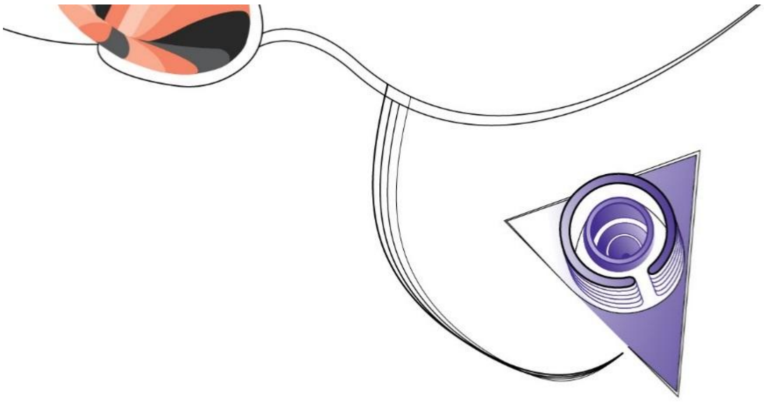

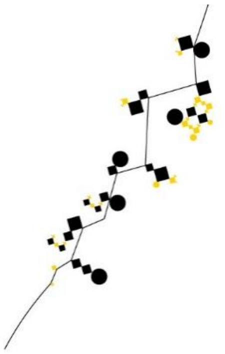

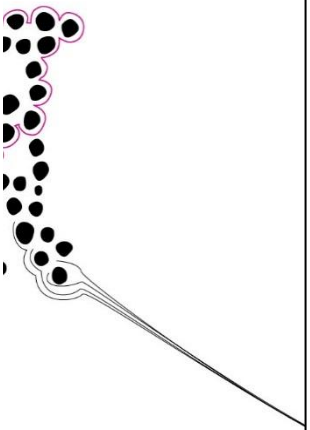

Bachelor Thesis

Subject: E-health platforms for COPD patients and their effectiveness on the health of the patient

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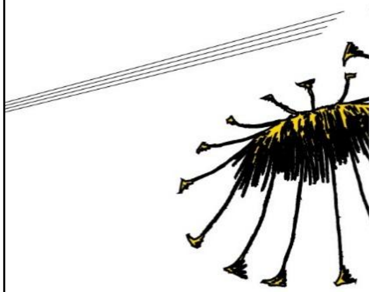

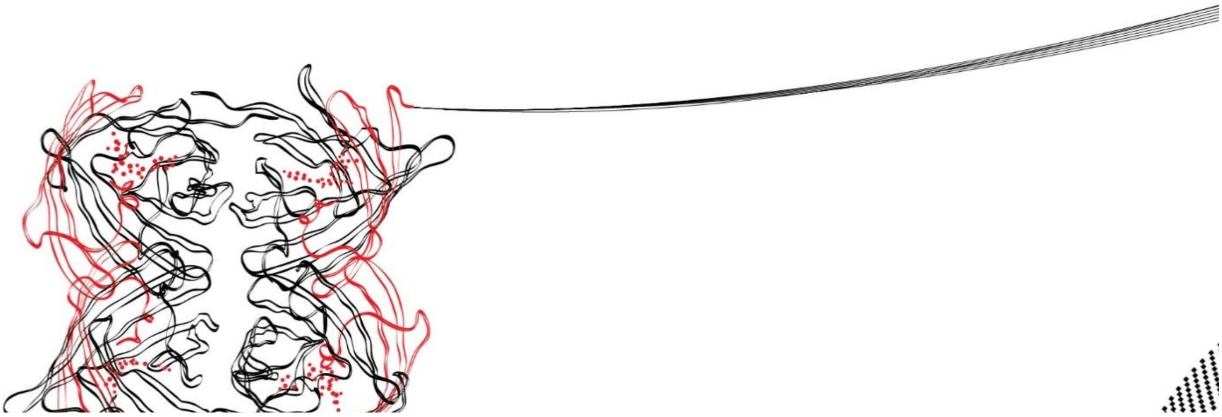

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Abstract

Objective: This systematic review of ten studies is conducted to evaluate which kinds of e-health platforms for COPD patients exist and of what kinds of elements they compose. In addition to that it is analyzed which effects these different elements have on the patient and by that, which elements should be optimally included on e-health platforms for COPD patients to be effective. At least, the actual development of e-health platforms for COPD patients is analyzed.

Background: Chronic Obstructive Pulmonary Disease (COPD) is a rising cause of mortality. E-health platforms are potential self-management opportunities to improve patients' health. An overview about the kinds of e-health platforms and their elements does not yet exist, nor the evaluation of the effectiveness of those elements.

Method: A comprehensive search strategy was designed and implemented across the databases Scopus and PubMed. The search resulted in a final sample of ten studies. Included studies had to include COPD patients as main users, the e-health platform had to be web based and patients needed to have access to their data. Selected articles had to give answer on the question, how e-health platforms are designed and how effective the different elements provided seem to be in regard to the health and satisfaction of its users.

Results: There are different kinds of e-health platforms, using devices as websites, mobile phone applications and measuring instruments for health data. The provided elements of these e-health platforms are (1) information, (2) recording of personal health data, (3) education and (4) contact to professionals. Electronic health diaries and having access to the own medical results were most beneficial and most often used. Interventions regarding smoking cessation and physical activity show a positive effect on patients' health. The majority of studies can be located in the Operationalization phase and is by that not evaluated yet.

Conclusion: E-health platforms for COPD patients show a positive effect on the health and satisfaction of patients and can increase the quality of life. Because findings indicated a significant gap in the literature for e-health interventions directing health outcomes as the outcome of interest, it is recommended to focus this in the future.

Abstract

Doel: Dit systematische review van tien studies is uitgevoerd om te evalueren welke typen e-health platforms voor COPD-patiënten bestaan en van welke soorten elementen ze zijn samengevoegd. In aanvulling op dat wordt nagegaan, welke effecten de verschillende elementen op de patiënt hebben, en daarmee welke elementen in ieder geval zouden worden opgenomen, voor e-health platforms voor COPD patiënten om effectieve te zijn. Tenslotte, is de actuele ontwikkeling van de e-health platforms voor COPD-patiënten geanalyseerd.

Achtergrond: Chronic Obstructive Pulmonary Disease (COPD) is een rijzende oorzaak van sterfte. E-health platforms zijn potentiële self-management mogelijkheden om de gezondheid van de patiënten te verbeteren. Een overzicht over de soorten e-health platforms en hun elementen bestaat nog niet, noch de evaluatie van de effectiviteit van deze elementen.

Methode: Een uitgebreide zoekstrategie werd ontworpen en geïmplementeerd in de databases Scopus en PubMed. De zoektocht resulteerde in een uiteindelijke steekproef van tien studies. Inbegrepen studies moesten COPD-patiënten als belangrijkste gebruikers omvatten, de e-health platform moest webgebaseerd zijn en patiënten die moesten toegang tot hun gegevens hebben. Geselecteerde artikelen moesten antwoord geven op de vraag, hoe e-health platforms zijn ontworpen en hoe effectief de verschillende elementen lijken te zijn met betrekking tot de gezondheid en de tevredenheid van de gebruikers.

Resultaten: Er zijn verschillende soorten van e-health platformen, die gebruik maken van apparaten zoals websites, mobiele telefoon applicaties en meetinstrumenten voor gezondheidsgegevens. De elementen van deze e-health platforms zijn (1) informatie, (2) registratie van gezondheidsgegevens, (3) onderwijs en (4) contact met professionals. Elektronische medische dagboeken en toegang hebben tot de eigen medische resultaten waren het meest voordelig en het meest gebruikt. Interventies over stoppen met roken en lichamelijke activiteit hebben zich positief op de gezondheid van de patiënten uitgewerkt. De meeste studies kunnen worden gesitueerd in de Operationalisatie fase en zijn derhalve nog niet geëvalueerd.

Conclusie: E-health platforms voor COPD-patiënten vertonen een positieve effect op de gezondheid en de tevredenheid van de de patiënten en kunnen de kwaliteit van leven verbeteren. De bevindingen vermelden een aanzienlijke kloof in de literatuurm want e-health interventies hun focus niet op de evaluatie van gezondheidsresultaten richten. Derhalve is het raadzaam de focus in de toekomst ook op de evaluatie van de interventies te richten.

1. COPD

Chronic obstructive pulmonary disease, with the shortened form COPD, is a disease which causes a growing number of morbidity and mortality worldwide. In 2012, more than 3 million people died of COPD, which is equal to 6% of all death globally that year.

COPD is a term of wide comprehension for different chronic lung diseases that cause restrictions in the peak airflow of the lung (WHO, 2015). In the case of COPD it comes to an obstruction, a narrowing of the air passages. COPD is characterized by persistent reduced maximum expiratory flow and slow forced emptying of the lungs. The underlying changes of the lung persist for a lifetime, are usually progressing and not fully recoverable with medication. The most frequent symptoms of the respiratory passages are cough, the production of sputum and a difficulty to take breath, called dyspnoea. Furthermore, sounds during exhalation and chest tightness are noticed (GOLD, 2014). With progression of the disease to more severe stages, the malfunction of the respiratory can lead to cardiac failure. Multiple morbidities related to COPD are cardiovascular disease, osteoporosis, diabetes, lung cancer and depression (Rodriguez Roisin et al., 2009). Another disease associated with COPD is pulmonary cachexia, characterized by involuntary and progressive loss of skeletal muscle mass with variable loss of fat mass (Evans et al., 2008). The worldwide prevalence of COPD is 7.6% and significantly more males are affected. The incidence of COPD is 2.9% per year (Afonso et al., 2011).

