MASTER THESIS

Active levels of self-management of COPD via e-health

-A scoping review-

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Abstract

Objective: This scoping review of fourteen studies is conducted to explore self-management for COPD patients via e-health and to map key concepts of it. Thereby, the content aspects of e-health self-management platforms, the level of self-management and the form of communication are analyzed.

Background: Chronic Obstructive Pulmonary Disease (COPD) is a rising cause of mortality. E-health platforms provide opportunities for supporting active self-management for COPD patients to improve their health. Up to this day, the literature about the levels of self-management of e-health for COPD is scarce. Therefore, this scoping review tries to answer this gap scientifically.

Method: A comprehensive search strategy was designed and implemented across eight different databases, in which 110 Studies were identified. 48 abstracts were reviewed, resulting in 22 full-text reviews. A final sample of 14 studies was analyzed in this scoping review. To answer the research questions, a predesigned rating framework was used to extract content aspects of self-management for COPD patients, the levels of activity in self-management and the forms of e-health technology and communication.

Results: It is found that most technologies use up to six different content aspects. The most frequent used content aspect is "symptom management". Regarding the level of activity in self-management, the majority of technologies uses content aspects of more than level of self-management. Half of the technologies used content aspects of level 0 and all technologies used content aspects of level 1. Significantly fewer technologies used content aspects of level 2 and just one technology used content aspects of level 3, where the patient was autonomous in health-related decision-making. The patient takes initiative of communication most often and the communication is one most frequently. However, technologies that use interactive two-way communication between patient and healthcare professional, of which the studies are also published more recently, reach higher levels of self-management.

Conclusion: There is no prevailing guideline for the design of e-health self-management technologies for COPD patents. Future studies should focus on the design of e-health technologies reaching higher levels of self-management, by that conceding autonomous health-related decision-making to the patient.

Abstract

Doel: Deze scoping review van veertien studies wordt uitgevoerd om zelfmanagement voor COPD-patiënten via e-health te onderzoeken en om belangrijke concepten ervan in kaart te brengen. Daarbij worden inhoudelijke aspecten, het niveau van zelfmanagement en de vorm van technologie en communicatie geanalyseerd.

Achtergrond: Chronische obstructieve longziekte (COPD) is een toenemende doodsoorzaak. E-health biedt mogelijkheden om het actieve zelfmanagement voor COPD-patiënten om hun gezondheid te ondersteunen en te verbeteren. Tot op heden, is de literatuur over e-health zelfmanagement voor COPD schaars.

Method: Een uitgebreide zoekstrategie werd ontworpen en in acht verschillende databases geïmplementeerd. De zoektocht heeft 110 studies geïdentificeerd. 48 abstracts werden onderzocht, wat resulteert in 21 full-tekst recensies. Een uiteindelijke sample van 14 studies is onderzocht en samengevat. Om de onderzoeksvragen te beantwoorden, is een vooraf gedefinieerde framework gebruikt om de inhoudelijke aspecten van zelfmanagement voor COPD-patiënten, het niveau van de activiteit in zelfmanagement en de vormen van e-health technologie en communicatie te extraheren.

Resultaten: De meeste technologieën gebruiken maximaal zes verschillende inhoudelijke aspecten. Het vaakst voorkomende inhoudelijke aspect is "symptom management". Met betrekking tot het niveau van de activiteit in zelfmanagement, is vast te stellen, dat het merendeel van de technologieën inhoudelijke aspecten van meer dan een niveau van zelfmanagement gebruikt. De helft van de technologieën gebruikt inhoudelijke aspecten van niveau 0 en alle technologieën benutten inhoudelijke aspecten van niveau 1. Significant minder technologieën gebruiken inhoudelijke aspecten van niveau 2 en slechts een technologie maakt gebruik van inhoudelijke aspecten van niveau 3, waarbij de patiënt autonoom is in het nemen van gezondheid gerelateerde beslissingen. De patiënt neemt het initiatief van communicatie het vaakst en de meest voorkomende communicatie is eenrichtingscommunicatie. Echter, technologieën die interactieve tweeweg communicatie tussen patiënt en zorgverlener gebruiken, waarvan de studies ook meer recent zijn gepubliceerd, bereiken een hoger niveau van zelfmanagement.

Conclusie: Er is geen overheersende richtlijn voor het ontwerpen van e-health zelfmanagement technologieën voor COPD- patiënten. Toekomstig onderzoek moet gericht zijn op het ontwerpen van e-health technologieën die hogere niveaus van zelfmanagement te bereiken, door toe tegeven aan autonome gezondheid gerelateerde besluitvorming van de patiënt.

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Dedication

I dedicate this Master Thesis to my father, who always stood behind me and knew I would succeed, especially when I did not.

"Führend gehst du mir voraus, bleibst treu an meiner Seite und stehst doch immer hinter mir. Dafür Papa danke ich Dir."

Daddy, I love you forever and always.

And above all, I dedicate this Master Thesis to my mother who suffered from COPD since five years and died by lung cancer as a long-term consequence of COPD on 21st April 2016, after she lost her fight of 4 months and 13 days. Every single page is dedicated to you, because without you, I would have probably never written this Thesis. As you said,

"Menschen gehen, aber Erinnerungen bleiben für immer und ich liebe Dich bis zum Mond und zurück."

Acknowledgement

I would like to express my gratitude to my supervisor M.Sc. Floor Sieverink and Prof. Dr. Lisette van Gemert-Pijnen for the useful comments, remarks and engagement through the learning process of this master thesis. Furthermore, I would like to thank you both for your understanding of my personal situation and your willingness to supervise and support me even though it was a little more complicated, because my situation made feedback over a distance often necessary.

1. Introduction

1.1 COPD

Chronic obstructive pulmonary disease, an airflow obstruction disease with the shortened form COPD, is one of the global leading causes of morbidity and mortality. At this point of time, COPD is the fourth leading cause of dead worldwide. In 2020 it will rise up to the third leading cause of dead worldwide [1].

The global prevalence of COPD is 7.6% and significantly more males are affected, but the number of female COPD patients rises rapidly. The average incidence of COPD is 2.9% per year. The prevalence in 2011 shows that 361.781 people are diagnosed with COPD and the incidence is also high with 32.495 people, in absolute numbers [2]. COPD is an umbrella -term for the combination of chronic bronchitis, small airway obstruction and lung emphysema that lead to a persistent reduced maximum expiratory flow and slow forced emptying of the lungs [3].

The disease is progressive and characterized by a decrease in the lung elasticity, affecting the tissue of the lung. People who suffer from COPD experience a permanent narrowing of the air passages [4]. The damage of the lung is irreversible, usually progressing and is not fully recoverable with medical treatment.

1.2 Symptoms of COPD

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 a feeling of chest tightness are noticed [4]. Because of the fact that COPD is progressive, the symptoms deteriorate in more severe stages. Especially in progressed stages, the frequency of exacerbations rises. Exacerbations are defined as an acute and sustained worsening of the patient's condition, which demand a modification in the medical treatment [5,6].

With progression of the disease, multiple morbidities as cardiovascular disease, osteoporosis, loss of muscles and weight, diabetes, lung cancer and depression can accompany COPD [7]. The causes of COPD are multifactorial. Undoubtedly the commonest risk factor in the developed world is tobacco smoke [8]. There are also environmental factors found to contribute to COPD, such as the exposure to air pollution, various dusts, chemicals, vapours and fumes, for example in workplace [9].

Infections play a major role in the development and the progression of the COPD as well. Repeated respiratory tract infections, especially in childhood are found to cause a predisposition for the disease [10].

A genetic factor found to contribute to the development of COPD is a lack 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 risk increases even more, if the person is smoker or often exposed to tobacco smoke [11].

