Devices Used for Non-Invasive Tele Homecare for Cardiovascular Patients

A Systematic Literature Review

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Abstract: The aim of this Systematic Review (SLR) was to provide an overview of devices used for non-invasive tele health care by patients diagnosed with heart failure (HF). All English studies published in the past 10 years that focused on tele home care for coronary heart diseases, cardiac arrhythmia or heart failure patients were systematically searched in Scopus and Pubmed. Articles were selected if added value of tele-monitoring for these patients was studied. Selected titles and abstracts were screened to determine eligibility for further review. Types and number of devices per disease were then withdrawn and categorized for the three diseases. Eight devices were found in the literature to be used in non-invasive tele homecare for patients diagnosed with heart failure, of which weight scales and blood pressure monitors were most commonly used and are the most frequently occurring combination. The knowledge on which tele homecare devices are most commonly used gives insights into which devices are the best choice needed for patients with heart failure, where product suppliers and healthcare providers can respond to. The results create future directions for studying different aspects of tele homecare devices, such as usability aspects, which is an important factor for acceptance of telemedicine.

1 INTRODUCTION

Due to the aging and growth of the population, the prevalence of most diseases especially chronic diseases has been increased in the past decade, and this increase is expected to continue (RIVM, 2014). In 2011, there were more than 5.2 million people with a chronic disease in the Netherlands, which accounts for 32% of the population (RIVM, 2014). One of the main chronic diseases is cardiovascular disease (CVD). Worldwide, cardiovascular diseases have the highest prevalence of all chronic diseases (WHO, 2010), and are the main cause of death (Bashi, 2017). Within cardiovascular diseases the highest burden is caused by coronary heart disease, stroke, and heart failure (RIVM, 2014). The prevalence of CVD in the Netherlands is expected to increase to 1,426,000 in 2040 due to aging and growth of the population (Bots, 2015).

To keep healthcare affordable despite these demographic changes, self-management and self-care are suggested to be utilized (Lorig, 2001). The application of technology in the home setting can have positive effects on the self-care and self-management of patients, and may result in saving costs, better care access and improving outcomes (Peeters, 2016). An example of the application of technology in the home setting is tele homecare, which is a technology that aids in self-care and self-management. It is often used by people with a chronic disease, like diabetes or CVD (Schers, 2012). Tele homecare, which is a form of telemedicine, is increasingly used in healthcare. Few studies creating awareness of the importance of success factors of telemonitoring have been published in the last few years (Inglis, 2011). There is no overview of current demand of the market, which is an important aspect for both care providers and product suppliers in this rapidly growing sector. No Systematic Literature Review (SLR) has been performed yet that researches the devices that are used for tele homecare of coronary heart disease, cardiac arrhythmia, or heart failure. The objective of this SLR is therefore to provide an overview of these devices.

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2 METHODS

The systematic search was performed in March 2017, using the PubMed and Scopus databases for English-language, full-text articles with focus on devices that were used for healthcare professionals and patients with coronary heart diseases, cardiac arrhythmias, or heart failure.

2.1 Search Strategy

The following search query was used in the final search to search as broad as possible:

((telemonitor* OR telehealth OR telemedicine OR telehomecare* OR tele-mon*) AND (heart failure* OR coronary* OR arrhythmia*) NOT (implement* OR machine learning OR robot* OR meta-analys* OR review OR ICD OR pacemaker* OR child* OR infant*)).

After applying the search strategy and identifying possible hits, duplicate articles were removed. Next, the articles were reviewed based on title and abstract and irrelevant articles were excluded. Finally, the full-text articles were assessed to determine the appropriateness for inclusion.

2.2 Inclusion and Exclusion Criteria

For this study we included papers which focus on non-invasive tele homecare for cardiovascular diseases. Since the literature on tele homecare (and it's added value) began to expand during the past 10 years, only articles that were published in the last 10 years (i.e., from January 2007 to March 2017) were included. All observational and experimental studies, as well as randomized clinical trials and quasi experimental studies were included. We selected English language articles that investigate ambulant adult patients who are diagnosed with one of the cardiovascular diseases with the highest prevalence in the Netherlands (i.e. coronary heart disease, cardiac arrhythmia and heart failure (Public Health & Care, 2017)), and who are able to independently use tele homecare devices. Articles that address the added value for patients or healthcare professionals for one of these diseases were included. Grey literature, opinion papers, and letters were excluded to ensure the quality of the included studies. Additionally, SLRs and meta-analyses were excluded as well, but their reference lists were checked for any additional articles to be included in our study. Articles investigating the usage of tele homecare outside of the home setting or using invasive devices/interventions were excluded.

2.3 Analysis

The following data were extracted from the final included articles: (1) study design; (2) country; (3) study duration; (4) participant characteristics; and type of cardiovascular disease; (5) study objective; (6) description intervention group; and the control group (7) tele homecare devices used; (8) added value; (9) usability aspects.

In the next phase, demographic data of the included studies were described. The added value of tele homecare was reported generally. The number of devices and their types were categorized per disease to give an overview of what types of devices were used. We also investigated the prevalence of common combinations of devices.