1. 1 Risk Factors for COPD

There are several risk factors for the triggering of COPD known. Research shows that the interaction between genetic factors and the exposure to different environmental factors causes a higher risk to get affected. The most essential risk factor contributing to COPD is tobacco smoke. In high-income countries, 73% and in low-income countries, 40% of mortality caused by COPD is ascribed to smoking (Lopez et al., 2006).

A genetic factor contributing to the development of COPD is a deficiency of the serine protease α1 antitrypsin. If the concentration of this enzyme is low, there is an increased risk for getting affected by COPD. This factor gets even more strengthened if the person is smoker or often exposed to smoke (Stoller & Aboussouan, 2005). Environmental factors found to contribute to COPD is the exposure to various dusts, chemicals, vapours, and fumes, for example in workplace. This is especially found in low- and middle-income countries is greater, because of less-stringent laws (Hnizdo et al., 2002). A significantly smaller risk is constituted by the atmospheric contamination such as ozone and fine dust (Lopez et al., 2006). Infections play a major role in as well the development as the progression of the disease. Repeated respiratory tract infection, especially in childhood is found to cause a predisposition to bronchiectesis, a widening of the bronchia, which is accompanied by a chronical bacterial infection of the lungs (Wedzicha, 2007).

1. 2 Consequences of COPD

The consequences of COPD for patients suffering from the disease are far reaching, from an altered daily living to an overall impaired quality of life. COPD patients can for example experience anxiety and depression, fear of dying or exacerbations, alteration of relationships or loss of control and independence. Impaired physical and social dimensions of daily living can therefore result social isolation and an inability to participate in many activities of daily living (Guthrie et al., 2001). In addition to that, the economic burden caused by COPD must not to be underestimated and are expected to increase in the future. In the USA, the total economic costs of COPD were almost US$50 billion, in 2010. In the Netherlands, the annually economic burden of COPD was estimated to be 350€ million per year. This is 0.05% of the whole gross national product. The annual cost calculated per patient are 1144€ per patient. These costs are composed of indirect costs, such as unemployability and direct costs, such as hospitalizations and medications. Hospital stays make up the largest part of costs. Furthermore, with an increase of the severity of the disease, the costs per person increase and with an increase in the prevalence rate, the total annual costs increase. In addition to that, COPD is found to have an increased incidence. Therefore a constant or decreasing number of caregivers has to provide care for an increasing number of COPD patients (Hoogendoorn, 2011). Because of the increasing number of new cases and with that the increase of economic costs, it is important to provide care directly at the beginning of the disease. By that, rising costs, which develop during the course of the disease, can be restrained.

Another field which is affected by COPD is the quality of life. Especially the final stages of COPD have a huge influence on the quality of life of all persons concerned (Zamzam et al., 2012). Several studies show a significant impairment in quality of life on all dimensions, compared to healthy persons. The major emotional disturbance was found to be depression. Primary interferences on social level are difficulties with home management and the decline in social interactions. Other factors found to be impacted by the disease are mobility, sleep, anxiety of further exacerbations, vitality and pain (McSeeny et al., 1982; Mahler & Mackowiak, 1995).

1.3 Diagnosis of COPD

For a complete diagnosis, the degree of severity of COPD has to be established. Therefore the lung function, the respiratory volume, named spirometry, the symptomatology and risk factors have to be determined and can be categorized in four stages.

According to the GOLD stage model, in stage one, there is a mild limitation in air flow and sometimes but not always, sputum and chronic cough occurs. At this stage, patients often do not even notice an impairment of their lungs. At stage two, there is a decline in the volume of air flow and a reduction of breathing spell during exertion. Most patients seek medical help at this stage, because the symptoms they realize are classified as an exacerbation of COPD. The third stage, which is called severe stage is marked by further worsening of the limitation in air flow and further reduction of breathing spell. In addition to that, there is a limitation in the ability to exert and there is a reduction in quality of life, because of repeated exacerbations. At stage four, patients undergo a severe limitation in air flow, accompanied by a deeply impaired quality of life. Furthermore exacerbations in this stage can be dangerous to life (GOLD, 2015).

It is important to know the severity of COPD based on stages. With this, patients can understand their disease better and physicians can give better treatment to people suffering from COPD. This leads to more satisfaction and a higher quality of life of patients which is targeted in this research (GOLD, 2015).

1.4 Treatment of COPD

If the diagnose is made, treatment is essential for different reasons. At first, treatment is necessary to stop the progression of the disease. Second, it is needed to improve the physical capacity of the affected persons. Furthermore treatment of COPD patients aims to alleviate afflictions and to improve the general health of the patient. Another reason why treatment is required is that exacerbations, complications and comorbidities have to be prevented and treated. Another important reason for using treatment is to obtain the highest possible quality of life (Zamzam et al., 2012).

Smoking cessation interventions are the most effective factor in COPD management, where the primary goal of chronic COPD management is stabilization of chronic disease and prevention of acute exacerbations. Smoking cessation is most important, because this is the only risk factor which can directly be influenced. There are two different forms of treatment. First, there is medical treatment where primarily bronchodilators, which extend the bronchias are used. From Stage III there is an additional medication by inhalation of corticosteroids, which serves to reduce the incidence of acute exacerbations (GOLD, 2013).

Second, there are drug-free therapies which are used inpatient, thus in hospital, outpatient, which does not need the patient to stay in hospital, or in rehabilitation programs. Those therapies are for example or physiotherapeutic respiratory therapy such as pursed lip, linkage of breath and movement, respiratory facilitating positions or breathing techniques. Furthermore, there are physical measures as endurance training, power training or respiratory muscle training, which shows to enhance the fitness of COPD patients and a reduced risk for hospital admission and a lower risk for mortality (Garcia-Aymerich, 2006). In addition to that there is occupational therapy, behavioral training, educational programs for the management of COPD or relaxation training (Weiner, Azgad & Ganam, 1992). A new form of treatment for COPD patients is self-management. By that, the patients become able to manage their symptoms or treat themselves in the daily living (Gallefoss & Bakke, 2002).

1.5 Self-Management

A method used to obtain and improve the quality of life of the patients and to reduce the economic costs of the disease, is self-management. It is defined as, the individual's ability to manage symptoms, treatment, physical and psychological consequences and life style changes, inherent in living with a chronic condition. Efficacious self-management encompasses ability to monitor one's condition and to effect the cognitive, behavioral and emotional responses necessary to maintain a satisfactory quality of life (Barlow, 2001). This term indicates the expertise to shape the own personal development widely independent from outside influences. Therefore skills as motivation, ambition, planning, organizational skills, learning ability, success checking and feedback are necessary (Lorig et al., 2001).

Ranging in duration, self-management first of all includes the participation in disease related education programs. Besides, it aims to prepare patients to manage the daily challenges of the disease. Another factor is teaching behaviors needed in special situations and learning skills and abilities needed to control the disease (McGowan, 2005). Self-management is very important for COPD patients, because, even with medication treatment they experience symptoms and can therefore have difficulties to manage their disease (Zwerink et al., 2014). Even if patients get medication, every exertion causes limitations. Emerging from that, patients avoid tiring situations or activities, which in turn impacts their quality of life. Therefore, self-management can provide psychological support, to cope with anxiety and difficult situations, COPD patients experience. Self-management is a possibility to support patients by teaching the mentioned skills to maintain and improve the quality of life of COPD patients, which is shown to be impacted by this disease (McSeeny et al., 1982). Self-management is found to be effective in the treatment and supporting of patients suffering from COPD. The aim of self-management in COPD is to enable patients to manage the disease by themselves. Self-management programs provide information and teach skills to improve the patient's self-care and the interaction between provider and patient. Thereby, the most important factor is smoking cessation. To provide help for smoking cessation in self management programs for COPD patients is especially important, because smoking is the most common risk and the sustaining factor for COPD. To control the disease, knowledge about the effect and dosage of medication is needed. That means, patients have to know for sure, which medication is needed for example during an acute exacerbation, and how often they have to use how much of the medicament. In addition to that, it is necessary to know after what time they experience the effect of the medicament, so that an overdose, fearing the desired effect does not occur, can be avoided. Furthermore, the knowledge and application of correct behavior in critical situations is important to handle the disease. So, that patients get a feeling of self-efficacy which in turn improves the quality of life (Gallefoss & Bakke, 2002).

In addition to that, COPD patients benefit from self-management during acute exacerbations. Furthermore, patients who used self-management, are found to have an increased daily physical activity level and a reduced healthcare utilization, which is accompanied by cost savings (Zwerink et al., 2014).

Effective self-management skills that can be used by patients are gathering information, managing medication, managing symptoms, managing psychological consequences, adjusting lifestyle, using social support and communicating effectively (Kaptein, Fischer & Scharloo, 2014). In practice, self-management skills for COPD patients could include stopping with smoking and living in a smoke free environment, comply with medication, managing breathing, conserving energy, managing stress and anxiety, prevent and manage symptoms and nevertheless, managing an active life style.

1.6 E-health

One method, which is used to support self-management possibilities for COPD patients is electronic health management, shortened e-health. It is especially appropriate for COPD patients, because they can use e-health from their home. Often, COPD patients are not able to travel long-distance to contact professionals or to participate in COPD self-support groups, because they do not have the energy to take those exertions. E-health is a term used for the improvement of health care by application of internet based electronic equipment for medical care. Although, there is no universal definition, e-health can be described as a new field in the science of medical informatics, public health and business, including health services and information provided via Internet and other technological devices (Eysenbach, 2001).