According to the GOLD stage model, a categorization of four stages of the severity of the disease is made, based upon pulmonary function. With the progression of the disease, more symptoms occur, the severity of the impairment increases and the quality of life decreases [12]. People who suffer from COPD do not only experience the abovementioned symptoms, they are also impaired in their physical condition and social life, they were used to have. The loss of control and independence, the social isolation or the fear of dying, COPD patients experience, can lead to anxiety or depression [13]. Furthermore, COPD leads to psychosocial consequences, because people who suffer from COPD experience to be stigmatized. The stigma develops as COPD patients are held responsible for their illness, because it is focused on their smoking behavior as the cause of the disease. The oxygen equipment or body changes can lead to social stigmatization, too. These findings are underpinned by this diseases' colloquial name "smokers' lung" [14].

Next to that, there are significant disease-related economic costs. With 956 million euro, COPD caused 1.3% of the total health care costs solely in the Netherlands in 2013 [15]. Even though there is no complete cure of COPD, treatment is necessary for different reasons. With an individually adapted treatment it is possible to slow down the progress of the disease and to reduce the symptoms and comorbidities. Moreover, the exercise tolerance can be improved, so the person can be more active than without treatment. Next to that, treatment is needed to improve the overall health of the affected person and the quality of life. During the progress of the disease, the frequency of exacerbations and complications become more frequent, which makes treatment absolutely essential [16].

The treatment of COPD can be categorized into medical treatment and drug-free therapies. In the medical treatment, bronchodilators are used to extend the bronchias, so that breathing gets facilitated. With a progression of the disease, the treatment gets extended by inhalation of corticosteroids, to reduce the occurrence of acute exacerbations. In even more severe stages, patients get provided with liquid oxygen [17].

There are drug-free therapies as well, which are usually used in combination with medical treatment. In drug-free therapies patients learn for example respiratory techniques to facilitate breathing [18]. In drug-free therapy there can also be occupational therapy, behavioral training, educational programs for the management of COPD or relaxation training [19]. Also smoking cessation is an important component in the treatment of COPD patients, because smoking cessation is the only risk factor that can be influenced by behavior change.

All in all, treatment of COPD patients focuses on creating awareness, monitoring changes and alleviating symptoms and enhancing physical functioning of the patient to gain the highest possible quality of life. The aim of self-management is to enable the patients to manage their symptoms or treat themselves in their daily living condition [20]. Since the past decade, self-management becomes the new focus in the treatment of COPD. Therefore, the focus of this study will lie on self-management for COPD patients.

1.3 Self-Management

Self-management refers to health-related decisions or behavior, made by patients with chronic diseases. It is defined as the 'active participation of people in their own health' [21]. It inquires the patients` involvement and emphasizes the patient as an active decision maker, instead of the professionals. Therefore, adopting attitudes and learning skills and entering a partnership with professionals are necessary to manage the disease. Barlow [22] gives a more detailed description and defines self-management as the 'individual's ability to manage symptoms, treatment, physical and psychological consequences and life-style changes inherent in living with a chronic condition. It encompasses the ability to monitor one's condition and to affect the cognitive, behavioral and emotional responses necessary to maintain a satisfactory quality of life'.

Furthermore, self-management can support patients and their families, to help them in understanding their role and managing their day-to-day care, needed for the disease [23]. This support can be described as strategies provided to assist patients to practice self-management [24]. Self-management enables the patient to preserve personal development and the highest possible quality of life, independent from external support. According to Lorig and Holman [23], self-management can be divided into medical management, role management and emotional management. Medical management refers to the correct intake of medication. Role management means an appropriate behavior due to the disease, for example adopting new recreational activities or changing responsibilities in household. Emotional management

describes a shift in the patients' own view to their disease and their future by replacing negative emotions through more accepting emotions for a higher psychological well-being [23]. To develop effective self-management skills, six skills are necessary. They are "decision-making", "resource utilization", "formation of a patient provider partnership", "action planning", and "self-tailoring" [23].

Self-management is especially beneficial for COPD patients, because it is associated with an improved health related quality of life and an improvement in dyspnoea [25]. It is shown that COPD patients who apply self-management skills into their daily life have a higher physical activity level and smoke less cigarettes than COPD patients who do not practice self-management, which is accompanied by cost savings and an improved health [26, 27]. All in all, self-management aims to arouse a higher self-responsibility of the patient in relation to his own health condition, because patients often lack the abilities for effective self-management, which leads to a lower reported health status and a lower reported physical condition [28]. If patients learn how to self-manage themselves effectively, societal and economic costs can be decreased, because patients become able to deal with their disease, with less need of support by professionals. This leads to a higher reported quality of life [29].

1.4 Content Aspects of Self-Management

If the future aim is to improve self-management, it is important to identify the content aspects of self-management. A complete overview, showing all content aspects of self-management for COPD patients is missing, but several authors list aspects of self-management, either in general or especially for COPD. Barlow et al. [30] lists general aspects of self-management. According to them, information regarding the disease, drug management, symptom management, management of psychological consequences, life style management, social support and communication make up the components of self-management.

In addition to that, five disease management behaviors are identified for COPD patients to manage their disease and especially to overcome acute exacerbations or dyspnoea attacks. These disease management behaviors are 'symptom management', 'activity and exercise implementation', 'environmental control', 'emotional adaptation' and 'maintaining a healthy lifestyle' [31]. Effing et al [32] extents the list of self-management aspects for COPD patients by 'symptom management', 'exacerbation management', 'smoking cessation', 'physical activity' and 'nutrition'. An overview of the aspects, including a more detailed description is given in Table 1.

Table 1. Content aspects of self-management

	Content Aspect sof self-management	**Barlow et al., 2002 [30]**	**Chen et al., 2008 [31]**	**Effing et al., 2012 [32]**
1	Information (about the disease)	Information about condition and treatment		
2	Symptom Management	Breathing, cognitive symptom management, emergency treatment, sleep, warning signs (e.g. asthma), relaxation, self-monitoring	Reducing activity and resting, breathing control and effective coughing, emergency approaches	Dyspnoea management
3	Exacerbation management			Exacerbation self-recognition and treatment
4	Medication management	Taking medication, adherence	Taking medication regularly	
5	Smoking cessation	Smoking cessation	Quitting smoking	Smoking cessation advice and support
6	Physical activity	Exercise motivation and overcoming barriers, holiday/ leisure activities	Activity and exercise implementation, following rehabilitation instructions, lowering speed and shortening distance, choosing sedentary activities and alternative methods	Physical exercise and physical activities
7	Nutrition	Nutrition and diet		Nutritional advice
8	Environmental management		Environmental control: temperature and humidity, choosing a certain environment, rearranging furniture	
9	Psychological management	Managing emotions, stress, depression	Emotional adaption, positive thinking, accepting fate, getting used to the symptoms	
10	Social support:	Relations with peers and family		
11	Communication	Assertiveness, communication strategies		
12	Goal setting and decision making	Personal goal setting, decision making, problem solving, access support services		

1.5 Levels of Activity in Self-management

The participation of patients in their treatment ranges from passive and dependent on professionals, to active and autonomous disease-related decision-making.

According to Schermer [33], three levels of self-management can be distinguished. In the first level, “Compliant self-management”, the patient becomes an extension of the professionals by taking over tasks, such as measurements. This level does not contain any decision-making, nor autonomy of the patient.

In the second level, the patient becomes a proto-professional, by interpreting measurements and taking action, based on professional advice. The patient becomes able to alter medication dosage or changing lifestyle aspects as diet or activity level. Thereby, the patient gets more executive autonomy and less dependent on professionals, which increases the quality of life. The first and second level can be combined to 'compliant self-management' which intends to promote the patients' own perspective, but does not empower the patient fully.

The third level is called “concordant self-management”. Here, the patient gets enabled and stimulated to daily manage his life conditions, by promoting knowledge, understanding and practical skills, necessary to deal with his conditions. The patient is autonomous in decision-making which does not always have to be conform to professional advices. However, the advantage is that the patients' quality of life increases by integrating the values or ideas into a prescribed medical treatment. The relationship between patient and professional can be described as collaborative, contrasting the first two levels, where the relationship is compliant [33]. The most beneficial level of self-management for the autonomy and wellbeing of the patient is the 'concordant' level, which requires active participation of the patient and the professional. In Table 2, an overview of the three levels of self-management is given.

