting solutions that: i) are not focused on the monitoring of health conditions; ii) target more than one chronic condition (e.g. diabetes together with congestive heart failure); iii) target long-term health condition not related to older patients (e.g. paediatric conditions); iv) do not target the patients (i.e. studies that were clinicians focused or were intended primary to deal with the problems of caregivers rather than the patients); and v) were designed to be used in an institutional environment and not in the domicile of the patients.

2.2 Review Selection

After the removal of duplicates and articles not published in English, the selection of the remainder articles was performed by two authors in three steps:

- First, the authors assessed all titles for relevance and those clearly not meeting the inclusion criteria were removed.

- Afterwards the abstracts of the retrieved articles were assessed against the inclusion and exclusion criteria.
- Finally, authors assessed the full text of the articles according to the outlined inclusion and exclusion criteria.

In all these three steps any disagreement between the two authors was discussed and resolved by consensus.

2.3 Data Extraction

The following characteristics of the retrieved articles were extracted: i) authors, title and year of publication; ii) aims of the review or meta-analysis; iii) target chronic disease; iv) technologies being used; v) search strategy; vi) inclusion and exclusion criteria; vii) quality assessment; viii) data extraction procedure; ix) total number of primary studies; x) total number of random clinical trials (RCT); xi) total number of participants; xii) primary outcomes; xiii) secondary outcomes; xiv) author's interpretations; and xv) author's conclusions.

The relevant data were extracted and recorded independently by two authors. Once more, any disagreement between the two authors was discussed and resolved by consensus.

3 RESULTS

The present study comprises a narrative synthesis of the retrieved systematic reviews and meta-analyses and followed the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher, 2009). Figure 1 presents the respective flowchart.

A total of 2681 articles were retrieved from the initial searches on PubMed (822 articles), Web of Science (1263 articles), Scopus (550 articles) and IEEE Explorer (46 articles). The initial screening yielded 1429 articles by removing the duplicates (1210 articles) or the articles without abstracts or without the names of the authors (42 articles). After exclusions based on title alone 563 articles were retrieved. Additionally, 315 articles were eliminated based upon review of their abstracts.

The full texts of the 248 remaining articles were assessed and 213 articles were eliminated, due to the following reasons: i) the studies target multiple chronic diseases - 102 articles; ii) the main goals of the studies are health promotion related to general population - 48 articles; iii) the studies are not focused on home monitoring of patients with chronic diseases - 31 articles; iv) the studies are not systematic literature reviews or meta-analysis - 12 articles - or are reviews of reviews - 3 articles; v) the target users are not the patients but the caregivers - 8 articles; vi) the reported solutions are to be used in an institutional environment or are related to acute conditions - 4 articles; vi) the studies were not reported in English - 5 articles.

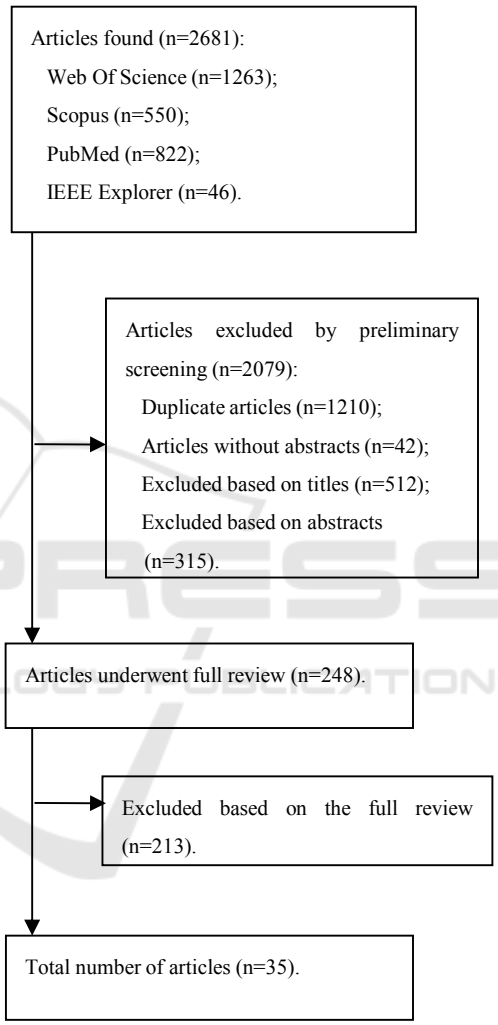

Figure 1: PRISMA Flowchart.