There is no answer, which kinds of e-health platforms exist and what kinds of services are provided. However, the literature says, that for implementation of e-health, different forms are developed. Examples of applied e-health are for example virtual health care teams, which consist of professionals who work and share information with patients through electronic equipment, electronic health cards, which store information about a patient and health portals, which provide information about diseases for patients and make it possible to share information with other patients or professionals. Additionally e-health platforms can provide education or interventions to change behavior of patients (Ahern et al., 2006).

The most frequently used form of e-health is electronic health records, operated by institutions, facilitating the communication of data of one patient between different physicians. This is possible in a private, confidential and secure way. Electronic health records, in short EHR, can be defined as an online version of a patient’s paper chart, that make information available and shared instantly and securely among authorized users (Charles, Harmon & Jordan, 2005). Those are of interest for COPD patients, because they give a comprehensive overview of the patients' health, containing the medical and treatment histories of patients and aim to give a broad view of a patient and his care. Those health records can comprehend a wide spectrum of data, such as, demographics, medication, medical history, test results, radiology images, vital signs, diagnoses, treatment plans or personal data (Charles, Harmon & Jordan, 2005). For the patient it is not possible to fill in medical data, EHR's just allow access for professionals to evidence-based tools that providers can use to make decisions about a patient’s care.

Next to that, there are personal health record platforms, where health data and information related to the care of a patient is maintained by the patient. The aim of personal, health records is to establish a complete overview of an individual's medical history, which is accessible online, by the patient and by professionals. The dataset can include among others, the patient's and his family's medical history, medication, illnesses and hospitalizations, surgeries, imaging reports, test results and observations of daily living. Furthermore, the patient not only receive and fill in information, he can also receive training how to act in emergency situations or how to quit smoking for example. In addition to that information related to the disease can be found and sometimes direct contact to a coach or professional can be made. For personal electronic health, there are two methods by which the data is filled into the platform. At first, the patient may enter the data directly by himself. And second, an electronic health record platform of a physician can be connected to the personal health record platform of a patient. Then the data can be transmitted automatically (Kupchunas, 2007). By that, electronic and personal health records can support self-management of COPD patients, because they allow constant access to the own health data, which can be reviewed by professionals. This can give COPD patients security about the own situation and helps them to estimate the severity and to manage symptoms.

1.7 Effects of e-health

Physicians are generally satisfied with e-health system and they believe in an improving effect. They report a positive effect of e-health systems on the quality of clinical decisions and they rate the communication with other providers and patients as beneficial (DesRoches et al., 2008). Furthermore, prescription refills and the timely access to medical records can benefit from those systems. In addition to that there is a positive effect on the avoidance of medication errors (DesRoches et al., 2008).

The benefit for patients consists of the completeness and accuracy of the data used in e-health systems. With e-health it is possible to record daily charting, medication administration, physical assessment, nursing care plans, referral, present complaint (e.g. symptoms), past medical history, life style, physical examination, diagnoses, tests, procedures, treatment, medication, discharge, history, diaries, problems, findings and immunization. With this comprehensive dataset it is possible to give the patient optimal care (Häyrinen, Saranto, & Nykänen, 2008). Therefore, patients may get a more personalized and comprehensive treatment, which may in turn improve their health.

Not only physicians and patients can benefit from e-health systems, but there are also financial benefits if e-health is used. With e-health, financial savings can be made because of the time efficiency, easy recording, retrieval and coordination of data. But there are also financial costs which have to be estimated. Physicians probably have to invest in additional hardware and maintenance costs. To the present day it is not possible to give an exact value which can be saved is not possible (Hillestad et al., 2005). It is important, that more research is carried out, to estimate the effects of e-health. If e-health really is effective, it is a complete new way to provide optimal and comprehensive care for patients from a distance, which additionally entails financial savings.

1.8 E-health in COPD

With regard to the initial topic of COPD, e-health is used to improve the self-care of patients and with this giving them a higher quality of life in their own domestic environment. In the case of COPD, e-health is used as a part of long-term management. It facilitates the necessary monitoring of patients for early detection or even prevention of exacerbations. In addition to that, e-health can preserve actual health status and can prepare for imminent medical interventions or surgeries (Bartoli et al., 2009). A significant effect of e-health systems on COPD patients is found in the quantity and duration of their hospital stays. Patients with continuously participation in e-health systems are found to have four hospital stays less on average, compared with patients who do not participate in e-health systems. This point is accompanied by a reduction of days spent sick in bed and with this less days unemployable. This generates considerable annual savings. The biggest effect can be achieved by getting patients participated at a young age, respectively at the earliest stage of their disease (Hillestad et al., 2005). This is in accordance with earlier findings, which state that care has to be provided directly at the beginning of the disease to decrease the economic costs and to maintain and improve the quality of patients' life (Hoogendoorn, 2011; Gutherie et al., 2001). Another group, who benefits from e-health, is the provider. It is found out, that COPD patients often contact their providers to obtain knowledge about their actual health state (Hillestad et al., 2005). With e-health COPD patients do not have to contact their provider, because they have the possibility to check their data from wherever they are, just by checking their personal e-health system account. With this, providers can save time and dedicate their work to more important things than just searching and giving information. In addition to that, patients would feel more secure about their own health, because they can monitor and fill in their own health data and can take care for themselves.

As already mentioned, e-health is a relatively new field in research and therefore, e-health platforms are not sufficiently examined up to this day. The results of some studies, which examine e-health platforms for COPD patients are even not available today. Therefore, CeHRes Roadmap shows a holistic approach to improve the development of e-health technologies in an iterative way. It is an iterative cycle which serves as a practical guideline to plan, coordinate and carry out the development of e-health platforms. Furthermore, it aims to serve as an instrument for the estimation of the phase of development of the e-health platforms (Van Gemert-Pijnen et al., 2011).

For better understanding, a figure (Figure 1) and a short description of the CeHRes Roadmap is given.

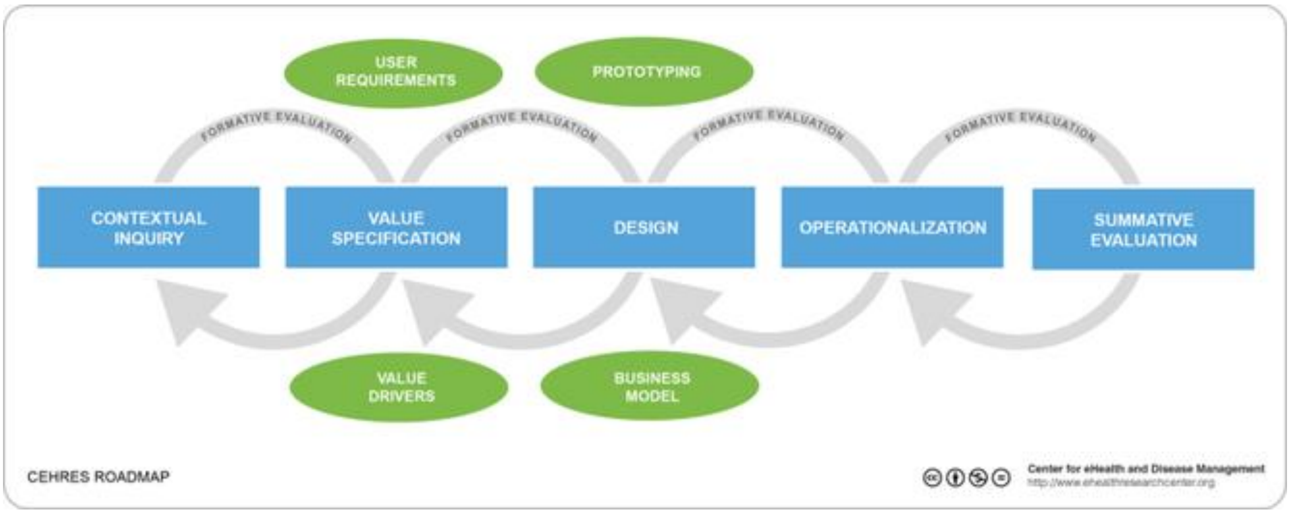


Figure 1. Pictorial Representation of CeHRes Roadmap for the Development of e-health Technologies

The first phase is *Contextual Inquiry*, here an analysis of the prospective users and their environment is made. In addition to that, the advantages and limitations of actually provided care is estimated. In the second phase, *Value Specification*, user requirements are determined, based upon user's values, wishes and needs. The third phase is the *Design*. The e-health technology is developed based upon the user requirements. According to the Roadmap, it is most successful to develop the technology together with prospective users. In phase four, *Operationalization*, the technology is implemented, marketing plans are made and organizational working procedures are carried out. In the fifth and last phase, *Summative Evaluation* is made. The usage of the e-health technology and its effect on patient's health are estimated. With the help of CeHRes Roadmap it is possible to give answer to the question how far the development of e-health platforms for COPD patients is until now. This is especially important for this research, because finally recommendations regarding e-health platforms for COPD patients shall be given, which include impulses about how future research about e-health platforms for COPD patients should look like.

Up to this day there is not much research conducted to evaluate electronic health platforms. There is no comprehensive answer about what kind of elements, including services, such as for example education, information, electronic or patient health records patients can use on those platforms. And especially the effectiveness of different elements provided on such platforms is not evaluated until now. However, this is of great importance for future developments of e-health platforms. If it is known, which kinds of elements are provided on e-health platforms for COPD patients and which of those elements are effective, it is recommended to provide exactly the effective elements on e-health platforms to improve patients' health. Therefore, this research aims to fill this gap scientifically, to provide instructions for an online platform with optimal effectiveness for the health of COPD patients using the platform.