Table 2. *Levels of activity in self-management*

Level	Name	Description
0	No active self-management	- Patient does not take over any practical task (e.g. educational material provided by the technology)
1	Compliant - lower level	- Patient takes over practical tasks (e.g. measurement)
		- No autonomy or decision-making of the patient
2	Compliant - higher level	- Patient takes over interpretative/ decisional tasks
		- Patient takes action (e.g. adapting medication)
		- executive autonomy
3	Concordant level	- Patient takes own decisions and choices
		- autonomous
		- relationship to professional is collaborative

Up to this point, it is not estimated which levels of self-management are used in interventions for COPD patients. Therefore, this study aims to answer this gap.

1.6 E-health

It is apparent that the problems caused by COPD are becoming larger. As the Internet becomes more and more popular and accessible for the general public, it offers opportunities to support self-management by technological methods [34].

One method which is invented to promote self-management is electronic health management, with the shortened form “e-health”. Even though there is no agreed-upon universal definition, Eysenbach [35] introduced a definition which is widely used today. “E-health is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology”. E-health is regarded as a new care concept, which can be a tool in empowering the self-management abilities of the patients, enabling them to life widely independent with their disease and to manage the symptoms by themselves.

There are different kinds of e-health technologies developed, reaching from simple information websites up to interactive health communication applications with the aim to

improve the well-being of the user [36]. With help of e-health applications, administrative data of the patient can be stored, managed and accessed by a professional at a distance, to provide healthcare [37].

When e-health technologies are implemented as interactive interventions, the offered support can be continuous and adapted to the special needs of the patient [38]. E-health platforms additionally aim to improve the decision-making and the responsibility regarding the patients' health, which is the desire of most patients. This brings up cost savings and contributes to realizing the full potential of the self-management abilities of the patients, at the same time [39].

Although the literature on e-health for COPD patients is scarce, Elbert et al [40] acknowledged in a systematic review, that e-health technologies show to have a positive effect on primary health outcomes in patients with somatic diseases. Another systematic review found that e-health technology had a positive influence on health outcomes, quality of life and satisfaction of chronically ill, such as COPD patients. Additionally, e-health interventions are found to be more cost-effective than usual care [41]. In COPD, e-health is used as an element of long-term management of the disease. Thereby, e-health has shown to facilitate the required monitoring of symptoms to detect and prevent exacerbations. E-health is especially appropriate for COPD patients, because they do not always have the energy to travel long distance to contact professionals. Therefore, e-health can form a suitable alternative by managing their disease without leaving their own domestic environment. In addition to that, e-health can protect patients from imminent medical interventions and it facilitates the early detection or prevention of exacerbations, by monitoring symptoms [42, 43]. Next to that, e-health applications for COPD patients have shown to prevent from hospitalization, because patients become able to manage for example exacerbations by themselves, which leads to additional cost savings and a higher reported quality of life. These findings can be supported by the discovery of Hillestad et al [44], who found that the use of e-health interventions in COPD patients leads to a reduction in days spent in bed sick and with this,less days this being unemployable. This results in significant annual savings. The same author also found out, that the providers and healthcare professionals are another benefitting group. Due to the fact that COPD patients often contact their provider and healthcare professional to receive knowledge about their actual health status, e-health offers the possibility for patients to check their personal data in their e-health account from anywhere at any time. Thereby, healthcare providers can save their time and dedicate apply themselves to more important things instead of just providing information. Consequently,

it is found out that patients feel more secure about their own health if they can monitor and check their data on their own [44].

Certain e-health technologies have also shown to be well accepted by COPD patients [45]. Thus, it becomes clear that e-health applications which aim to put self-management for COPD patients forward, have the potential to enable the patient to handle the disease by themselves and by that, reaching the highest possible quality of life.

1.7 Forms of e-health technology and communication

Just like the definition of e-health is very broad, the devices which are used for e-health are diverse as well. There are e-health applications for different media devices, such as pc's, tablets, PDAs, TVs or smartphones [46]. In addition, monitoring devices, like oximeters, spirometers or accelerometers are used to store and transmit health data of the patient to be assessed by a professional [47, 48]. Also, an e-diary can be used to monitor symptoms or changes regarding the disease [49]. The technologies that are used for delivering the described devices are informational websites, interactive health communication applications, online health care portals and electronic health records [36]. The function of those technologies is to measure and record vital signs or symptoms of the patient, to remind the patient of medication or to provide information or support, with the overarching aim to promote self-management [50]. The communication is another component of e-health. Communication can either be initiated by the patient self, by a professional or by the technology. The interaction in e-health applications can be human-to-human, technology-to-human or human-to-technology.

1.8 Evaluation of e-health technologies

The evaluation of e-health technologies covers a broad range of outcomes: Some studies analyze the cost-effectiveness of e-health interventions, or the relationship of user and professional. Other evaluations of e-health interventions show rather clinical results, for example the benefits of monitoring symptoms of COPD patient [51]. Also, there are studies that show behavioral results of e-health interventions, regarding an improved knowledge about the disease or an improved self-management [26]. Other shown effects describe the usability or satisfaction of user with an e-health intervention [52, 53, 54]. Even though a broad range of evaluation exists already, the form of e-health technologies is insufficiently studied. In Table 3, an overview of the possible forms and types of communication is given.

Table 3. *Forms of e-health technologies, functions, communication outcomes*

Category	**Example**
Device	- PC, smartphone, tablet, PDA, TV website, e-diary - monitoring device (spirometer, oximeter, accelerometer)
Function of the technology	- measure, record data/ symptoms, - monitoring - reminding - access data/ information/ self-management - provide support
Communication	- patient initiated - professional initiated - technology initiated - human-to-human - human-to-technology - technology-to-human
Outcomes	- cost effectiveness - relationship - clinical results - behavioral results - user feedback (usability or satisfaction)

1.9 Development of e-health technologies according to the CeHRes Roadmap

CeHRes Roadmap is a holistic approach to improve the development of e-health technologies in an iterative way. The CeHRes roadmap can be used as a practical guideline to plan, organize and accomplish the development of e-health platforms. [36]. This study can be categorized into the first phase of the CeHRes roadmap, called "Contextual Inquiry". In this phase the goal is to find out who potential users of the e-health technology are and how their environment looks like. Next to that, advantages and disadvantages of actually provided care are examined and it is determined how the technology can be of added value in a certain context.

This scoping review aims to ascertain how the state of the art of e-health technologies for COPD patients looks like. Therefore, this study tries to fill this gap scientifically, to lay the foundation for future improvements in the developmental process of e-health technologies.

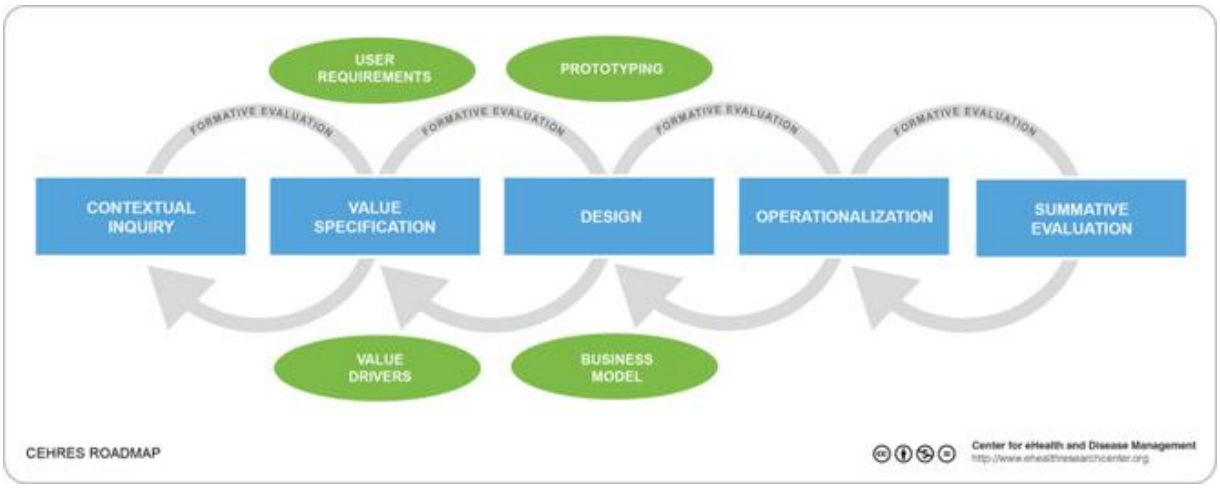

Figure 1. Pictorial Representation of CeHRes Roadmap for the development of e-health technologies