3.1 Characteristics of the Studies

The 35 resulting articles from the filtered queries synthesize evidence of home monitoring to support patients with chronic diseases. After an analysis of the full text of the retrieved articles, they were categorized into 4 clinical domains: i) diabetes - 20 articles; ii) congestive heart failure - 9 articles; iii) chronic obstructive pulmonary disease - 5 articles; and iv) hypertension - 1 article. The following

subsections present the results of these 4 categories.

3.2 Diabetes

Of the 35 retrieved articles, 20 dealt with home monitoring of patients with diabetes. A significant number of articles focuses both type 1 and type 2 diabetes (Jaana and Paré, 2007; Verhoeven et al., 2007; Baron, McBain and Newman, 2012; El-Gayar, 2013; van Vugt et al., 2013; Or and Tao, 2014; Huang et al., 2015; Tildesley, Po and Ross, 2015; Riazi et al., 2015; Garabedian, Ross-Degnan and Wharam, 2015). Others articles focus type 2 diabetes (Jackson, 2006; Ramadas et al., 2011; Frazetta, Willet and Fairchild, 2012; Cassimatis and Kavanagh, 2012; Tao and Or, 2013; Huang et al., 2015; Hunt, 2015; Ortiz, Felix and Sosa, 2015; Arambepola, 2016). Only one of the retrieved studies focuses exclusively on type 1 diabetes (Peterson, 2014).

By principle, the articles of the diabetes category include primary studies with high quality scientific evidence. All the 20 retrieved articles considered RCT primary studies and 11 of them considered RCT as one of the inclusion criteria (Jaana and Paré, 2007; Verhoeven et al., 2007; Cassimatis and Kavanagh, 2012; Baron, McBain and Newman, 2012; Pal et al., 2013; Tao and Or, 2013; van Vugt et al., 2013; Or and Tao, 2014; Huang et al., 2015; Tildesley, Po and Ross, 2015; Arambepola, 2016). On the other hand, aggregating all the primary studies included in the 20 studies of the diabetes category it is evident that the number of the involved patients is relatively significant (e.g. 1 article reports the involvement of 3578 patients (Pal et al., 2013) and other reports the involvement of 3798 patients (Huang et al., 2015)).

In technological terms, several articles (Ramadas et al., 2011; Frazetta, Willet and Fairchild, 2012; El-Gayar, 2013; Pal et al.; Tao and Or, 2013; van Vugt et al., 2013; Huang et al., 2015; Tildesley, Po and Ross, 2015; Riazi et al., 2015; Hunt, 2015) refer web-based applications (Table 1). In general, these applications allow synchronous (e.g. instant messaging or chat) and asynchronous (e.g. electronic mail or bulletin board) communications together with web pages to register clinical parameters (e.g. weight or blood pressure) and medication.

Besides web-based applications, there are other technological solutions reported in different articles:

- Computer-assisted applications integrating the management of clinical data with electronic practice guidelines, reminder systems, and feedback to the patients (Jackson, 2006; El-Gayar, 2013).
- Smartphones (i.e. standalone smartphones and smartphones integrating specific devices such as glucometers for automatic glucose level upload) (Frazetta, Willet and Fairchild, 2012; Cassimatis and Kavanagh, 2012; Baron, McBain and Newman, 2012; El-Gayar, 2013; Pal et al., 2013; Peterson, 2014; Tildesley, Po and Ross, 2015; Garabedian, Ross-Degnan and Wharam, 2015; Hunt, 2015; Ortiz, Felix and Sosa, 2015; Arambepola, 2016).
- Automatic patient data transmission by means of monitoring devices (i.e. devices to monitor vital signals or devices to monitor behaviour outcomes such as pedometers or accelerometers connected by wireless communications to monitor physical activity (Jaana and Paré, 2007)).
- Video-conference (Verhoeven et al., 2007; El-Gayar et al., 2013).
- Telephone calls (Riazi et al., 2015).

The main outcome of most of the articles included in the diabetes category is the control of glycaemia by using glycosylated haemoglobin (HbA1c) as a proxy. However, in all the studies, this aim is complemented with other health related outcomes (e.g. health related quality of life (Verhoeven et al., 2007; Ramadas et al., 2011; Pal et al., 2013; van Vugt et al., 2013), weight (Ramadas et al., 2011; Pal et al., 2013; Huang et al., 2015; Garabedian, Ross-Degnan and Wharam, 2015), depression (Pal et al., 2013), blood pressure (Verhoeven et al., 2007; Or and Tao, 2014; Riazi et al., 2015; Garabedian, Ross-Degnan and Wharam, 2015), cholesterol level (Ramadas et al., 2011; Or and Tao, 2014), triglycemius level (Or and Tao, 2014), fluctuation index (Ramadas et al., 2011)), behaviour outcomes (e.g. physical activity) (Jackson, 2006; Verhoeven et al., 2007; Ramadas et al., 2011; Cassimatis and Kavanagh, 2012; van Vugt et al., 2013; Riazi et al., 2015; Garabedian, Ross-Degnan and Wharam, 2015; Hunt, 2015; Arambepola, 2016), patient self-motivation (Tildesley, Po and Ross, 2015), patient-clinician communication (Tildesley, Po and Ross, 2015), medication adherence (Cassimatis and Kavanagh, 2012; Hunt, 2015)), and structural outcomes related to care coordination (Jaana and Paré, 2007; Verhoeven et al., 2007).