Four research questions are constructed to bridge this gap scientifically:

1. Which kinds of e-health platforms for COPD patients exist and of what elements, such as education, information or interventions do these compose?

2. Which kinds of effects show these different elements of e-health platforms to have?

3. Which elements shall be included on e-health platforms for COPD patients to show a positive effect on their health?

4. At which stage of development are the selected e-health studies according to CeHRes Roadmap?

The aim of this research is to evaluate at first, which kinds of e-health platforms for COPD patients exist and of what elements they compose. And second, which effects of the different elements of the platform could be measured on the health of a COPD patient. Third, an instruction for the future will be given, which parts have to be definitively included to show a positive effect on the health of COPD patients. This is made, to provide optimal and effective care with the help of e-health platforms for COPD patients. Finally, it will be pointed out at which stage of development the selected studies are. By that, a comprehensive picture about the development of e-health platforms for COPD patients can be obtained. Not at least because of future recommendations for where more research is needed.

2. Method

As the main interest of this study was to describe and discuss e-health services for COPD patients, this research is conducted through a systematic literature review, aiming to summarize previous e-health studies in relation to chronic illness care, to resolve the research questions already mentioned. The methodology implementation included four steps: literature search from predefined databases, literature filter by criteria, data extraction on research questions and data analysis in legible diagrams.

The literature is studied based upon the question how e-health platforms are designed and how effective the different elements provided seem to be in regard to the health and satisfaction of its users. Therefore, a continuously comparing of data is made to find the elements used on e-health platforms for COPD patients and determine, which of these elements are effective. The process of comparing is done with help of a predesigned extraction schedule and with a self-designed table. All in all, data are simultaneously collected, compared, analyzed and finally presented in tables.

2.1 Databases

Systematic research is conducted to make up publications related to COPD and electronic health platforms. The publications are derived from standard bibliographic databases for medical sciences, social sciences and technology. To be exact, PubMed and Scopus are used.

2.2 Search Strategies

A systematic review consists of a comprehensive, objective data search, which must be reproducible (Petticrew & Roberts, 2006). During the first search, existing and potentially relevant studies in relation to COPD and e-health platforms are identified. Therefore, a defined number of databases is visited and searched with help of an advanced search filter. Subsequently, there is a pool of existing studies with the requested topic identified.

In this systematic review, the research question had been broken down in the beginning. The main concepts, which are used in this study, are COPD and electronic health platforms. For these concepts, expressions, synonyms and alternative writing styles are devised. For the term COPD the following terms are composed: "chronic obstructive pulmonary disease", with short form "COPD" (Vestbo, 2013).

For electronic health the following terms and spellings are composed: "eHealth", "e-health", "online health", "electronic health records", "web page", "web application", "web based", "internet based", "internet mediated" or "internet supported".

The primary search was performed on online databases, including PubMed and Scopus by using the terms mentioned above. Therefore combinations of the terms regarding COPD and terms regarding electronic health are made, as shown in Table 1.

For the reproducibility and transparency, the whole search process is replicable with help of the information given in the following table.

Table 1
Combinations of Search Terms and Number of Found Articles per Database and per Combination

	PubMed	Scopus
COPD AND eHealth	150	23
COPD AND e-health	13	25
COPD AND electronic health records	72	212
COPD AND online health	46	70
COPD AND web page	4	3
COPD AND web based	63	108
COPD AND web application	13	25
COPD AND internet based	46	110
COPD AND internet mediated	4	4
COPD AND internet supported	7	7
Total	418	587

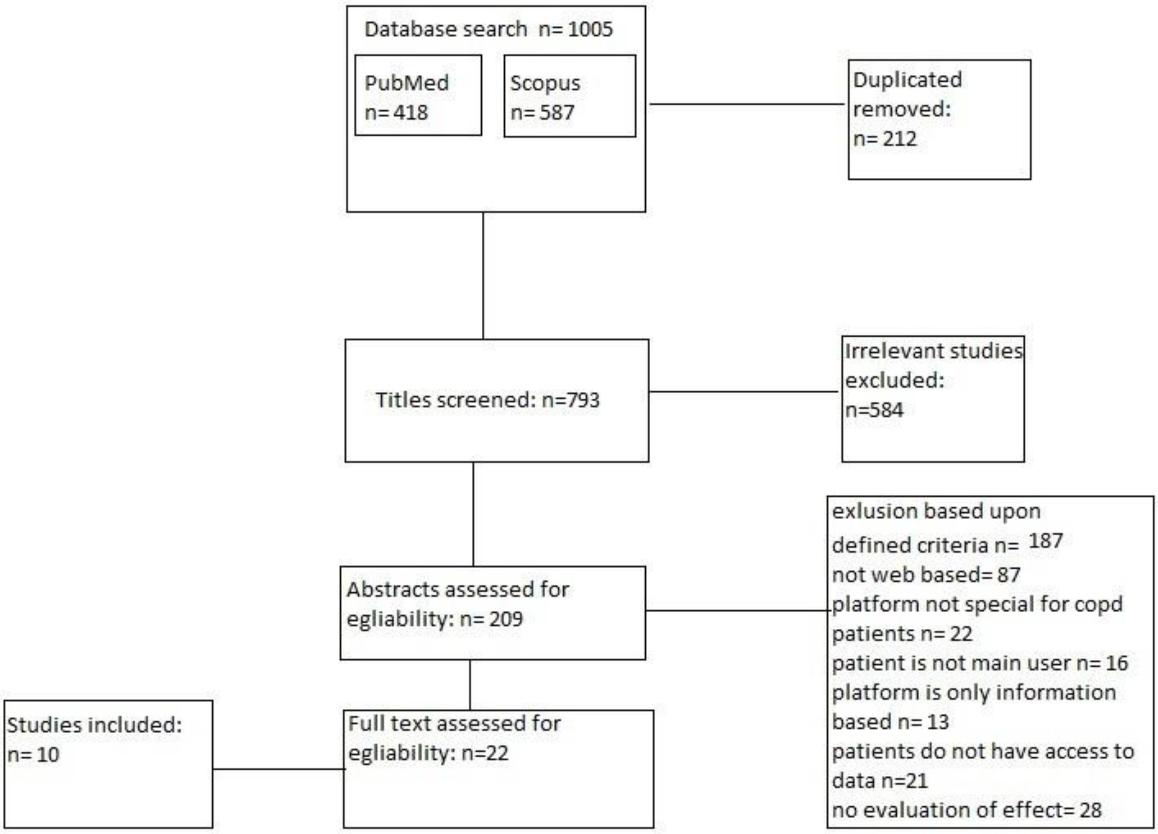
2.3 Article Selection

The selection criteria are composed to exert relevant studies that provide useful information which helps to answer the research question.

To concentrate on answering the research question, studies were screened based on predefined criteria. The first applied criteria is that only articles in English language, which were published between January 2000 and April 2015, which are available in full text, were exerted. This date is defined, because the first e-health definitions were found in the beginning of 2000 (Goldstein, 2000). Selected studies include adult people, diagnosed with COPD, who used electronic health platforms. Electronic health platforms are defined according to the following criteria: (i) the patient is the main user; (ii) the system used is web-based; (iii) patients have access to their own health data (e.g. lung function test or acute symptoms); and patients can (iv) use their data (for example, to work on their own health by getting more physically active or reducing the smoked cigarettes per day).

Studies were excluded if: (i) the electronic health platform was not specific, or among other diseases, for COPD patients; (ii) the online platform included only general information about COPD as a disease and no option for using that data, for example in contacting health care professionals or the possibility to fill in and monitor the patient's data; or if (iii) no information about what services are provided on the application was given. The screening of the studies started with scanning the titles. If those were eligible, the next step was to screen the abstracts. There is no difference made for the kind of research method used in the studies. That means, studies were not excluded based on kind of study protocol or intervention used. If the abstract was found to be eligible, the full-text was screened, based upon in- and exclusion criteria, already mentioned. Out of 1005 studies, ten articles are finally selected. The other articles were excluded, because they did not meet one or more of the composed criteria.

The following figure (Figure 2) shows the selection process of articles:



Fugure 2. Flow Chart of Selection Process for Eligible Articles. Applied criteria for inclusion were (1) thematic accordance of content, e- health platforms designed for COPD patients; (2) content dealing with personal health record platforms for COPD patients; (3) the publication date was January 2000 through March 2015; (4) the research publication is available in English language.

2.4 Data Extraction

The aim of data extraction is to line up findings in a comparable manner for later summary, analysis and interpretation (Kitchenham, 2004). For this data extraction a predesigned schedule is used to extract important data in a structured form (data extraction form, available in Appendix 2). The schedule helps to determine key features of the studies and has already been used more frequently for studies regarding e-health. Among others, the description and the elements of the kind of e-health platform the study deals with, the implementation of the study or the found results are recorded in the schedule. Based on the information in this schedule, the research question will ultimately be answered.

2.5 Quality Assessment

The methodological quality of the studies is evaluated and taken into account, but does not serve as an eligibility criterion. In this systematic review an already mentioned extraction schedule (available in Appendix 1) is used and contains a modified version of quality assessment criteria, based upon criteria established by Pandit & Yentis (2005). This scoring system is to be found in the extraction schedule, detached into the appendix. To estimate the quality of the different studies, 20 different items, divided in three main concepts are measured: general conduct, technical conduct and strength of evidence. For the first concept, *general conduct*, it is analyzed if there is: a clear hypothesis, ethical approval, background information, a clear description of the intervention and its main findings. For the second concept, *technical conduct,* it is examined if: surrogate measured and appropriate measurement tools are used, randomization and blinding is done properly (if it is done at all), there are defined groups and control groups, statistics, significance and confidence intervals are done and interpreted appropriate, sample size is considered, the outcomes are useful, the study provides an answer to the hypothesis and if the study provides questions for future research. The *strength of evidence* is investigated by the persuasiveness of the results, the support of the results by other sources and by the solidness of the outcomes. Based upon this scoring system the quality of the different studies is categorized in low, moderate and high. The categorization is self-devised. If zero up to ten items are answered with yes, the quality is defined as low. If eleven up to 15 items are answered with yes, the quality is moderate. And if 16 or more items are answered with yes, the quality is estimated to be high.