1.10 Aim of this research

Up to this day there is not much research conducted to evaluate self-management support in e-health technologies for COPD patients. There is no comprehensive overview of the content aspects for self-management that are addressed in e-health self-management applications for COPD patients. Especially what levels of active self-management are addressed is not evaluated until now. It is important to examine which levels of self-management are addressed in the development of e-health technologies, because higher levels of self-management are related to the autonomy and wellbeing of the patient [33]. It is therefore important to evaluate which higher and potentially more effective levels of self-management are already embedded in self-management technologies. It is of great importance to estimate the actual development of e-health technologies for COPD patients. This will help to compare the actual development with scientific recommendations for effective e-health technologies. Furthermore, it is unknown what forms of e-health technology and communication are used in self-management applications for COPD patients. Another point, underlining the importance of the self-management in combination with e-health is the actual development and importance of online media. In present time nearly everyone has access to the Internet and accompanied to web based applications, technologies and also social media. In times of rural depopulation of healthcare professionals, it is easy, simple and proportionally cheap for healthcare professionals to reach and monitor their patients from distance by the help of web based technologies [55].

Three research questions are constructed to bridge this gap scientifically:

1) What content aspects for self-management are addressed in e-health technologies for COPD patients?

2) What levels of active self-management are addressed in e-health technologies for COPD patients?

3) What forms of e-health technology and communication are used in 1 and 2?

2. Method

This research is conducted through a scoping review, aiming to map key concepts of complex research areas [56]. 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.

2.1 Databases

A systematic research is conducted to collect publications related to COPD, self-management and electronic health platforms. The publications are derived from standard bibliographic databases for medical sciences, social sciences and technology. More specifically, Scopus, Web of Science, PubMed, Science Direct, Google Scholar, Picarta, PsychInfo and IEEE Explore are used for data collection.

2.2 Search Strategies

The described databases are visited and searched with help of an advanced search filter. Therefore, the following three search concepts are combined. The main three search concepts are: 'COPD', 'self-management' and 'e-health'. For these concepts, expressions, synonyms and alternative writing styles are devised, as shown in Table 4. Subsequently, there is a pool of existing studies with the requested topic identified.

Table 4. *Search strategy*

Search fields	Search terms
TITLE-KEY	COPD OR "chronic obstructive pulmonary disease"
	AND "self-management" OR "self care" OR "self help"
	AND "eHealth" OR "e-health" OR "telehealth" OR "internet" OR "web" OR "online" OR "application" OR "mobile*" OR "m-health" OR "mHealth" OR "eCoach" OR "e-coach"

2.3 Article Selection

To meet the requirements of this scoping review, articles had to fulfill some predefined criteria. First, the selected articles had to focus on (1) e-health technologies designed for COPD patients, and (2) with the aim to improve or support self-management skills. Furthermore, only original articles that are available in the English language and in full-text and that are published between 2005 and 2016 were included in this review. This timeframe is chosen, because it gives a comprehensive overview of the literature over the topic, which is the aim of a scoping review [57]. Articles were not included if they did not fulfill the mentioned criteria or if their study design was a systematic review, a protocol or a design study and by that no results were described in the article. Furthermore, studies which solely focus on telemonitoring are excluded, because the primary function of telemonitoring is to monitor the patient from a distant and not to provide a tool for self-management [58]. For a better understanding, the in- and exclusion criteria are summarized in Table 5.

Table 5. *In- and exclusion criteria of articles*

Criteria	Inclusion	Exclusion
Year of publication	2005 to 2016	
Language	English	
Thematic accordance	E health for COPD and self-management	Focus on telemonitoring only
Design of the study		Review, protocol or design study

After the first search process, a total of 110 articles is found. Out of these 110 articles, 38 duplicates are excluded. The remaining 72 articles are reviewed for the title. After that, again

24 articles are excluded based on their title, because they did not meet up the criteria mentioned above. Then, 48 abstracts are reviewed and 27 of them are excluded. 21 articles are reviewed for full text. The number of finally found 14articles are rated by a predesigned extraction schedule (available in Appendix 1), based on the information given in the articles. Figure 2 shows the selection process of articles and the reasons for exclusion in every step.

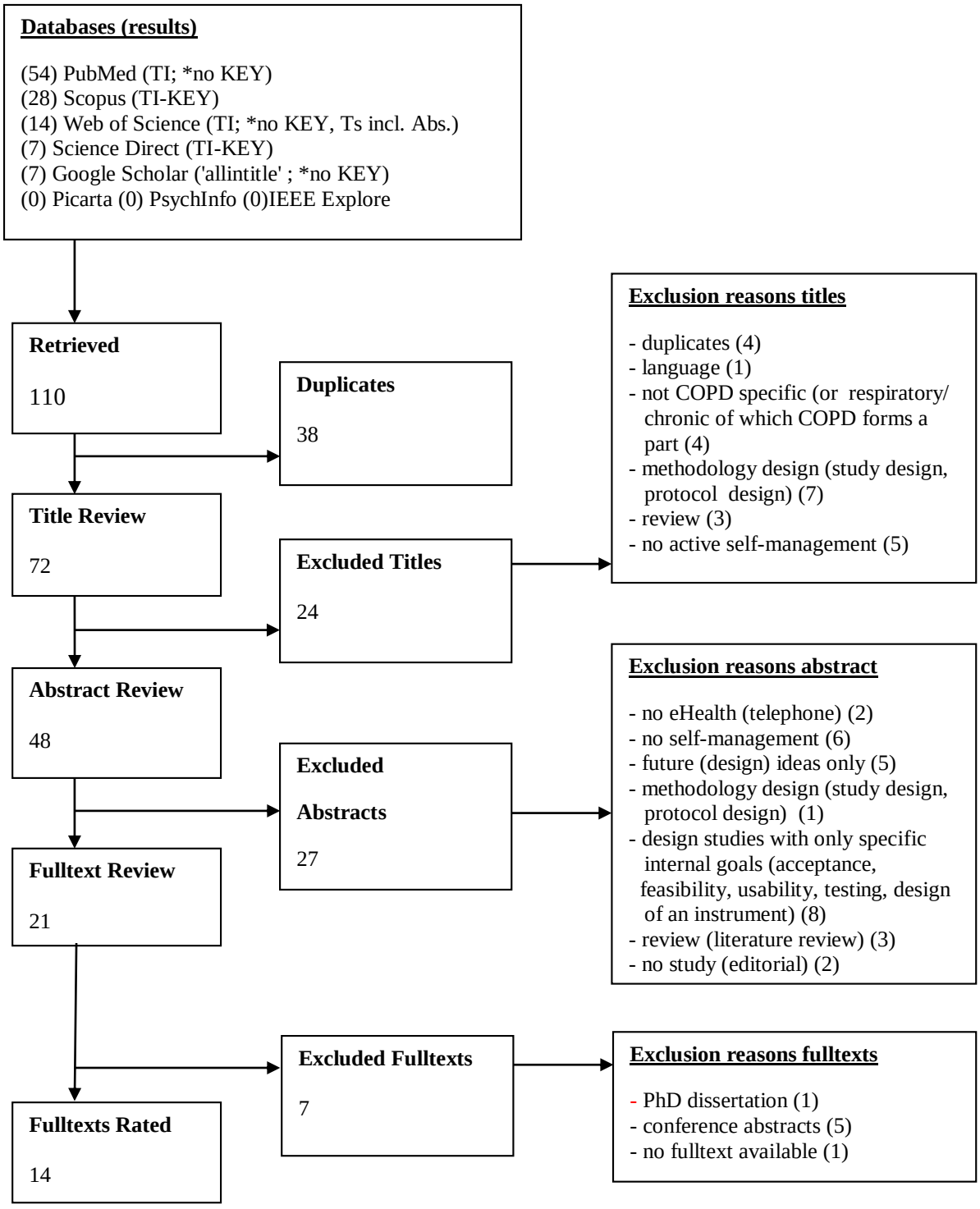

Figure 2. Flow chart of selection process for eligible articles. Applied criteria for inclusion were (1) thematic accordance of content, e- health platforms designed for COPD patients; (2) content dealing with self-management for COPD patients; (3) the publication date was January 2005 to January 2016; (4) the research publication is available in English language.