3 RESULTS

3.1 Search Outcome

After the initial search, a total of 1,463 studies were identified for this review, of which 1,461 were found by the initial search of the databases and 2 were additionally identified through other sources. After the removal of duplicates, the titles and abstracts of remaining articles were screened. In this screening stage, 1195 studies were excluded, resulting in 156 studies for the full-text assessment for eligibility. In the full-text assessment, 112 studies were eliminated because they did not meet the inclusion criteria. As such, 44 studies remained in the final set for data extraction, which are included in this systematic literature review.

3.2 Study Characteristics

As shown in Table 1, a total of 44 studies remained in the final set to be examined for the devices for coronary heart disease, cardiac arrhythmia, and heart failure. Most of these studies were conducted in Europe (48%) and the United States (48%).

Of the included studies, only eight studies paid attention to the feasibility or usability of the devices. However, no in-depth results were provided.

No studies were found in this SLR that focused on cardiac arrhythmia. The given percentage of coronary heart disease and heart failure is based on the total number of included studies for that specific

disease (coronary heart disease: n=5. heart failure: n=39).

For coronary heart disease, significant positive results were found for 10 aspects of the added value (91% of the total measured values were positive) and 1 aspect gave significantly negative results (9% of the total measured values was negative).

For heart failure, 26 aspects were significantly positively proven (90% of the total measured values was positive)) and 24 were significantly negatively proven (10% of the total measured values was negative).

Table 1: Demographic data related to the included studies.

	Coronary Heart Disease (CHD)	Heart Failure	Total
Total number of studies	5 (100%)	39 (100%)	44 (100%)
Location			
Europe	4 (80%)	17 (44%)	21 (48%)
North-America	1 (20%)	21 (54%)	22 (50%)
Asia	0 (0%)	1 (3%)	1 (2%)
Publication period			
2007-2012	2 (40%)	25 (64%)	27 (61%)
2013-2017	3 (60%)	14 (36%)	17 (39%)
Sample size			
> 100 patients	3 (60%)	23 (59%)	26 (59%)
> 100 healthcare professionals	1 (20%)	0 (0%)	1 (2%)
Gender			
Male	5 (100%)	19 (49%)	24 (55%)
Female	0 (0%)	15 (39%)	15 (34%)

3.3 Tele Homecare Devices

A total of eight different devices were used in the included studies. The number of included devices, and the types of these devices can be found in Table 2. Most of the included studies (74%) studied 1 to 3 devices in their study. Weight scale and blood pressure devices (BPDs) were by far the most commonly used devices in the included studies, followed by heart rate and ECG devices. Pedometers and motion sensors were only used once. The given percentage of coronary heart disease and heart failure is based on the total number of included studies orf that specific disease (coronary heart disease n=5, heart failure n=39).

The most commonly occurring combination of used devices is blood pressure devices (BPDs) with weight scales (57% of the studies included this combination). The combination of BPDs and heart rate devices occurred in 39% of the papers. This is a noticeable result, since the heart rate monitor is only used in combination with BPDs. The combination of weight scales and heart rate devices occurs in 36% of the articles, indicating that the combination of heart rate monitors and weight scales occurs in all articles but one. Lastly, the combination of pulse oximeters and BPDs occurs often, in 23% of the articles. Pulse oximeters are used in 10 of the articles, and in all these, it occurred in combination with the BPD.

When looking at a combination of three devices, the BPD, weight scale, and heart rate monitor is noticeable. This combination occurs in 36% of the articles. In a combination of 4 devices, BPDs, weight scales, heart rate devices, and ECG devices occurs most commonly: in 9% of the articles. A combination of 5 devices occurs in 5% of the articles, with the combination of BPD, weight scale, heart rate monitor, ECG device, and a device measuring the urine output data being the most common.

3.3.1 Disease Specific Analysis

When specifically focusing on CHD, it can be seen that none of the included articles used more than three devices. The combination of two devices is found with the BPD and pedometer, and with the BPD and ECG device (20% of the articles). When looking into a combination of three devices the BPD, ECG device, and pulse oximeter is most often used (20% of the articles).

When looking into heart failure, the most commonly used combination of devices is BPDs with weight scales (64%), followed by BPDs and heart rate devices (44%) and BPDs and pulse oximeters (26%). When looking into the combination of three devices, BPDs, weight scales, and heart rate monitors are often used together (41%). The combination of four devices can be found with BPDs, weight scales, heart rate monitors, and ECG devices (10%) and BPDs, weight scales, heart rate monitors, and pulse oximeters (8%). Additional information is available on request.

We found an increase in the average number of devices that are used for tele monitoring over the past few years (Figure 1).

Table 2: Types and Number of Tele Homecare Devices.