2.6 Risk of Bias

In most studies, allocation was based on place of residence. Other studies used computer-generated random allocation or allocation based upon patient characteristics, such as severity of the disease. It is judged, that all this can lead to a high risk of bias. Another reason for high risk of bias is that in most studies no control groups were used. In most studies the allocation was not known by investigators or staff. Therefore, the risk of bias is considered to be low. In none of the studies it was reported, that staff or participants were blinded, which is understandably, because of the nature of the intervention. Nevertheless, blinding describes a process that keeps participants or people involved into the management and implementation of the study unaware of allocation for example, so that these persons and by that the results of the study, are not influenced by their knowledge (Day & Altman, 2000). However, the amount of bias caused by not-blinding can not be estimated. Additionally, not all outcome measures were reported in all studies, sometimes, because the studies were not evaluated up to this day.

2.7 Data Analysis

During the process of data analysis, two main processes are followed to derive the final answer to the research question. The first process was to reduce the data of the studies to the essential factors answering the research question of this review. This is done with help of the schedule and table mentioned above (available in Appendix 1). And the second process was to find underlying similarities between the studies. Therefore, patterns were taken together, presented in the scheme mentioned above. Subsequently, accumulating patterns were taken together for more detailed analysis to give a comprehensive answer to the research question.

First, it was analyzed which devices the different e-health platforms used. Second, it was estimated of which elements, such as education, information or interventions the platforms consisted. Third, if the studies were already evaluated, it was estimated, which effects the different elements showed to have. Fourth, the main results of the selected ten studies, which are important for answering the research question of this systematic review, are recorded in a table (Table 6, available in Appendix 1). Therefore, the following factors are included in the table: author, year of publication, location, design of study, kind of service provided, type of study (e.g. protocol, usability of platform or effect of platform), quality of study and additionally, the developmental phase of the study, according to CeHRes Roadmap. For the purpose of this paper, the CeHRes Roadmap is used to estimate the stage of development of different e-health platforms. The estimation is made based upon the goal of the study, such as evaluation of an application or the pure description of an application without any results. By that, an answer can be given on question, how far the development of e-health platforms for COPD patients is until now.

3. Results

In the following, at first the e-health platforms and the content of those are presented. In the second passage, the evaluation of the elements of e-health platforms and the results are exposed. An in the third paragraph, the elements of the platforms are analyzed in relation to the results. Finally, an estimation of the actual development of e-health platforms is given, based on CeHREs Roadmap.

3.1 The different kinds of e-health platforms for COPD patients and their elements

In the following, an overview of different forms of e-health platforms designed for COPD patients is given, which is presented in a table below (Table 2).

There are different forms of platforms for COPD patients, including an online website (Voncken-Brewster et al., 2013), an application which can be installed on the own mobile phone (Zhang et al., 2013), a tablet computer with preinstalled software and oximeter to measure heart rate and oxygen saturation (Farmer et al., 2014) and an application using television and computer of the patient (Burkow et al., 2013). In addition to that, there are applications, which make use of different devices, such as a smartphone app in combination with a web page and an accelerometer (Verwey et al., 2014) or just a web page in combination with an accelerometer (Tabak et al., 2014).

In most of the studies, a computer is used as the main device of an e-health platform for COPD patients (Voncken-Brewster et al., 2013; Burkow et al., 2013; Verwey et al., 2014; Tabak et al., 2014). In half of the studies, a computer is used detached and in the other half of the studies, a computer is used in combination with other devices.

Table 2
The Devices of e-health Platforms

Author	Computer	Mobile Phone	Tablet	Television	Accelerometer	Oximeter
Voncken-Brewster et al, 2013	x					
Zhang et al., 2013		x				
Farmer et al., 2014			x			x
Burkow et al., 2013	x			x		
Verwey et al., 2014	x	x			x	
Tabak et al., 2014	x				x	

In addition to that, on these platforms different elements are provided for COPD patients (Table 3). Patients can find (1) information regarding COPD, risk factors and treatment of the disease (Voncken-Brewster et al., 2013; Farmer et al., 2014; Burkow et al., 2013). One the one hand, information regarding smoking cessation, treatment of exacerbations, general information about COPD, exercise plans or advice regarding coping with depression and anxiety are sent online to the device of the patient. On the other hand, the patient has the opportunity to choose and click just the information he wants to know. That means, that there are two ways of getting information, plans or advices. First, the patient gets them passive, or he has to become active and chooses just the information or elements important or interesting for him. In addition to that, information can be presented in textual form, video clips or verbal.

Furthermore, they can (2) record their personal health data by themselves, which is reviewed by a professional (Zhang et al., 2013; Farmer et al., 2014; Verwey et al., 2014; Tabak et al., 2014). Therefore, most often, the personal health data is filled in a daily symptom diary. Another possibility to record health data are external measuring instruments, such as accelerometer and oximeter.

Moreover patients can receive (3) education regarding health behavior, physical activity, coping with stress situations or smoking cessation (Zhang et al., 2013; Voncken-Brewster et al., 2013; Farmer, 2014; Tabak et al., 2014, Burkow et al., 2013). The difference between information and education is that, in information, the patients just gets knowledge presented. In education patients get taught practical knowledge, how to behave in different situations. Education can thereby be delivered in different forms, for example by presenting exercise videos, illustrations, videos to imitate or hyperlinks to other pages. Education can be accompanied by behavior change interventions. Therefore, patients' actual behavior gets analyzed and new behavior goals are set. Behavior change interventions can include a personal plan, personalized feedback and regular sent motivating prompts to reach the set goals. In addition to that, patients can make contact to other COPD patients, who participate in the intervention or to professionals.

Another service provided is (4) contact to professionals (Zhang et al., 2013; Verwey et al., 2014; Farmer et al., 2014; Tabak et al., 2014, Burkow et al., 2013). This can either be done by calling, starting a video-conference, making an appointment online or visiting the professional directly. In the analyzed studies, patients had most often the opportunity to record and view their personal health data, get education and make contact with professionals. Patients had the opportunity to participate in behavior-change interventions or to find information about COPD, less frequent.

Table 3
Components of e-health Platforms for COPD Patients

Author	Information	Monitoring	Education	Behavior-Change Intervention	Contact
Voncken-Brewster et al., 2013	x	x	x	x	
Zhang et al., 2013		x	x		x
Farmer et al., 2014	x	x	x		x
Burkow et al., 2013	x		x		x
Verwey et al., 2014		x		x	x
Tabak et al., 2014		x	x	x	x

3.2 The effects of the different elements of e-health platforms for COPD patients

In the following, an overview over the evaluated elements and the results are given and presented in table 4. Knowledge and use of e-health platforms is more frequent in younger, higher educated patients, and less frequent for patients with a worse self-rated health status. In addition to that, it is notably, that respondents, who know of a specific application, for example they know what electronic health records are, are more interested in additional information about e-health, compared to respondents, who do not know of an application (Hofstede et al., 2014; Duplaga, 2013). Although the term *e-health* itself is only known by 8% of patients, knowledge about e-health applications is significantly higher if examples of different applications are given (Hofstede et al., 2013). That means, the term e-health itself is not very popular. But applicated e-health, for example in the form of internet platforms where patients can participate in interventions, are more popular.

The general attitude towards e-health applications is positive (Hofstede et al., 2013; Duplaga, 2013; Burkow et al., 2013). Respondents rated the applications as less time-consuming than regular caregiver visits, user-friendly and more individual because they could use it, when they actually needed it and not only at fixed points of time (Hofstede et al., 2013). Patients especially like to search for COPD related information online, making appointments with caregivers online and having direct access to their own medical health records. Furthermore, they value the active part they can take in their health-related decision-making process. Additionally, patients report to benefit from group education and its social aspect, where they can talk about their strategies how to handle the disease, which is more favorable than education from a caregiver, who is not suffering from COPD (Voncken-Brewster et al., 2014; Tabak et al., 2014; Burkow et al., 2013). Patients do not value unreliable information and they are feared of unsafe data transmission and the decrease in human contact (Hofstede et al., 2013).

Electronic health diaries and having access to the own medical results are most beneficial and are used most often (Hofstede et al., 2013; Tabak et al., 2014). In addition to that, it turned out, that e-health platforms aiming to change behavior are successful. Patients, who use e-health platforms to improve their physical activity, become significantly more active (Voncken-Brewster et al., 2014; Verwey et al., 2014). In addition to that, COPD patients, who use platforms, which contain modules for smoking cessation, show to smoke significant fewer cigarettes per day. However a complete cessation of smoking was not reached in one of the studies. Furthermore, patients feel supported to change behavior and feel more self-efficient in difficult situations. Especially the higher awareness of their behavior, initiated through the different platforms and their active role in disease self-management is rated positive (Voncken-Brewster et al., 2014; Verwey et al., 2014).

It turns out that the general usability of and satisfaction with e-health platforms is high. Especially the use of a daily symptom diary increases the use and the satisfaction of COPD patients, because they can monitor their symptoms daily and recognize changes directly. However, activity modules are used less frequent, which makes it necessary to be improved in future studies.