2.4 Data Extraction

Since the results of this study are summarized, analyzed and interpreted later, the aim of the data extraction is to collect and present the findings in a concise way [59]. Therefore, a predesigned scheme is used to extract important data in a structured form to identify key features. Among others, the description, the elements and the level of self-management, of e-health platforms 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. The data extraction form can be found in Appendix 1.

2.5 Data Analysis

Two main processes are followed to derive the final answer to the research questions. 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 extraction form (available in Appendix 1).

The second process was to find underlying key concepts between the studies, which is the main purpose of a scoping review [57]. Therefore, patterns within the identified studies were taken together, to give a comprehensive answer to the research question. First, it was analyzed which content aspects for self-management are targeted in the e-health intervention. Second, the levels of active self-management according to Schermer [33] are addressed. Third, it is evaluated which forms of e-health technology and communication are used. Therefore, the following factors are included in the table: author, year of publication, location, design of study, type of self-management instrument provided, type of study (e.g. protocol, usability of platform or effect of platform), and additionally, the level of the active self-management of the patient. By that, an answer can be given on the question, how far the development of self-management e-health platforms for COPD patients is until now.

3. Results

Primarily, an overview of the description of the fourteen studies is given. In second paragraph the content aspects of e-health technologies for self-management for COPD patients are presented. In the third paragraph, the levels of active self-management in the different e-health technologies are shown. In the fourth paragraph, the form of e-health technologies and communication used in content aspects and self-management via e-health for COPD patients are described.

3.1 Description of the studies

The fourteen studies on e-health self-management technologies for COPD patients are written by ten different first authors and concern ten different e-health technologies. One author published four articles, of which three articles address the same e-health technology and one article describes another e-health technology [60-63]. One author has published two articles describing the same e-health technology [26, 64]. Furthermore, two different authors published one article each on the same e-health technology [65, 66]. The other six authors each published one article about each one technology [48, 67-71]. All studies were published between 2005 and 2016.

The technologies vary widely in their content and they use different devices, as phones [48, 63, 67, 68, 70, 71], tablets [65, 66], TV [69] and different monitoring devices [48, 60-63, 66, 67, 71]. The functions of the technologies vary from education, monitoring or teleconsultation, with the aim of self-management support.

The type of the studies that were used to evaluate the e-health technologies are pilot studies, RCT's, quasi experiments, clinical trials, observational studies, qualitative studies, mixed method studies and cohort studies. The number of participants in every study reaches from 10 to 1325 participants. An overview of the study descriptions is given in Table 6.

Table 6. *Overview of the studies*

Author, (year) location	Project Description	Aims	Study Design	n
Nguyen USA	Internet-based dyspnoea self-management program (iDSMP) for COPD patients			
2005 [60]		Determine the feasibility and acceptability of a nurse-facilitated, internet-based dyspnoea self-management program	Pilot study without control group	16
2008 [61]		Compare the efficacy of an internet-based (eDSMP) and a face-to-face (fDSMP) dyspnoea self-management programs on the primary outcome of dysapnoea	RCT + concealed allocation	50 39 completed eDSMM = 26 dDSMP= 24
2013 [62]		Test the efficacy of an internet-based (eDSMP) and a face-to-face (fDSMP) dyspnoea self-management compared with general health education (GHE) on the primary outcome of dyspnoea with activities	RCT	125 110 completed eDSMM = 38 fDSMP= 35 GEHE= 37
Nguyen (2009) USA [63]	Cell phone-based exercise persistence intervention to enhance self-management for patients with COPD	Determine the feasibility and efficacy of a first generation cell phone-based exercise persistence intervention for patients with COPD	Quasi-experimental study with randomization	17 MOBILE-Choached= 9 MOBILE-Self-Monitored= 8
Kim et al. (2012) Korea [67]	Ubiquitous health services (u-health): telemonitoring and teleconsultation for COPD patients	Investigate the effectiveness in improving the patient's knowledge about COPD self-management, u-health usage skills and attitudes. Investigate if u-health delivered by voice or video is more effective	Quasi-experimental study without control group	144 EG1= 78 EG2= 26 EG3= 20

Table 6. *Overview of the studies - continued*

Author, (year) location	**Project Description**	**Aims**	**Study Design**	**n**
Barberan-Garcia et al. (2013) Spain, Norway, Greece [71]	Community.based cardiopulmonary rehabilitation (CPR) and self-management program, supported by ICT for COPD patients	Assessment of a community-based CPR and self-management program, supported by ICT. Minimize or overcome limitations in long term sustainability of training-induced effects on exercise into a healthier lifestyle leading to enhanced quality of life	Overall pragmatic clinical trial, partly randomized	154
De San Miguel et al. (2013) Australia [68]	Telehealth monitoring for COPD patients	Assess self-monitoring via home-based telehealth equipment, combined with ongoing remote monitoring by a nurse. Assess knowledge on health service utilization, cost-effectiveness and any associated benefits of telehealth monitoring.	RCT	71 Intervention= 36 Control= 35
Tabak et al. (2014) Netherlands [48]	Telehealth intervention as blended care in patients with COPD	Investigate the use of and satisfaction with a COPD telehealth program applied in primary and secondary care.	Pilot RCT	12
Voncken-Brewster et al. Netherlands	Web-based patient self-management support application			
2014 [26]		Assess the feasibility of integrating a web-based patient self-management support application into the existing disease-management approach	Observational study without control group	11
2016 [64]		Test the effectiveness of a web-based computer-tailored COPD self-management intervention	RCT	1325 Intervention= 662 Control= 663

Table 6. *Overview of the studies - continued*

Author, (year) location	**Project Description**	**Aims**	**Study Design**	**n**
Burkow et al. (2015) Norway [69]	Internet-enabled home program	Assess patient acceptability of the delivery mode and components of a comprehensive pulmonary rehabilitation program for any stage of COPD, as well, as technology usability, patient outcomes and economic aspects	Mixed Method Pilot study	10
Williams et al. (2014) UK [65]	Multi-component mHealth intervention, delivered via a tablet computer	Evaluate the efficacy of a multi-component mHealth intervention, delivered via a tablet computer, to improve quality of life in patients with COPD. To complement current clinical care pathways to support self-management behavior	Qualitative study	19
Hardinge et al. (2015) UK [66]	Mobile telehealth based (mHealth) application on a tablet for COPD patients	Develop and test the efficacy of an internet-linked tablet computer based mobile health (mHealth) system	Cohort Study	18
Verwey et al. (2016) Norway [70]	Monitoring and feedback tool to support COPD and diabetes patients in achieving an active lifestyle	Evaluate the performance, acceptance and user-satisfaction of a tool to stimulate physical activity.	Three armed RCT	120

3.2 Content aspects of self-management via e-health for COPD patients

In the three studies of Nguyen [60-62] which all describe the same technology, four content aspects of self-management for COPD patients are addressed. In another study of the same author, regarding another technology, five content aspects are addressed. In the two studies of Voncken-Brewster et al [26, 64], about the same technology, six content aspects of self-management are mentioned. The other studies each contained between two and nine content aspects.