Table 1: Articles that focus diabetes.

Study	Technology	(*)
Jackson et al., 2006	Web-based applications, computer assisted applications and standard telephone calls	26/14
Jaana et al., 2007	Automatic patient data transmission by means of monitoring devices	17/17
Verhoeven et al., 2007	Video-conference	39/39
Ramadas et al., 2011	Web-based applications	13/8
Frazettaet al., 2012	Smartphones	7/7
Cassimatis et al., 2012	Smartphones	13/13
Baron, et al., 2012	Smartphones	24/24
El-Gayar et al., 2013	Web-based applications, smartphones, computer assisted applications and video-conference	104/60
Pal et al., 2013	Web-based applications and smartphones	16/16
Tao et al., 2013	Web-based applications	43/43
van Vugt et al., 2013	Web-based applications	13/13
Or et al., 2014	Web-based applications	67/67
Peterson	Smartphones	14/1
Huang et al., 2015	Web-based applications and standard telephone calls	18/18
Tildesley et al., 2015	Web-based applications and smartphones	22/22
Riazi et al., 2015	Web-based applications and standard telephone calls	67/52
Garabedian et al., 2015	Smartphones	1479
Hunt, 2015	Web-based applications and smartphones	14/9
Ortiz et al., 2015	Smartphones	8/4
Arambepola et al., 2016	Smartphones	13/13

(*) Number of RCT included in the review / Number of primary studies include in the review.

Most of the articles of the diabetes category report moderate to large significant reduction of HbA1c when compared with usual care (Jackson, 2006; Jaana and Paré, 2007; Frazetta, Willet and Fairchild, 2012; Cassimatis and Kavanagh, 2012; Tao and Or, 2013; Or and Tao, 2014; Peterson, 2014; Huang et al., 2015; Tildesley, Po and Ross, 2015; Riazi et al., 2015; Garabedian, Ross-Degnan and Wharam, 2015; Hunt, 2015; Ortiz, Felix and Sosa, 2015; Arambepola, 2016). However, several studies are not conclusive about the reduction of HbA1c (Verhoeven et al., 2007; Ramadas et al., 2011; Baron, McBain and Newman, 2012; Pal et al., 2013). In particular, computer-based diabetes self-management interventions (Pal et al., 2013) and consultations supported by video-conference (Verhoeven et al., 2007) appear to have a small beneficial effect on glycaemia control.

An article (El-Gayar et al., 2013) reporting research gaps of the technological approaches identifies the need to improve the usability of the applications as well the need for more comprehensive solutions, including real-time feedback to the patients and the integration of electronic health records systems supporting the service providers.

3.3 Congestive Heart Failure

The number of RCT and non-RCT primary studies included in the 9 articles dealing with congestive heart failure varies from 9 to 42 (Table 2). The majority of the articles (i.e. 6 articles (Chaudhry et al., 2007; Dang, Dimmick and Kelkar, 2009; Polisena et al., 2010a; Ciere, Cartwright and Newman, 2012; Conway, Inglis and Clark, 2014; Nakamura, Koga and Iseki, 2014)) considered RCT as one of the inclusion criteria.

Considering the supporting technologies (Table 2), automatic patient data transmission by means of monitoring devices is being used together with video-conference and standard telephone calls to allow the assessment of symptoms and vital signs, as well as the transmission of automatic alarms.

In terms of clinical outcomes, the main concerns are the impacts of home monitoring in heart failure-related hospitalizations and all-cause mortality (Conway, Inglis and Clark, 2014) when compared with usual care. However, several secondary outcomes are also considered such as self-care behaviour (e.g. adherence to prescribed medication, daily weighing or adherence to exercise recommendations (Ciere, Cartwright and Newman, 2012)).

Table 2: Articles that focus congestive heart failure.