Table 4

Evaluated Elements and Results of e-health Platforms for COPD Patients

Author	Satisfaction	Usage	Activity Level	Smoking Cessation	Self-Management	Results of the Evaluation
Duplaga, 2013		x				Use is higher for respondents with lower age and higher education.
Hofstede et al., 2014	x					Most popular applications: electronic patient records, online purchase of medications, making appointments online. Patients are generally satisfied.
Verwey et al., 2014	x		x			Physical activity increased with the use of the application. Patients state to benefit from it.
Voncken-Brewster et al., 2014	x		x	x	x	Number of smoked cigarettes per day decreased and activity level increased significantly. Application increased self-management.
Tabak et al., 2014		x				Daily symptom diary was used most often.
Burkow et al., 2013	x	x			x	Patients are satisfied with education, group contact and individual consultations- Daily-health diary enhanced self-management.

3.3 Recommendations, which elements should be included on e-health platforms for COPD patients

Research shows, that the interest in health related online search is high in principle (Duplaga, 2013). Therefore, professional platforms should be created with the awareness of patients' wishes, needs, and elements that have already proven to be effective. It is found out, that patients benefit from – and wish for availability of a symptom diary, electronic monitoring, online purchasing of medication and devices or making appointments with healthcare professionals via internet as very positive. To create a platform with a positive effect on patients' health, the mentioned elements should be included. In addition to that it is especially important to make sure and visible, that the presented information are reliable, patient data and particularly the transmission of patient data is safe. Furthermore, patients fear that the human contact is decreased by the use of e-health platforms (Hofstede et al., 2014; Duplaga, 2013; Tabak et al., 2014). This problem could be overcome by giving the opportunity to use video conferencing with professionals or other patients, where patients show to benefit from and rate this kind of social contact as positive (Burkow et al., 2013).

Two important modules, which should be included to improve patients' health, are smoking cessation and physical activity. Platforms containing this modules show to decrease the number of cigarettes smoked per day and to increase the physically active minutes per day (Voncken-Brewster et al., 2013; Voncken-Brewster et al., 2014; Farmer et al., 2014).

Furthermore, prompts or stimulating cues, such as activity minutes that can be earned, show to motivate patients to maintain and reach their goals (Verwey et al., 2014).

In addition to that, patients benefit from behavior change modules with a personal action plan, set with a professional, where they get personalized feedback afterwards (Voncken-Brewster et al., 2013; Tabak et al., 2014; Voncken-Brewster et al., 2013; Verwey et al., 2014). If this feedback is short and personalized with the patient's name for example, it is even more effective. Furthermore, patients and nurses like the progress in self-management of patients and the active-role patients took for their own health care by using online health platforms. This gives patients a feeling of self-efficacy (Voncken-Brewster et al., 2014).

3.4 Development of e-health platforms for COPD patients

As mentioned earlier, CeHRes Roadmap is an instrument to plan, organize and implement the developmental process of e-health platforms. To gain insight into the actual stage of development of e-health platforms, the reviewed studies are now categorized according to the different stages of CeHRes Roadmap in table 5 (Van Gemert-Pijnen et al., 2011).

Two of the studies belong to the second stage of CeHRes Roadmap, *Value Specification* (Hofstede et al., 2014; Duplaga, 2013). Getting an understanding of prospective users and their context is characteristic for this stage. One of the studies analyzed the knowledge, use and attitude COPD patients have about e-health platforms in general. It is estimated, if patients have heard about e-health platforms in general, they are familiar with the use of those and think more positive about e-health platforms (Hofstede et al., 2014). The second study figured out the user behaviour toward different e-health applications and services and the attitude towards different applications. In addition to that, future wishes and needs of prospective users were determined (Duplaga, 2013).

Another six studies can be categorized in the *Operationalization* phase of CeHRes Roadmap. Characteristic of this fourth stage is the planning, adaption and internalization of the e-health technology (Van Gemert-Pijnen et al., 2011). The e-health platforms are planned and constructed in different ways, for example as smartphones, tablet computers, web links or additional measuring instruments to record vital data (Voncken-Brewster et al., 2013; Farmer et al., 2014; Tabak et al., 2014; Voncken-Brewster et al., 2013; Burkow et al., 2013; Zhang et al., 2013). Additionally, these studies are implemented into a defined setting and are available for a defined number of COPD patients. Thereby, one study does not make use of the iterative process, which is necessary for CeHRes Roadmap (Tabak et al., 2014) and another study uses methods from the *Design* phase actually in the *Operationalization* phase (Voncken-Brewster et al., 2013).

In addition to that, there are two studies which can be categorized into the *Summative Evaluation* phase of CeHRes Roadmap. Both studies evaluate the effect on the health of the user. The first study evaluates the effect of the application with regard to the daily physical activity of the patient (Verwey et al., 2014). And the second study of this phase evaluates the effect of the application on physical activity, smoking cessation and quality of life of its users (Voncken-Brewster et al., 2014).

All in all, there are many studies describing the structure of different e-health platforms, but for most of them evaluation data are missing. In addition to that no studies are found to be categorized in the stages *Contextual Inquiry* and *Design*, according to CeHRes Roadmap.

Table 5

Classification of the Studies According to CeHRes Roadmap

Author	Contextual Inquiry	Value Specification	Design	Operationalization	Summative Evaluation
Duplaga, 2013		x			
Hofstede et al., 2014		x			
Voncken-Brewster et al., 2013				x	
Farmer et al., 2014				x	
Tabak et al., 2014				x	
Voncken-Brewster et al., 2013				x	
Burkow et al., 2013				x	
Zhang et al., 2013				x	
Verwey et al., 2014					x
Voncken-Brewster et al., 2014					x

4. Discussion

This study aims to map which different kinds of COPD online health platforms already exist, of which parts they compose and what their effectiveness seems to be. Because there is no comprehensive study, which shows how far research is in this field, this study is accomplished to provide guidance with regard to, the effectiveness of different elements which should be included on e-health platforms for COPD patients.

The first research question was *which kinds of e-health platforms exist and of what parts they compose.* After reviewing the studies up to this day, it is discovered, that a standard website presented on a computer, is the most often used device for e-health platforms for COPD patients. Next to that, there are applications, which are installable on the own mobile phone, tablet computers with preinstalled software and additional oximeter or accelerometers to measure heart rate, oxygen saturation physical activity of the patient. Sometimes e-health platforms for COPD patients make use of more than one device by combining different devices.

On these platforms, different services are provided for COPD patients. The most frequent services provided on the e-health platforms are the possibility to record personal health data in a daily symptom diary, get education and make contact to professionals. Additionally, patients can find general information about their disease, but also about smoking cessation, self-treatment of exacerbations, exercise plans or advice regarding coping with depression and anxiety. This is important, because with the use of e-health, patients do not need to travel to professionals. This is advantageous, because COPD patients are not always in a good physical condition, which allows them to travel (Guthrie et al., 2001).

Furthermore, patients can receive education regarding health behavior, physical activity, coping with stress situations or smoking cessation. Patients can find exercise videos, illustrations, videos to imitate or hyperlinks to other pages. In addition to that, some e-health platforms provide behavior change interventions. If patients make use of such interventions, patients' actual behavior gets analyzed, and new behavior goals are set. Patients then get a personal plan, personalized feedback and regular sent motivating prompts to reach the set goals (Voncken-Brewster et al, 2013; Verwey et al, 2013; Tabak et al., 2014). The proven effectiveness of those interventions is especially important, because those elements are recommended to be used in the development of future e-health platforms for COPD patients. The most essential and the only influencable risk factor contributing to COPD is tobacco smoke (Lopez et al., 2006). Interventions focusing on smoking cessation should therefore be provided on e-health platforms for COPD patients, because with that, a worsening of the health can be stopped. This can be supported by Godtfredsen et al (2008) who did a literature review on the morbidity and mortality of COPD patients after smoking-cessation. They found, that even in advanced stadia of COPD, smoking cessation slows the accelerated decline of lung functions and improves the survival of COPD patients, compared to continued smokers. Therefore, future research should focus on smoking cessation interventions on COPD e-health platforms.

To answer the second research question, *which effects elements of e-health platforms for COPD patients show to have*, it can be noted, that young and higher educated patients form the main group of users (Duplaga, 2013; Hofstede et al., 2014). This is in accordance with the literature, which says, that higher educated and younger people are the main users of e-health platforms. Most users are between 18 and 34 years (Kontos et al., 2012). This is a problem, because COPD mainly affects people over 40 (Lopez et al., 2006). Therefore, a way has to be found to address older people for using e-health platforms for COPD patients. This gap could be overcome by advice of the lung specialist by the COPD patient. The lung specialist could recommend the usability and effectiveness of e-health platforms for COPD patients. Additionally, one COPD patient who actually uses e-health platforms himself could serve as a role model. The role model could explain the use of e-health platforms practically for other COPD patients and could give personal examples of the effectiveness of the platform. The literature supports this by stating that the use of a role model can increase the expectations of self-efficacy, which is part of self-management (Bourbeau et al., 2004).