The content aspect that was addressed most frequently, more precisely in nine out of ten technologies is "Symptom management" [26, 48, 60-63, 65-69, 71] "Exacerbation management" was addressed eight times [26, 48, 60-63, 65-67, 69]. With seven times, "Physical activity" was mentioned slightly less frequent [26, 48, 60-63, 69-71]. "Information" regarding COPD and its treatment was addressed in five out of ten technologies [63, 65, 66, 70, 71]. “Goals” were also mentioned in five out of ten technologies [26, 48, 60-63, 70]. "Medication management" was included in four technologies [26, 48, 65, 66, 69]. Three technologies addressed "Smoking cessation" [26, 65, 66, 69]. Next to that, two technologies addressed "Nutrition"[65, 66, 69]. Seldom offered in each one technology were "Psychological management" and "Social support" [69]. "Environmental management" and "Communication" were not mentioned at all. An overview of the content aspects is given in Table 7.

Table 7. *Content Aspects of self-management for COPD patients*

Author (Year)	Information	Symptom management	Exacerbation management	Medication management	Smoking cessation	Phys. activity	Nutrition	Environmental management	Psychol. management	Social support	Communication	Goals, Info. problems
Nguyen (2005; 2008; 2013) [60, 61, 62]		x	x			x						x
Nguyen (2009) [63]	x	x	x			x						x
Kim et al. (2012) [67]		x	x									
Barberan-Garcia et al. (2013) [71]	x	x				x						
De San Miguel et al. (2013) [68]		x	x									
Tabak et al. (2014) [48]		x	x	x		x						x
Voncken-Brewster et al. (2014, 2016) [26, 64]		x	x	x	x	x						x
Williams et al. (2014), Hardinge et al. (2015) [65,66]	x	x	x	x	x		x					
Burkow et al. (2015) [69]	x	x	x	x	x	x	x		x	x		
Verwey et al. (2016) [70]	x					x						x

3.3 Levels of activity in self-management via e-health for COPD patients

All analyzed studies contained elements that address the first level of activity in self-management for COPD patients, where the active tasks of the patient consisted of monitoring health-related values [26, 48, 60-63, 65, 67-71].

Seven studies also included elements without any active task for the user, such as the presentation of disease- and treatment-related educational material [48, 63, 65-67, 69-71]. Five studies also included elements addressing the second level of self-management, such as the treatment of exacerbations by the patient himself or adapting behavior according to the results of specific measurements [26, 48, 60-62, 66, 70]. Only one study addressed the highest level of self-management by including the creation of personal-life goals and making decisions to fulfill these goals [70].

3.4 Evaluation of used devices and tools for e-health, depending on the level of self-management

3.4.1 Self-management level 0

Seven technologies cover aspects of self-management level 0, whereby smartphone and tablet are the devices most often used followed by computers and TV. In one study, a healthcare professional takes over a function of a device in this level of self-management [67]. This means that the healthcare professional visits the patient at home and carried out tasks, which were in other technologies performed by the e-health technology. The most frequent tool, provided on the devices, is educational material. The function of the technology is most often education, followed by motivating the patient in changing behavior and using the technology through sending motivational cues or prompts. Whereby cues serve as a reminder to begin a task and prompts are used to motivate and encourage the patient to begin a certain task. In level 0, communication mostly goes from the client. Thereby, the client has to take action by himself most often, such as executing exercises or reading presented information. This initiative of action taking is a little bit less often taken by the technology, through sending cues or prompts for example. The interaction goes mostly from technology-to-human, because the technology presents information or sends prompts very often. The interaction from human-to-technology is less common, because the patient does not have to input information frequently. The interaction from human-to-human via technology is not provided in level 0. An overview of

devices and tools for e-health, depending on the level of self-management, initiative- and interaction- groups is given in Table 8.

Table 8 *Level 0 -Devices and tools for e-health, depending on the level of self-management, initiative- and interaction-groups*

Author (Year)	**Device**	**Tool**	**Initiative***				**Function**	**Interaction****			
			T	CL	HCP	2		H>H	H>T	T>H	H<>H / T
Kim et al. (2012) [67]	Healthcare Professional who takes over the function of a technology	Supplementary Home visits		x	x		Establish u-health service + control of difficulties in uitilization	x			
Barberan-Garcia et al. (2013) [71]	Smartphone	Website and CPR-program		x			Educational training		x	x	
		SMS	x				Prompts for adherence			x	
Tabak et al. (2014) [48]	Smartphone	Web-based exercise program	x	x	x		Pat. Executes exercise, feedback is sent to physiotherapist		x	x	
							Education of exacerbations		x	x	
							Daily motivational cues			x	

Table 8 *Level 0 -Devices and tools for e-health, depending on the level of self-management, initiative- and interaction-groups* - continued

Author (Year)	**Device**	**Tool**	**Initiative***				**Function**	**Interaction****			
			T	CL	HCP	2		H>H	H>T	T>H	H<>H (T)
Williams et al. (2014) [65]	Tablet	Multimedia educational + self-management material	x	x			Information on smoking cessation, diet, and breathing techniques, as well as video information on the correct use of inhalers			x	
Burkow et al. (2015) [69]	TV with internet, remote control, camera, headset	Video- and text-based material	x	x			Health education	x	x		
Hardinge et al. (2015) [66]	Tablet	Multimedia educational material	x	x			Information on smoking cessation, diet, breathing techniques, use of inhalers			x	
Verwey et al. (2016) [70]	Computer/ Smartphone	Online web lecture	x	x			Information on disease+ phys. activity			x	

Note. *Initiative: T= Technology; CL= Client, HCP= Healthcare Professional; 2= Client and Healthcare Professional in the same amount; **Interaction: H>H= Human to Human; H>T= Human to Technology, T>H= Technology to Human; H<>H (T)= Human to Human via Technology

3.4.2 Self-management level 1

In level 1, smartphones are used most frequently as a device. PDAs (predecessor of the smartphone), computers, tablets and TVs are used less often. Smartphones are in itself often used for monitoring, but they are also often linked to different monitoring devices like spirometers, accelerometers, pulse oximeters or electronic stethoscopes linked.

The tools provided by the devices are questionnaires and e-symptom-diaries. Communication tools, such as SMS, E-Mail or teleconsultation modules are used very rarely for supporting level 1 self-management skills. Furthermore, a behavior change module is used only one time. The functions of the different devices are monitoring and recording of patient's physical and symptom data most often. Self-management for exacerbation and home exercising are each addressed one time. The initiative of action in level 1 is taken as often by the client, as by the technology. The healthcare professional takes action a little bit less frequent. Initiative taking by client and HCP in the same proportion is very rarely.

The way of interaction in level 1 is most often from human-to-technology, followed by the interaction between human-to-human and technology-to-human in the same amount. The interaction from human-to-human via technology is significantly less frequent. An overview of devices and tools for e-health, depending on the level of self-management, initiative- and interaction-groups is given in Table 9.