Study	Technology	(*)
Martínez et al., 2006	Automatic patient data transmission by means of monitoring devices	42/13
Chaudhry et al., 2007	Automatic patient data transmission by means of monitoring devices and standard telephone calls	9/9
Clark et al., 2007	Automatic patient data transmission by means of monitoring devices and standard telephone calls	14/14
Dang et al., 2009	Automatic patient data transmission by means of monitoring devices	9/9
Polisena et al., 2010a	Automatic patient data transmission by means of monitoring devices	9/9
Ciere et al., 2012	Automatic patient data transmission by means of monitoring devices and standard telephone calls and video-conference	12/7
Grustam et al., 2014	Automatic patient data transmission by means of monitoring devices and standard telephone calls and video-conference	32/21
Conway et al.	Automatic patient data transmission by means of monitoring devices and standard telephone calls	25/25
Nakamura et al., 2014	Automatic patient data transmission by means of monitoring devices, including external, wearable, or implantable electronic devices	13/13

(*) Number of RCT included in the review / Number of primary studies include in the review.

Accordingly the reviewed articles home monitoring has a positive effect on clinical outcomes in community dwelling patients with congestive heart failure. Home monitoring reduces mortality when compared with usual care and it also helps to lower both the number of hospitalizations and the use of other health care services (Dang, Dimmick and Kelkar, 2009; Polisena et al., 2010a; Conway, Inglis and Clark, 2014; Nakamura, Koga and Iseki, 2014).

However, there is a need for high-quality trials (Chaudhry et al., 2007). Additionally, Grustam et al. (2014) state that evidence from the scientific literature related to home monitoring to support congestive heart failure patients is still insufficient. Also, more full economic analyses are needed to reach a sound conclusion. This means that further research is required in terms of comparisons of home monitoring with usual care of patients with congestive heart failure.

3.4 Chronic Obstructive Pulmonary Disease

All the retrieved articles dealing with chronic obstructive pulmonary disease analyse RCT primary studies (Table 3). In particular, 3 of them considered RCT as one of the inclusion criteria (Polisena et al., 2010b; Pedone and Lelli, 2015; Lundell et al., 2015).

Home monitoring is supported by commercially available devices to measure and transmit different types of information (e.g. weight, temperature, blood pressure, oxygen saturation, spirometry parameters, symptoms, medication usage or steps in 6-minutes walking distance). In some cases the automatic data acquisition is complemented by clinical staff using questionnaires in telephone interviews (Polisena et al., 2010b; Pedone and Lelli, 2015). Video-conference can also be used to provide feedback to the patients (Lundell et al., 2015).

Table 3: Articles that focus chronic obstructive pulmonary disease.

Study	Technology	(*)
Polisena et al., 2010b	Automatic patient data transmission by means of monitoring devices and standard telephone calls	10/10
Bolton et al. 2011	Automatic patient data transmission by means of monitoring devices	6/2
Pedone et al., 2015	Automatic patient data transmission by means of monitoring devices and standard telephone calls	12/12
Lundell et al., 2015	Automatic patient data transmission by means of monitoring devices and video-conference	9/9

(*) Number of RCT included in the review / Number of primary studies include in the review.

In what concerns the primary and secondary outcomes, 3 studies (Polisena et al., 2010b; Bolton et al. 2011; Pedone and Lelli, 2015) compare home monitoring with usual care of patients with chronic obstructive pulmonary disease, considering mortality, admissions to hospital or other health care utilization as primary outcomes. Secondary outcomes include, among others, health related quality of life, patient satisfaction, physical capacity and dyspnea.

Home monitoring was found to reduce rates of hospitalization and emergency department visits, while the findings related to hospital bed days of care varied between studies (Polisena et al., 2010b; Pedone and Lelli, 2015). However, 1 study (Polisena et al., 2010b) reports a greater mortality in a telephone-support group compared with usual care. Additionally, there is evidence that home monitoring has a positive effect on physical capacity and dyspnea (Lundell et al., 2015) and it is similar or better than usual care in terms of quality of life and patient satisfaction outcomes (Polisena et al., 2010b).

The evidence systematized by the articles of the category related to chronic obstructive pulmonary disease does not allow drawing definite conclusions, as the studies are small. The benefit of home monitoring of patients with chronic obstructive pulmonary disease is not yet proven and further research is required before wide-scale implementation be supported.

3.5 Hypertension

Finally, concerning patients with hypertension 1 article systematizes the results of 12 RCT using devices with automated data transmission, and video-conference.

The article reports improvements in the proportion of participants with controlled blood pressure compared to those who received usual care, but the authors conclude that more interventions are required and cost-effectiveness of the intervention should also be assessed (Chandak and Joshi, 2015).

4 DISCUSSION

According to the findings of the systematic review reported in the present article, diabetes, congestive heart failure, chronic obstructive pulmonary disease and hypertension are the most relevant chronic diseases in terms of the use of technologies for ageing in place to support home monitoring (i.e. the first research question of the present study).