COPD patients were generally satisfied with e-health platforms and especially appreciated, that e-health platforms are less time-consuming than regular caregiver visits, user-friendly and more individual. Beside the active-part patients can take in their health-decision makings, patients benefit from behavior change interventions regarding physical activity or smoking cessation. This is in accordance to the literature, because patients want to take an active role in their own medical decision making and want a relationship to their health care professionals, which is a partnership. It turned out, that participants of those interventions significantly smoked less and became significantly more active. Patients explained those results by the motivation they got by personalized feedback and prompts, which were used in the interventions (Voncken-Brewster et al., 2014). A systematic review dealing with e-health platforms for diabetes patients reports, that the distress of diabetes patients is significantly reduced if they use e-health platforms (Osborn et al., 2010). This is similar to findings of this systematic review, because patients reported a significantly increased quality of life, after using e-health platforms for COPD patients. Most often used and most beneficial services provided are electronic health diaries and having access to the own medical results. The third research question was to identify w*hich parts shall be included on e-health platforms for COPD patients, to show a positive effect on health, usability or satisfaction of users.*

With the results of the study it is possible to create e-health platforms with high user satisfaction and positive effect on the health of patients. The review of the studies shows that e-health platforms, which aim to be most effective, should contain a symptom diary, electronic patient records, the possibility to purchase medication online and making appointments with healthcare professionals. By doing this, the patient does not need to travel, which is important for COPD patients who do not always have the energy for traveling long-distance (Gutherie, 2001). Additionally two important modules which have shown to be effective and therefore should be included to improve patients' health are smoking cessation and physical activity. Platforms containing this modules show to decrease the number of cigarettes smoked per day and to increase the physically active minutes per day. Stimulating cues and personalized feedback improve the satisfaction and effect on health of patients and should therefore be included, too. The literature says that prompts are helpful to capture the attention of the patient or to focus the attention of a patient onto a specific fact (Bangert & Valdez, 2005).

Before doing this systematic review, there were little defined expectations of the results. The research field is still very young and during the article selection procedure it turned out, that not many studies deal with this particular topic at all and if they do, the evaluation results are not available up to this point of day. Therefore, the results of this study have to be supported with more future research results, regarding the effectiveness of different elements of e-health platforms for COPD patients and if the results of this study are generalizable. Nevertheless, during the literature search for the introduction it was expected, that computers and with that, standard websites are the main devices used for e-health platforms. A reasonable explanation might be, that most people have access to a computer with internet access, but probably not always to a smartphone with internet access. Additionally, it was expected, that patients had more often the opportunity to take part in intervention programs. For COPD patients it is important to decrease or more preferably to stop smoking and to increase daily physical activity. It was not expected, that just 8% of patients had knowledge of the term *e-health*. Even though this field is still new, it was expected, that people could make use of the term. The unfamiliarity with the term e-health has to be resolved in the future. This can for example be done in a conversation with the general practitioner, where it is explained what the term e-health means and how it can be used for improving the health of COPD patients. Another possibility would also be the use of a role model as already mentioned above.

This study holds some important limitations. Firstly, it is relied on correct data and interpretation by the authors of the reviewed studies. Second, the reviewed studies differed completely in kind of intervention, study population, presence of a comparison group, kind of study intention and outcomes. Therefore it is difficult to compare the studies and their results. Third, because some pilot studies are limited to just a small number of patients, the research results may not be generalizable to other populations. The research results have to be used carefully and may not simply be generalized to other populations. In addition to that, it was hard to find studies dealing with e-health platforms in relation to COPD patients. This is probably the case, because e-health is a research field, just getting started. In total just 10 studies could be found. The sample is probably too small to generalize the results.

Hence, more research analyzing and evaluating e-health platforms for COPD patients have to be carried out to confirm the results and to gain even more insight into the effectiveness of different elements of e-health platforms. A categorization of the studies according to CeHRes Roadmap is made to gain insight into the actual stage of development of e-health platforms. Thereby, two studies can be categorized in the stage of Value Specification, identifying patients' wishes and needs. With six studies, the clear majority belongs to the *Operationalization* stage, where planning, adaption and internalization of the e-health platform take place. Just two studies, can be categorized into the *Summative Evaluation* phase, evaluating the effect of the application with regard to physical activity of the patient and smoking cessation. It is remarkably, that for most of the studies no evaluation results are available up to this present day. If evaluation results would be available for all studies, the results of this systematic review could look different.

Finally, e-health platforms seem to be an effective practical implementation of self-management for COPD patients because it enables patients to manage the daily challenges of the disease by themselves and additionally offers the opportunity for constant monitoring which can also be viewed by the care giver. This systematic review has also proven that COPD patients, who use e-health platforms realize an increase in the quality of life and feel more self-efficient in difficult situation, compared to patients who do not use e-health platforms (Voncken-Brewster et al., 2014, Verwey et al., 2014).

For future research it is recommended to compare the results of the evaluation of more studies with the results found in this systematic review, because the evaluation results of this study are not enough to make generalizations. In addition to that one study found out, that only 8% of COPD patients know about the term *e-health.* Since this study shows, that e-health platforms for COPD patients show a positive effect on the health and satisfaction of COPD patients, future studies should aim to find out how to make those platforms more popular. If this would be the case, more COPD patients can use e-health platforms to improve their own health. Furthermore, it is important to research how to get patients use activity modules more often, to enhance the effect of smoking cessation- and physical activity modules, because those modules have shown to be effective in improving patients' health. Moreover, an assessment of outcomes should be made over the long term (>12 months), because the results of the studies are short time and comprise just a period of one year. Long term assessment could yield different results. Elements which have shown no effect in this short term assessment could show an effect over long-term, but this is not proven at this point of time and has therefore be assessed over the long term.

5. Conclusion

E-health interventions for COPD patients are associated with improvement in health, composed of a reduction in smoked cigarettes, increase in physical activity per day and increase in quality of life. Additionally, patients show to be satisfied with the structure, usage and effects of the applications in general. Daily symptom diaries and personal health records are the services most preferred by COPD patients and have shown to be most beneficial for patients' health at the same time. Prompts and personalized feedback contribute to sustaining of the motivation of COPD patients to continue the use of e-health platforms. Therefore, it is recommended to include both services in future developed e-health platforms for COPD patients. However, because of the low number of analyzed studies and the even smaller number of studies with available evaluation results, it is hard to generalize the results to the whole population of COPD patients.

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7. Appendix

Appendix 1:

Table 6

Selected Articles

Author	Year	Location	Phase of CeHRes Roadmap	Design	Objective of the Study	Quality	Main Findings
Hofstede et al	2014	Netherlands	Value Specification	Telephone Survey	Investigate Knowledge, use and attitude towards e-health applications	Moderate	Most COPD patients know of different e-health applications, but the use is low. The attitude is more positive of people who have experience with e-health
Duplaga	2013	Poland	Value Specification	Questionnaire	assess the acceptance of the use of e-health applications of COPD patients access laboratory test re-sults, view educational resources, and renew prescription	Moderate	COPD patients most often searched online for diseases and treatments. The highest acceptance was found for booking of appointments.
Zhang et al	2013	China	Operationalization	Pre- and Posttest	investigate the effect of the application on the management of patients with stable COPD	Low	No results available yet
Voncken-Brewster et al	2013	Netherlands	Operationalization	Two-arm randomized controlled trial, compareing a web-based, compu-ter-tailored self-management intervention with usual care	testing the effecttiveness of a web-based, computer-tailored self-management intervention to change health behaviours of people with or at risk for COPD	Low	No results available yet

Farmer et al	2014	England	Operationalization	randomised controlled trial	determine whether an intervention delivered through an easy-touse tablet computer can improve the quality of life of COPD patients	Low	No results available yet
Tabak et al	2014	Netherlands	Operationalization	a pilot randomized controlled trial	investigate the use of and satisfaction with a chronic obstructive pulmonary disease (COPD) telehealth program	Low	The use (86% of days) and the user satisfaction was high (86% of days). Especially the symptom diary was highly frequented.
Voncken-Brewster et al	2013	Netherlands	Operationalization with methods from design phase	usability evaluation with mixed methods design + iterative cycles of improvement and evaluation	evaluate and improve the usability of the e-health intervention	Moderate	After some improvements, participants found the application to be easy to use
Verwey et al	2014	Netherlands	Summative Evaluation	subsequent randomised controlled trial with interviews	developing and testing an application supporting patients in achieving an active lifestyle was developed and tested	Moderate	Patients' attitude towards the application was positive. Physical activity and quality of life increased significantly

Burkow et al	2013	Norway	Operationalization	field trial + interview	Describe a home-based e-health system for COPD management, present the design and implementation of a prototype for home based education, exercises, treatment and following-up, with the TV and a remote control as user interface	Low	high usability of the system, and the trial participants found the system easy to learn and easy to use by means of a TV and a remote control
Voncken-Brewster et al	2014	Netherlands	Summative Evaluation	mixed methods desgin	gauge the feasibility of adding a web-based patient self-management support application, by assessing patients' self-management, patients' health status, the impact on the organization of care, and the level of application use and appreciation	Moderate	application supported self-management, Nurses reported benefits for the organization of care and made suggestions to optimize the use of the reports. Impact on patients' health could not be determined, because of too small sample size

Appendix 2: Data Extraction Form

1.1 Reviewer ID Click here to enter text.

1.2 Date

1.3 Status Choose an item.

2. Study Identification

2.1 Title Click here to enter text.

2.2 Authors Click here to enter text.

2.3 Affiliation Click here to enter text.

2.4 Country Click here to enter text.

2.5 Year of publication Click here to enter text.

2.6 Journal Click here to enter text.

2.7 SJR Click here to enter text.

2.8 Conflicts of interest, if any? Click here to enter text.

3. Abstract

Click here to enter text.

<u>4. the system</u>

4.1 Setting .

a. Provided by: Choose an item. Other: Click here to enter text.
b. Source of care: Choose an item. Other: Click here to enter text.