	Coronary Heart Disease	Heart Failure	Total
# of included devices			
1 – 3 devices	5 (100%)	29 (74%)	34 (77%)
4 – 5 devices	0 (0%)	10 (26%)	10 (23%)
Device used in # of studies			
Blood Pressure Monitor	2 (40%)	29 (74%)	31 (70%)
ECG Device	3 (60%)	10 (26%)	13 (30%)
Heart Rate	0 (0%)	17 (44%)	17 (39%)
Monitor Sensor	1 (20%)	0 (0%)	1 (2%)
Pedometer	1 (20%)	0 (0%)	1 (2%)
Pulse Oximeter	1 (20%)	9 (23%)	10 (23%)
Urine Output Data	0 (0%)	2 (5%)	2 (5%)
Weight Scale	0 (0%)	34 (87%)	34 (77%)

4 DISCUSSION

4.1 Main Findings

In this systematic review we synthesized recent evidence on the used devices for tele homecare for patients diagnosed with heart failure (HF). Eight devices were found in the literature to be used in tele homecare for patients diagnosed with the coronary heart diseases, cardiac arrhythmia, or heart failure. Our results showed that most studies used one to three devices in a study on tele homecare for heart failure patients. In these articles, the weight scale and blood pressure monitor are by far the most commonly used tele homecare device, and also the most commonly occurring used in combination with each other. The second most occurring combination is BPDs and heart rate monitors, of which it is noticeable that the heart rate monitor only occurs in combination with a BPD. Additionally, the combination of BPDs, weight scales and heart rate monitors occurred most often, when looking at the combination of three devices. Of the included studies, only eight studies paid attention to the feasibility or usability of the devices, mentioning that not much is known yet about this. However, they stress the importance of this aspect in the usage of tele homecare.

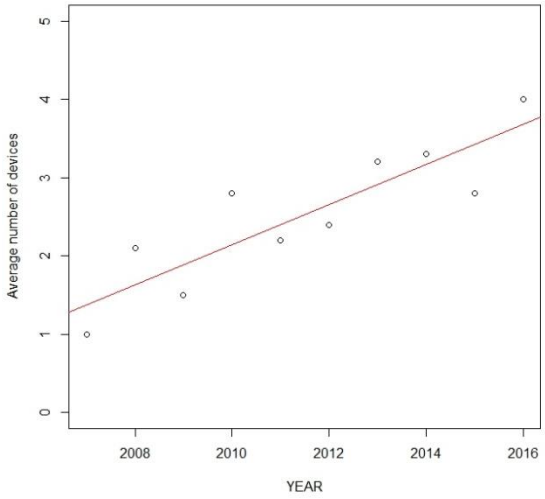

Figure 1: Average number of devices per year.

4.2 Implications

It is expected that this SLR will mainly have implications for product suppliers, and healthcare providers. It is expected that this SLR will give product suppliers insight into the current demand of the market regarding tele homecare devices for patients with heart failure. This, in turn, enables the product suppliers to better respond to the market demand. Additionally, these results can be the foundation for future research in which the reasons why these devices are used could be investigated. This will contribute to the overall knowledge on the use of these devices.

Our results showed that only eight studies created awareness of the importance of feasibility or usability of the devices. It is important to study usability, as it is one of the main success criteria of implementing and utilizing tele monitoring. This success depends on the features and design, which are incorporated in the device (Seto, 2012). Usability is however a fairly unknown topic in telecardiology and future studies are needed to study this topic more extensively. In addition, a set of comprehensive usability guidelines for these devices is needed to test the usability aspects of the devices in a standardized manner. Future studies are needed to generate these guidelines.

Our results also showed that there is an increase in the number of devices that are used for telemonitoring in the past fews years. This finding also supports the fact that usability of the devices

needs to be studied and improved in order to guarantee the success of the complex telemonitoring programs that utilize various devices.

The added value of the telemonitoring is studied for some of the CVDs. More studies are needed to generate more insight regarding the effect of the interventions.

Besides implications for product suppliers, also healthcare providers might benefit from the results of this SLR. They can use this knowledge on which devices are used worldwide. This could help healthcare providers in deciding which devices they should invest in.

4.3 Strength and Limitations and Future Directions

To the best of our knowledge, this is the first SLR systematically assessing tele homecare devices used for patients diagnosed with heart failure. We only included studies after 2007 to provide information on the more recently used technology. Although the search was accurate and thorough, it is still plausible that we missed articles.

This study also has some limitations. This research only investigated devices in the studies in which the added value of tele homecare devices was investigated. The inclusion of only these studies may cause missing devices in our overview. We did not investigate the added value of these devices thoroughly; therefore future studies are needed to study this aspect in depth. Lastly, future research is recommended to provide more information on why certain devices are more used than others, in order to provide more information for product suppliers, and healthcare providers. Gender related choices and analysis should be performed to give more insight in preferences and functionalities of devices. Usability aspects of these devices is needed to be studied as well, since usability is one of the success factors of accepting and using the devices and therefore telemedicine.

5 CONCLUSIONS

Having the knowledge on which tele homecare devices are most commonly used gives insights into which devices are mostly needed for patients with heart failure, to which product suppliers and healthcare providers can respond. The results create future directions for studying different aspects, such as usability of these devices as this is an important factor for the acceptance of telemedicine.

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