Type 1 and type 2 diabetes stand out from other chronic conditions with a total of 20 studies, which constitute 57.1% of the articles that were retrieved. In order of relevance, the second chronic condition is congestive heart failure (i.e. 28.6% of the articles that were retrieved), which was followed by chronic obstructive pulmonary disease (i.e. 11.4% of the articles that were retrieved). Furthermore, one article reporting a systematic review related to home monitoring of patients with hypertension was also included in the present systematic review.

Self-management of diabetes requires patient adherence to best practice recommendations (e.g. glucose monitoring, dietary management or physical activity) (Or and Tao, 2014), congestive heart failure has a high rate of hospital readmission (Bonow, 2005; Joe and Demiris, 2013) and key aspects of the natural history of the chronic obstructive pulmonary disease are episodes of acute exacerbations, which are considered related to a faster disease progression, presence of comorbidities, and worse functional prognosis (Calvo, 2014). Therefore, the results of the present systematic review are in line with the current strong motivation for using technological solutions as a way to monitor patients with chronic diseases at home and to promote an increasing compliance of self-care.

In terms of types, outcomes, and impacts of technologies supporting home monitoring of patients with chronic diseases (i.e. the second research question of the study reported in the present article), the results show that:

- The technological solutions being used include web-based applications, computer assisted applications, smartphones, automatic patient data transmission by means of monitoring devices, video-conference and standard telephone calls (Tables 1-3).
- In general, the systematic reviews compare home monitoring with usual care and the primary outcomes depend of the type of the patients being considered (e.g. glycaemia control for patients with diabetes, patient's readmissions and mortality for patients with congestive heart failure and patients with chronic obstructive pulmonary disease, or control of the blood pressure of patients with hypertension).
- Secondary outcomes are quite diverse and include health related quality of life, weight, depression, blood pressure, behaviour outcomes, self-management, care knowledge, medication adherence, patient-clinician

communication, or structural outcomes related to care coordination.

- The analysis of the retrieved articles suggest that home monitoring has positive effects with a moderate to large improvements of different outcomes when compared with usual care of patients with diabetes, congestive heart failure, chronic obstructive pulmonary disease and hypertension (although in this case the evidence is not as robust – only 1 article – as it is in the other 3 chronic diseases). However, some studies are not conclusive about this positive impact and only report small beneficial effects.

Despite a high level of technological innovation and implementation, one of the findings is that telephone calls are still an important channel for the communication between patients and care providers.

Furthermore, it seems that important aspects are neglected during the technological developments, since there are reports of usability drawbacks as well as reports of the need for more comprehensive solutions, including provision of real-time feedback and the integration of the electronic health records systems being used by the care providers (El-Gayar et al., 2013).

Therefore, the results show that not only disruptive technological solutions have a key role when dealing with home monitoring, since practical and robust solutions are required, which means that the integration and the interoperability of existing technologies assume a great importance.

In general, the retrieved studies suggest positive effects of home monitoring, but evidence provided for the real benefit of home monitoring in some aspects was not totally convincing. Further research, including large scale RCT trials with consistent primary and secondary outcomes, and robust analysis about long-term sustainability, is required to allow the full incorporation of home monitoring in the clinical practice.

5 CONCLUSION

Considering the large amount of articles that report studies related to home monitoring of patients with chronic diseases, the authors decided to perform a review of reviews and meta-analysis.

Although the authors tried to be as elaborate as possible in methodological terms to guarantee that the review selection and the data extraction were rigorous, it should be acknowledged that this study has limitations, namely the weaknesses inherent to secondary analyses (i.e. review of reviews and meta-analysis), the limitations related to the dependency on the keywords and the databases selected, or the assumption that the retrieved articles have a homogeneous quality, which was not verified.

Despite these possible biases, the authors believe that the systematically collected evidence contributes to the understanding of the use of technologies for ageing in place to support home monitoring of patients with chronic diseases.

In parallel with this study, the authors have used similar methods to analyse the role of technologies for ageing in place to empower patients with chronic diseases. However, due to several limitations, the authors decide not to report the results in this article. Therefore, these results will be the object of a future publication. Also, as a future work, further studies will be implemented, namely to analyse how technologies for ageing in place are being used to support daily activities and promote the participation in social, economic, cultural, civil or spiritual matters of older adults.

ACKNOWLEDGEMENTS

This work was partially supported by COMPETE - Programa Operacional Competitividade e Internacionalização (COMPETE 2020), Sistema de Incentivos à Investigação e Desenvolvimento Tecnológico (SI I&DT), under the project Social Cooperation for Integrated Assisted Living (SOCIAL).