4.2 For which patients is the system primary meant for?

a. Disease: Click here to enter text. ☐ Unknown
b. Age group: Click here to enter text. ☐ Not Specified
c. Other criteria Click here to enter text. ☐ Not Specified

4.3 Intended goals of the <u>system</u>

1. Click here to enter text.
2. Click here to enter text.
3. Click here to enter text.
4. Click here to enter text.

4.4 Development of and support for the technology

a. Is the system (or parts of the system) based on a model or theory?

☐ Yes, Click here to enter text.

☐ No/unclear

b. Is the system (or parts of the system) based on previous research?

☐ Yes, Click here to enter text.

☐ No/unclear

c. Has an user-centered design approach been applied?

☐ Yes ☐ No ☐ Unknown

4.5 Features system (what can the user do with the system?)

☐ Information

☐ Education (☐ With feedback ☐ Without feedback)

☐ Monitoring (☐ With feedback ☐ Without feedback)

☐ Exercises (☐ With feedback ☐ Without feedback)

☐ Setting / reaching goals (☐ With feedback ☐ Without feedback)

☐ Communication with peers

☐ Communication with healthcare providers

☐ Logistics (e.g. planning appointments)

☐ Other, Click here to enter text.

4.6 Is the system connected with other systems (e.g. medical health records)?

☐ Yes, with: Click here to enter text. ☐ No, the system is stand-alone

4.7 Who can access the patients' data?

☐ Medical specialist

☐ Patient

☐ Paramedics (e.g. physiotherapist, podiatrist)

☐ Nurse

☐ Pharmacist

☐ Family

☐ Other, Click here to enter text.

4.8 What motivational techniques are used?

☐ Reminders ☐ "Fun"-elements ☐ Extra feedback ☐ (Peer)-support

☐ Interactive elements ☐ Unknown/none

☐ Other: Click here to enter text.

4.9 Intended usage

Click here to enter text. times per Click here to enter text.

☐ Unknown

4.10 Are healthcare workers trained in using the system?

☐ No ☐ Yes, by Click here to enter text. ☐ Unknown

4.11 Are patients trained in using the system?

☐ No ☐ Yes, by Click here to enter text. ☐ Unknown

4.12 Is the system certified (e.g. ISO-certified)?

☐ Yes, by Click here to enter text.

☐ No

4.13 Specification of the intervention process

The "what", "how", "by who" detailing of the services

(description of the process, how the services relate and how the system is used in daily practice)

Click here to enter text.

4.14 Interaction

Who	Direction	With who	Medium	Synchronicity	Frequency	Character	Type of message
Choose an item.	Choose an item.	Choose an item.	Choose an item.	Choose an item.	Choose an item. Choose an item.	Choose an item.	
Choose an item.	Choose an item.	Choose an item.	Choose an item.	Choose an item.	Choose an item. Choose an item.	Choose an item.	
Choose an item.	Choose an item.	Choose an item.	Choose an item.	Choose an item.	Choose an item. Choose an item.	Choose an item.	
Choose an item.	Choose an item.	Choose an item.	Choose an item.	Choose an item.	Choose an item. Choose an item.	Choose an item.	
Choose an item.	Choose an item.	Choose an item.	Choose an item.	Choose an item.	Choose an item.	Choose an item.	

					Choose an item.		
Choose an item.	Choose an item.	Choose an item.	Choose an item.	Choose an item.	Choose an item. Choose an item.	Choose an item.	

5. Study design

5.1 Design Type

Choose an item.

5.2 Recruitment of participants

Choose an item. Channel: Click here to enter text.

5.3 Reach

Size of population: Click here to enter text.

Number of approached participants: Click here to enter text.

Number of actual participants: Click here to enter text.

5.3 What are the inclusion criteria?

Click here to enter text. ☐ Unknown

5.4 What are the exclusion criteria?

Click here to enter text. ☐ Unknown

5.5 Randomization

Choose an item.

5.6 Blinding

Choose an item.

5.7 Study Sample

Group	Description	Intervention	Size Included	Size post-treatment	Sort and % attrition[1]
1					% dropout ? %non-usage ? % onbekend
2					% dropout ? % non-usage ? % onbekend
3					? % dropout ? % non-usage ? % onbekend
4					? % dropout ? % non-usage ? % onbekend
5					? % dropout

					? % non-usage ? % onbekend

5.8 Duration of the intervention

Click here to enter text.

5.9 Quality assessment – General checklist (based on Pandit & Yentis + Downs & Black + Wentzel & Karreman)

Check which ones apply. [T1 and E3 might require short elaboration]

General conduct	
G1. Is there a clear hypothesis?	
G2. Is there ethical approval?	
G3. Is there clear background information?	
G4. Are interventions clearly described?	
G5. Are main findings clearly described?	
Technical conduct	
T1. Are surrogate measures being used?	
T2. Are the measurement tools (technological as assessment scores) appropriate? (6.8)	
T3. If applicable, is the randomization done properly? (5.3)	
T4. If applicable, is the blinding done as well as it could be? (5.4)	
T5. Are there well defined groups and proper controls? (5.6)	
T6. Are the statistics appropriate? (5.7)	
T6a. Is significance expressed and interpreted appropriately?	
T6b. Are Confidence Intervals used?	
T6c. Has sample size been considered / plausible power? (5.8)	
T7. Are the outcomes useful? (6.4)	
T8. Does the study provide clear answer to hypothesis? (6.4)	
T9. Does it provide further questions (future research, etc)?	
Strength of Evidence	
E1. Is the evidence persuasive (the logic of argument, statistics, methods, etc)?	
E2. Are the results supported by evidence from other sources?	

E3. Are the outcomes solid (no other explanations possible)?

6. measuring Effects

6.1 Which variables were reported?

Can be found in more places than just results section, so be keen on checking the discussion/conclusion or actually whole paper carefully

	Outcome	**Operationalization (+explanation)**	**Measurement**	**t1 t2 t3 (week)**	**Valid**
A					☐
B					☐
C					☐
D					☐

6.2 Which effects were reported?

	Group	**vs. group**	**Outcome**	**Difference between** **t.. & t..**	**Sign.**	**Winner**	**ITT ?**

1				&			☐
2				&			☐
3				&			☐
4				&			☐
5				&			☐
6				&			☐
7				&			☐
8				&			☐

6.2 Conclusions based on effects and outcomes

6.3 Other reported findings

7. discussion

7.1 Reported shortcomings of study

7.2 Reported facilitating factors for implementing the system

7.3 Reported prohibitive factors for implementing the system

7.4 Reviewer remarks on study design, if any

8. NOTES / REMARKS

. Study design

5.1 Design Type

Choose an item.

5.2 Recruitment of participants

Choose an item. Channel: Click here to enter text.

5.3 Reach

Size of population: Click here to enter text.

Number of approached participants: Click here to enter text.

Number of actual participants: Click here to enter text.

5.3 What are the inclusion criteria?

Click here to enter text. ☐ Unknown

5.4 What are the exclusion criteria?

Click here to enter text. ☐ Unknown

5.5 Randomization

Choose an item.

5.6 Blinding

Choose an item.

5.7 Study Sample

Group	Description	Intervention	Size Included	Size post-treatment	Sort and % attrition[1]
1					% dropout ? %non-usage ? % onbekend
2					% dropout ? % non-usage ? % onbekend
3					? % dropout ? % non-usage ? % onbekend
4					? % dropout ? % non-usage ? % onbekend
5					? % dropout ? % non-usage ? % onbekend

5.8 Duration of the intervention

Click here to enter text.

5.9 Quality assessment – General checklist (based on Pandit & Yentis + Downs & Black + Wentzel & Karreman)

Check which ones apply. [T1 and E3 might require short elaboration]

General conduct	
G1. Is there a clear hypothesis?	
G2. Is there ethical approval?	
G3. Is there clear background information?	
G4. Are interventions clearly described?	
G5. Are main findings clearly described?	
Technical conduct	
T1. Are surrogate measures being used?	
T2. Are the measurement tools (technological as assessment scores) appropriate? (6.8)	
T3. If applicable, is the randomization done properly? (5.3)	
T4. If applicable, is the blinding done as well as it could be? (5.4)	
T5. Are there well defined groups and proper controls? (5.6)	
T6. Are the statistics appropriate? (5.7)	
T6a. Is significance expressed and interpreted appropriately?	
T6b. Are Confidence Intervals used?	
T6c. Has sample size been considered / plausible power? (5.8)	
T7. Are the outcomes useful? (6.4)	
T8. Does the study provide clear answer to hypothesis? (6.4)	
T9. Does it provide further questions (future research, etc)?	
Strength of Evidence	
E1. Is the evidence persuasive (the logic of argument, statistics, methods, etc)?	
E2. Are the results supported by evidence from other sources?	

E3. Are the outcomes solid (no other explanations possible)?

6. measuring Effects

6.1 Which variables were reported?

Can be found in more places than just results section, so be keen on checking the discussion/conclusion or actually whole paper carefully

	Outcome	Operationalization (+explanation)	Measurement	t1 t2 t3 (week)	Valid
A					☐
B					☐
C					☐
D					☐

6.2 Which effects were reported?

	Group	vs. group	Outcome	Difference between t.. & t..	Sign.	Winner	ITT ?

1				&			☐
2				&			☐
3				&			☐
4				&			☐
5				&			☐
6				&			☐
7				&			☐
8				&			☐

6.2 Conclusions based on effects and outcomes

6.3 Other reported findings

7. discussion

7.1 Reported shortcomings of study

7.2 Reported facilitating factors for implementing the system

7.3 Reported prohibitive factors for implementing the system

7.4 Reviewer remarks on study design, if any

8. NOTES / REMARKS