Table 9. *Level 1 -Devices and tools for e-health, depending on the level of self-management, initiative- and interaction-groups*

Author (Year)	**Device**	**Tool**	**Initiative***				**Function**	**Interaction****			
			T	CL	HCP	2		H>H	H>T	T>H	H<>H T
Nguyen (2005, 2008 & 2013) [60, 61, 62]	PDA	Website	x	x	x		Individual face-to-face training, education	x			x
		Airwatch	x	x			Monitor respiration		x		
		Questionnaire	x				Record symptoms + dyspnoea		x		
		E-diary	x	x			Record exercise		x		
Nguyen (2009) [63]	Smartphone	Exercise booklet	x	x			Monitoring of symptoms + exercises	x	x	x	
		Pedometer	x				Monitoring exercises		x		
		Text messages	x		x		Reinforcement, supportive feedback	x		x	
		Action Plan	x	x	x		Exacerbation-management	x	x	x	

Table 9. *Level 1 -Devices and tools for e-health, depending on the level of self-management, initiative- and interaction-groups* - continued

Author (Year)	**Device**	**Tool**	**Initiative***				**Function**	**Interaction****			
			T	CL	HCP	2		H>H	H>T	T>H	H<>H / T
Kim et al. (2012) [67]	Spirometer, pulse oximeter, electronic stethoscope	Telemonitoring platform	x				Monitoring of symptoms + data transmission				
	Smartphone			x	x		Teleconsultation via voice and video/ pat. education by teleconsultation nurse, integrating data from the measurement devices	x	x		
Barberan-Garcia et al. (2013) [71]	Smartphone	Questionnaire	x	x			Monitor leg discomfort during exercise; monitor duration + intensity of exercise		x	x	
		SMS	x	x			Prompts for System adherence		x	x	

Table 9. *Level 1 -Devices and tools for e-health, depending on the level of self-management, initiative- and interaction-groups* - continued

Author (Year)	**Device**	**Tool**	**Initiative***				**Function**	**Interaction****			
			T	CL	HCP	2		H>H	H>T	T>H	H<>H / T
		Personal Health Folder	x				ICT- supported exercise plan + counseling in five domains: a) Questionnaires b) Agenda c) Follow-up d) educat. Information e) Information sharing	x	x		
	Oximeter	Linkcare platform for the case-manager)	x		x		Recording data for reviewing by the case-manager	x	x		
De San Miguel et al. (2013) [68]	Phone		x	x	x		Monitor phys. data, dyspnoea + communication between nurse and client, discussing measurement + support +making appointments	x	x		

Table 9. *Level 1 -Devices and tools for e-health, depending on the level of self-management, initiative- and interaction-groups* - continued

Author (Year)	**Device**	**Tool**	**Initiative***				**Function**	**Interaction****			
			T	CL	HCP	2		H>H	H>T	T>H	H<>H / T
		HealthHUB TM	x	x			Daily measure & record of vital signs		x		
		Questionnaire	x	x			Daily rating of general health		x		
		Telehealth web site	x				Recording of recommendations/ actions taken			x	
Tabak et al. (2014) [48]	Smartphone	E-diary	x	x	x	x	Self-management for exacerbations, decisions-support diary identifies exacerbations	x	x	x	x
		Web-based portal	x	x	x		Home exercising: breathing exercises, relaxation, mobilization, resistance & endurance training, mucus clearance		x	x	

Table 9. *Level 1 -Devices and tools for e-health, depending on the level of self-management, initiative- and interaction-groups* - continued

Author (Year)	**Device**	**Tool**	**Initiative***				**Function**	**Interaction****			
			T	CL	HCP	2		H>H	H>T	T>H	H<>H / T
		Teleconsultation module				x	exchange comments and questions with physiotherapist				x
	Accelerometer		x	x	x		Activity monitoring		x		
Voncken-Brewster et al. (2014) [26] Voncken-Brewster et al. (2016) [64]	Computer	Questionnaire	x	x			a) pat. demographics b) health related questions (smoking behavior, phys. activity, medication adherence)		x	x	
		Behavior-change module		x			Five components: motivational believes, social influence, action planning, self-efficacy, maintenance, feedback		x	x	

Table 9. *Level 1 -Devices and tools for e-health, depending on the level of self-management, initiative- and interaction-groups* - continued

Author (Year)	**Device**	**Tool**	**Initiative***				**Function**	**Interaction****			
			T	CL	HCP	2		H>H	H>T	T>H	H<>H / T
		Feedback messages	x		x		Feedback a) deviated from questionnaire, tailored to demographics b) recommendations by practice nurse			x	x
		Reports to nurses	x		x		Rating of pat. data			x	
			x		x						
Williams et al. (2014) [65]	Tablet	Symptom diary	x		x		Monitoring of symptoms		x		
Hardinge et al. (2015) [66]	Tablet	Symptom diary	x	x	x		Questions about general well-being, COPD+ exacerbation symptoms		x		
		Pulse oximeter	x	x	x	x	Remote self-monitoring, reviewed by respiratory nurse	x	x		

Table 9. *Level 1 -Devices and tools for e-health, depending on the level of self-management, initiative- and interaction-groups* - continued

Author (Year)	**Device**	**Tool**	**Initiative***				**Function**	**Interaction****			
			T	CL	HCP	2		H>H	H>T	T>H	H<>H / T
Burkow et al. (2015) [69]	TV, remote control, camera, headset	Communication	x	x			Audiovisual communication with healthcare professional	x	x		
		health diary	x	x			Disease related questions, vital signs		x		
		Hospital Information System (HIS)				x	Secure message transmission		x		
		Online group education	x	x	x						
Verwey et al. (2016) [70]	Smartphone/ Computer	E-diary		x			Record daily activity and examine questions about barriers + facilitators for phys. Activity		x		

Table 9. *Level 1 -Devices and tools for e-health, depending on the level of self-management, initiative- and interaction-groups* - continued

Author (Year)	**Device**	**Tool**	**Initiative***				**Function**	**Interaction****			
			T	CL	HCP	2		H>H	H>T	T>H	H<>H (T)
		Questionnaires		x			Estimate phys. activity + health, information			x	
		Mail		x	x		Examination + evaluation of: activity results, barriers, facilitators, creation of new phys. activity habits	x			x
		Activity monitor		x			Measure and record activity		x		

Note. * Initiative: T= Technology; CL= Client, HCP= Healthcare Professional; 2= Client and Healthcare Professional in the same amount; Interaction: H>H= Human to Human; H>T= Human to Technology, T>H= Technology to Human; H<>H (T)= Human to Human via Technology

3.4.3 Self-management level 2

In level 2 many different devices are used and there is no pattern recognizable. But it can be seen that smartphone and computer are used a little more frequent than tablet and PDA, but not remarkably. In addition to that, there are tools as communication tools, E-diary, behavior change modules and self-management modules used, but no dominating tool can be estimated The functions of the tools differ widely, whereby monitoring, self-management, changing of behavior and feedback can be named as tools, but no dominating function can be found. The communication is initiated by the client most often, closely followed by technology and healthcare professional. The interaction of communication is frequently from human-to-technology and closely followed by the interaction of technology-to-human. A little less common are human-to-human interaction and interaction from human-to-human via technology. An overview of devices and tools for e-health, initiative- and interaction- groups in level 2 is given in Table 10.

Table 10. *Level 2 -Devices and tools for e-health, depending on the level of self-management, initiative- and interaction-groups*

Author (Year)	**Device**	**Tool**	**Initiative***				**Function**	**Interaction****			
			T	CL	HCP	2		H>H	H>T	T>H	H<>H T
Nguyen (2005) [60] Nguyen (2008) [61] Nguyen (2013) [62]	PDA	E-mail	x		x		Feedback, support, communication, individual exercise plans + pat. sets goals, summary of exercises, monitoring of dyspnoea + pulmonary function, feedback, support, communication				x
		Live text chat		x	x		Individual- and grouptraining				x

Table 10. *Level 2 -Devices and tools for e-health, depending on the level of self-management, initiative- and interaction-groups*

Author (Year)	**Device**	**Tool**	**Initiative***				**Function**	**Interaction****			
			T	CL	HCP	2		H>H	H>T	T>H	H<>H T
Tabak et al. (2014) [48]	Smartphone	Web Portal	x	x	x		Self-management module, that enables patients to treat exacerbations themselves without intervention of a professional	x		x	
		E-diary	x	x			Decision-support diary to identify exacerbations	x		x	
Voncken-Brewster et al. (2014) [26] Voncken-Brewster et al. (2016) [64]	Computer	Behavior Change Module		x	x		Pat. chooses one behavior change objective (smoking cessation, medication adherence or physical activity) for three month	x	x	x	
		Messages	x		x		Feedback and recommendations			x	X

Table 10. *Level 2 -Devices and tools for e-health, depending on the level of self-management, initiative- and interaction-groups*