REFERENCES

Arambepola, C., Ricci-Cabello, I., Manikavasagam, P., Roberts, N., French, D.P. and Farmer, A., 2016. The impact of automated brief messages promoting lifestyle changes delivered via mobile devices to people with type 2 diabetes: a systematic literature review and meta-analysis of controlled trials. Journal of medical Internet research, 18(4).

Australian Institute of Health and Welfare, 2006. Chronic Diseases and Associated Risk Factors in Australia, 2006. Australian Institute of Health and Welfare.

Baron, J., McBain, H. and Newman, S., 2012. The impact of mobile monitoring technologies on glycosylated hemoglobin in diabetes: a systematic review. Journal of diabetes science and technology, 6(5), pp.1185-1196.

Bolton, C.E., Waters, C.S., Peirce, S. and Elwyn, G., 2011. Insufficient evidence of benefit: a systematic

review of home telemonitoring for COPD. Journal of evaluation in clinical practice, 17(6), pp.1216-1222.

Bonow, R.O., Bennett, S., Casey, D.E., Ganiats, T.G., Hlatky, M.A., Konstam, M.A., Lambrew, C.T., Normand, S.L.T., Pina, I.L., Radford, M.J. and Smith, A.L., 2005. ACC/AHA clinical performance measures for adults with chronic heart failure: a report of the American College of Cardiology/American Heart Association task force on performance measures (writing committee to develop heart failure clinical performance measures) endorsed by the Heart Failure Society of America. Journal of the American College of Cardiology, 46(6), pp.1144-1178.

Calvo, G.S., Gómez-Suárez, C., Soriano, J.B., Zamora, E., Gónzalez-Gamarra, A., González-Béjar, M., Jordán, A., Tadeo, E., Sebastián, A., Fernández, G. and Ancochea, J., 2014. A home telehealth program for patients with severe COPD: the PROMETE study. Respiratory medicine, 108(3), pp.453-462.

Cassimatis, M. and Kavanagh, D.J., 2012. Effects of type 2 diabetes behavioural telehealth interventions on glycaemic control and adherence: a systematic review. Journal of telemedicine and telecare, 18(8), pp.447-450.

Chandak, A. and Joshi, A., 2015. Self-management of hypertension using technology enabled interventions in primary care settings. Technology and Health Care, 23(2), pp.119-128.

Chaudhry, S.I., Phillips, C.O., Stewart, S.S., Riegel, B., Mattera, J.A., Jerant, A.F. and Krumholz, H.M., 2007. Telemonitoring for patients with chronic heart failure: a systematic review. Journal of cardiac failure, 13(1), pp.56-62.

Ciere, Y., Cartwright, M. and Newman, S.P., 2012. A systematic review of the mediating role of knowledge, self-efficacy and self-care behaviour in telehealth patients with heart failure. Journal of telemedicine and telecare, 18(7), pp.384-391.

Clark, R.A., Inglis, S.C., McAlister, F.A., Cleland, J.G. and Stewart, S., 2007. Telemonitoring or structured telephone support programmes for patients with chronic heart failure: systematic review and meta-analysis. Bmj, 334(7600), p.942.

Connelly, K., Mokhtari, M. and Falk, T.H., 2014. Approaches to Understanding the impact of technologies for aging in place: a mini-review. Gerontology, 60(3), pp.282-288.

Conway, A., Inglis, S.C. and Clark, R.A., 2014. Effective technologies for noninvasive remote monitoring in heart failure. Telemedicine and e-Health, 20(6), pp.531-538.

Cruz, V.T., Pais, J., Bento, V., Mateus, C., Colunas, M., Alves, I., Coutinho, P. and Rocha, N.P., 2013. A rehabilitation tool designed for intensive web-based cognitive training: Description and usability study. Journal of Medical Internet Research, 15 (12), p. e59. Doi: 10.2196/resprot.2899.

Cruz, V.T., Pais, J., Alves, I., Ruano, L., Mateus, C., Barreto, R., Bento, V., Colunas, M., Rocha, N. and Coutinho, P., 2014. Web-based cognitive training: patient adherence and intensity of treatment in an outpatient memory clinic. Journal of medical Internet research, 16(5), p. e122. Doi: 10.2196/jmir.3377.

Dang, S., Dimmick, S. and Kelkar, G., 2009. Evaluating the evidence base for the use of home telehealth remote monitoring in elderly with heart failure. Telemedicine and e-Health, 15(8), pp.783-796.

El-Gayar, O., Timsina, P., Nawar, N. and Eid, W., 2013. A systematic review of IT for diabetes self-management: are we there yet?. International journal of medical informatics, 82(8), pp.637-652.

Eysenbach, G., 2008. Medicine 2.0: social networking, collaboration, participation, apomediation, and openness. Journal of medical Internet research, 10(3), p.e22.

Frazetta, D., Willet, K. and Fairchild, R., 2012. A systematic review of smartphone application use for type 2 diabetic patients. Online Journal of Nursing Informatics (OJNI), 16(3).

Garabedian, L.F., Ross-Degnan, D. and Wharam, J.F., 2015. Mobile phone and smartphone technologies for diabetes care and self-management. Current diabetes reports, 15(12), pp.1-9.

Genet, N., Boerma, W.G., Kringos, D.S., Bouman, A., Francke, A.L., Fagerström, C., Melchiorre, M.G., Greco, C. and Devillé, W., 2011. Home care in Europe: a systematic literature review. BMC health services research, 11(1), p.1.

Grustam, A.S., Severens, J.L., van Nijnatten, J., Koymans, R. and Vrijhoef, H.J., 2014. Cost-effectiveness of telehealth interventions for chronic heart failure patients: a literature review. International journal of technology assessment in health care, 30(01), pp.59-68.

Househ, M., 2014. The role of short messaging service in supporting the delivery of healthcare: An umbrella systematic review. Health informatics journal, p.1460458214540908.

Huang, Z., Tao, H., Meng, Q. and Jing, L., 2015. MANAGEMENT OF ENDOCRINE DISEASE: Effects of telecare intervention on glycemic control in type 2 diabetes: a systematic review and meta-analysis of randomized controlled trials. European Journal of Endocrinology, 172(3), pp.R93-R101.

Hunt, C.W., 2015. Technology and diabetes self-management: An integrative review. World journal of diabetes, 6(2), pp.225-233.

Jaana, M. and Paré, G., 2007. Home telemonitoring of patients with diabetes: a systematic assessment of observed effects. Journal of evaluation in clinical practice, 13(2), pp.242-253.

Jackson, C.L., Bolen, S., Brancati, F.L., Batts?Turner, M.L. and Gary, T.L., 2006. A systematic review of interactive computer?assisted technology in diabetes care. Journal of general internal medicine, 21(2), pp.105-

Joe, J. and Demiris, G., 2013. Older adults and mobile phones for health: A review. Journal of biomedical informatics, 46(5), pp.947-954.

Kickbusch, I. and Nutbeam, D., 1998. Health promotion glossary. Geneva: World Health Organization.

Kitsiou, S., Paré, G. and Jaana, M., 2015. Effects of home telemonitoring interventions on patients with chronic heart failure: an overview of systematic reviews. Journal of medical Internet research, 17(3), p.e63.

Koch, S., 2013. Achieving holistic health for the individual through person-centered collaborative care supported by informatics. Healthcare informatics research, 19(1), pp.3-8.

Kvedar, J., Coye, M.J. and Everett, W., 2014. Connected health: a review of technologies and strategies to improve patient care with telemedicine and telehealth. Health Affairs, 33(2), pp.194-199.

Lundell, S., Holmner, Å., Rehn, B., Nyberg, A. and Wadell, K., 2015. Telehealthcare in COPD: a systematic review and meta-analysis on physical outcomes and dyspnea. Respiratory medicine, 109(1), pp.11-26.

Martínez, A., Everss, E., Rojo-Álvarez, J.L., Figal, D.P. and García-Alberola, A., 2006. A systematic review of the literature on home monitoring for patients with heart failure. Journal of telemedicine and telecare, 12(5), pp.234-241.

McBain, H., Shipley, M. and Newman, S., 2015. The impact of self-monitoring in chronic illness on healthcare utilisation: a systematic review of reviews. BMC health services research, 15(1), p.1.

Moher, D., Liberati, A., Tetzlaff, J. and Altman, D.G., 2009. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Annals of internal medicine, 151(4), pp.264-269.

Mori, A.R., Mazzeo, M., Mercurio, G. and Verbicaro, R., 2013. Holistic health: predicting our data future (from inter-operability among systems to co-operability among people). International journal of medical informatics, 82(4), pp.e14-e28.

Nakamura, N., Koga, T. and Iseki, H., 2014. A meta-analysis of remote patient monitoring for chronic heart failure patients. Journal of telemedicine and telecare, 20(1), pp.11-17.

Or, C.K. and Tao, D., 2014. Does the use of consumer health information technology improve outcomes in the patient self-management of diabetes? A meta-analysis and narrative review of randomized controlled trials. International journal of medical informatics, 83(5), pp.320-329.

Ortiz, P.M.V., Felix, P.M. and Sosa, E.S.G., 2015. Text messaging interventions to glycemic control in type 2 diabetes adults: systematic review/Mensajes de texto para el control glucémico en adultos con diabetes tipo 2: revisión sistemática. Enfermería Global, 14(1), p.445.

Pal, K., Eastwood, S.V., Michie, S., Farmer, A.J., Barnard, M.L., Peacock, R., Wood, B., Inniss, J.D. and Murray, E., 2013. Computer□based diabetes self□management interventions for adults with type 2 diabetes mellitus. The Cochrane Library.

Pastalan, L.A., 1990. Aging in place: The role of housing and social supports (Vol. 6, No. 1-2). Psychology Press.

Pedone, C. and Lelli, D., 2015. Systematic review of telemonitoring in COPD: an update. Pneumonol Alergol Pol, 83, pp.476-8484.

Peterson, A. (2014). Improving Type 1 Diabetes Management With Mobile Tools A Systematic Review. Journal of diabetes science and technology, 8(4), 859-864.

Polisena, J., Tran, K., Cimon, K., Hutton, B., McGill, S., Palmer, K. and Scott, R.E., 2010. Home telemonitoring for congestive heart failure: a systematic review and meta-analysis. Journal of Telemedicine and Telecare, 16(2), pp.68-76.

Polisena, J., Tran, K., Cimon, K., Hutton, B., McGill, S., Palmer, K. and Scott, R.E., 2010. Home telehealth for chronic obstructive pulmonary disease: a systematic review and meta-analysis. Journal of telemedicine and telecare, 16(3), pp.120-127.

Queirós, A., Carvalho, S., Pavão, J. and da Rocha, N.P., 2013. AAL Information based Services and Care Integration. In HEALTHINF 2013 - Proceedings of the International Conference on Health Informatics, pp. 403-406.

Queirós, A., Silva, A., Alvarelhão, J., Rocha, N.P. and Teixeira, A., 2015. Usability, accessibility and ambient-assisted living: a systematic literature review. Universal Access in the Information Society, 14(1), pp.57-66. Doi: 10.1007/s10209-013-0328-x.

Ramadas, A., Quek, K.F., Chan, C.K.Y. and Oldenburg, B., 2011. Web-based interventions for the management of type 2 diabetes mellitus: a systematic review of recent evidence. International Journal of Medical Informatics, 80(6), pp.389-405.

Riazi, H., Larijani, B., Langarizadeh, M. and Shahmoradi, L., 2015. Managing diabetes mellitus using information technology: a systematic review. Journal of Diabetes & Metabolic Disorders, 14(1), p.1.

Slev, V.N., Mistiaen, P., Pasman, H.R.W., Verdonck-de Leeuw, I.M., van Uden-Kraan, C.F. and Francke, A.L., 2016. Effects of eHealth for patients and informal caregivers confronted with cancer: A meta-review. International journal of medical informatics, 87, pp.54-67.

Tao, D. and Or, C.K., 2013. Effects of self-management health information technology on glycaemic control for patients with diabetes: a meta-analysis of randomized controlled trials. Journal of telemedicine and telecare, 19(3), pp.133-143.

Teixeira, A., Pereira, C., e Silva, M.O., Alvarelhão, J., Silva, A.G., Cerqueira, M., Martins, A.I., Pacheco, O., Almeida, N., Oliveira, C. and Costa, R., 2013. New telerehabilitation services for the elderly. I. Miranda, M. Cruz-Cunha, Handbook of Research on ICTs and Management Systems for Improving Efficiency in Healthcare and Social Care, IGI Global, pp.109-132. Doi: 10.4018/978-1-4666-3990-4.ch006.

Thrall, J.H., 2005. Prevalence and Costs of Chronic Disease in a Health Care System Structured for

Treatment of Acute Illness 1. Radiology, 235(1), pp.9-12.

Tildesley, H.D., Po, M.D. and Ross, S.A., 2015. Internet Blood Glucose Monitoring Systems Provide Lasting Glycemic Benefit in Type 1 and 2 Diabetes: A Systematic Review. Medical Clinics of North America, 99(1), pp.17-33.

van Vugt, M., de Wit, M., Cleijne, W.H. and Snoek, F.J., 2013. Use of behavioral change techniques in web-based self-management programs for type 2 diabetes patients: systematic review. Journal of medical Internet research, 15(12), p.e279.

Verhoeven, F., van Gemert-Pijnen, L., Dijkstra, K., Nijland, N., Seydel, E. and Steehouder, M., 2007. The contribution of teleconsultation and videoconferencing to diabetes care: a systematic literature review. J Med Internet Res, 9(5), p.e37.

World Health Organization, 2002. Active ageing: a policy framework: a contribution of the World Health Organization to the Second United Nations World Assembly on Ageing. Madrid (ES): World Health Organization.