Author (Year)	**Device**	**Tool**	**Initiative***				**Function**	**Interaction****			
			T	CL	HCP	2		H>H	H>T	T>H	H<>H (T)
Hardinge et al. (2015) [66]	Tablet	Self-management module	x	x			Advice on managing COPD including diet, medicine use and inhaler technique, receiving messages from nurse, personalized self-management plans		x	x	
Verwey et al. (2016) [70]	Smartphone/ Computer	E-diary		x			Pat. adapts activity according to measurements + collaborative goal setting		x		

Note. * Initiative: T= Technology; CL= Client, HCP= Healthcare Professional; 2= Client and Healthcare Professional in the same amount; ** Interaction: H>H= Human to Human; H>T= Human to Technology, T>H= Technology to Human; H<>H (T)= Human to Human via Technology

3.4.4 Self-management level 3

Only one study, that includes characteristics of level three [70]. The used devises are computer and smartphone, of which the patient can make a choice for one of the two devices. Both devices use the e-diary as tool. Here the patient makes decisions and takes choices by himself to fulfill life-goals, which were earlier set by the patient. The patient takes over initiative, communication goes on between him and the device, also between patient and the healthcare professional. An overview of devices and tools for e-health, initiative- and interaction- groups in level 3 is given in Table 11.

Table 11. *Level 3 -Devices and tools for e-health, depending on the level of self-management, initiative- and interaction-groups*

Author (Year)	**Device**	**Tool**	**Initiative***				**Function**	**Interaction****			
			T	CL	HCP	2		H>H	H>T	T>H	H<>H (T)
Verwey et al. (2016) [70]	Smartphone/ Computer	E-diary		x			Making decisions and choices to fulfill earlier set life-goals	x	x		

Note. *Initiative: T= Technology; CL= Client, HCP= Healthcare Professional; 2= Client and Healthcare Professional in the same amount; ** Interaction: H>H= Human to Human; H>T= Human to Technology, T>H= Technology to Human; H<>H (T)= Human to Human via Technology

4. Discussion

The main goal of this study was to examine the state of the art of self-management support for COPD patients via e-health technologies. The first research question targeted on an assessment of *which content aspects for self-management are addressed* in the fourteen studies. The results of this study showed that the content aspects "symptom management" and "exacerbation management" are addressed most frequently within the different e-health technologies. “Symptom management” includes for example the use of questionnaires to assess symptoms [71] or the use of symptom diaries, where the patient has to input his symptoms to compare them daily [69]. “Exacerbation management” means prevention and having a detailed schedule for emergency situations [69]. Another content aspect which is used frequently is "physical activity". “Physical activity” is achieved by the use of wearable devices to measure physical activity and by motivating prompts to enhance it [26]. It is found out that the different e-health technologies combined two to nine of the predefined twelve content aspects.

To answer the second research question, *what levels of active self-management are addressed*, it can be noted that in the analyzed studies, half of the studies offered content aspects which can be categorized in level 0, but no study is to be categorized in level 0 exclusively. In level 1, smartphones and additional monitoring devices are used to measure data of the patient. Due to the fact that all e-health technologies in this review address level 1 self-management aspects, an important part of self-management is covered, even though the patient has no autonomy or decision-making in this level at all. Due to the fact that exacerbations can occur at any time, the patient has to recognize his symptoms clearly. Therefore, the monitoring devices contribute to self-management, because with the help of these, the patient becomes supported in realizing the symptoms. Next to that, the monitoring devices lay a foundation for the development of higher level self-management skills, because first of all the patient has to realize the symptoms to become active in a second step. Significantly fewer studies include content aspects of level 2, with some interpretative and decision-making tasks for the patient, as adapting medication according to symptoms [66]. There is just one study that includes content aspects of level 3 [70]. In this study, the patient sets life goals and makes decisions on his own to fulfill these life goals.

The third research question addressed the *forms of e-health technology and communication that are used in content-aspects and levels of self-management*. It is found out that the patient is the person who takes initiative for communication most often. The interaction of communication is found to be one-way, between human and technology and vice versa, most

frequently. Additionally, it is figured out, that in level 0, the interaction is initiated by technology to the human and vice versa most often. In level 1, the interaction goes from human-to-technology and from human-to-human. In level 2, the interaction of human-to-human via technology and from technology-to-human is common. In level 3, the interaction direction of interaction is from human-to-human and from human-to-technology. This implicates that with a rising level of self-management, interaction between human and human, also by the help of technology, gains in importance.

All in all, e-health self-management technologies for COPD patients are most often offered via wearable devices. Additionally, all studies address level 1 of self-management, while the other levels are included less frequent. Furthermore, the communication is one-way most often, whereas two-way communication is used more frequent in higher levels of self-management.

It is remarkable that the research field of e-health self-management for COPD patients is still very new and that nine of the studies are published from 2013 to 2016, therefore future research on this field should base its search on this timeframe. It is not surprising that "Symptom management" was used so frequently as a content aspect. This is in accordance with the definition of self-management, which states that self-management is the ability to manage symptoms and treatment of a chronic disease by the patient himself [22]. This is important for COPD patients, because it is a progressive disease and exacerbations can occur at any point of time, without the immediate availability of a healthcare professional. This means that the patient has to recognize the symptoms and that he has to know how the symptoms have to be treated, so that the patient can take action if an exacerbation occurs. Also, Gott et al. [75] emphasizes that the progression of the disease and its symptoms leads to higher demands on care, because of a worsening in physical, psychological and social functioning. Therefore, it is necessary that the patient internalizes the skills to manage the symptoms by himself.

Because smoking is an important cause of COPD, it is remarkable that "smoking cessation" was only addressed in three studies, which seems to be very seldom. In fact, COPD patients are found to benefit from quitting smoking, despite actual stage of COPD according to GOLD, age or baseline lung function [76]. Even in a severe stage of COPD, smoking cessation decelerates the proceeding rate of lung function and increases survival, compared to continued smokers [77]. Internet-based smoking cessation interventions have shown to be effective in supporting smoking cessation for COPD patients. They have to be used six months or longer and are more effective if they are interactive and tailored to the individual [74]. Another

systematic review has shown that internet-based interventions for smoking cessation are superior to other broad reach cessation interventions (e.g. print materials), and that they are equivalent to other currently recommended treatment modes, such as telephone counseling [78].

It is astonishing that the communication between healthcare professional and patient is most often one-way. Literature shows that interactive communication is more efficient than one-way communication in decision-making. One-way communication is often faster, but in cases of emergencies, interactive communication is preferable [79]. This is transferable on COPD patients which often suffer from exacerbations. In those situations, they should have the possibility of interactive communication with a health-care professional to ensure the best possible help. Next to that, it is important to train the healthcare professional skills in partnership based roles to encourage self-management of the patient [80]. Furthermore, it is important that the healthcare professional is not too dominant in his way of communication [78]. This means that there should be an interactive communication with the initiative of the patient. However, this is not the case at this point of time, because the interaction has shown to be one-way most often. To reach a behavior change which can be part of self-management, it is important that the patient becomes empowered [79].

It is noteworthy that only one technology was to be categorized in level 3, because Schermer [33] detected that higher levels of self-management show to be more effective, because the patient gets empowered to manage the disease on his own. Therefore, it was expected that there should be some more studies covering level 3. An explanation for this unexpected discovery could be that different studies have shown that especially COPD patients in an advanced stage suffer from a high degree of anxiety, depression and psychological tension. Furthermore, they had low self-esteem and did not believe in the efficiency of therapy [72, 73]. Therefore, some patients fear to autonomously make disease-related choices. This can probably be a reason why this level of self-management is addressed just one time. An opportunity to make the patient more autonomous even though he fears decision-making on his own, parts of e-health interventions for anxiety patients could be integrated in those e-health self-management interventions for COPD patients.

The main strength of this review is its broad scope of the topic e-health self-management technologies for COPD patients. All studies which met the inclusion criteria were analyzed in this study. This led to a collection of studies, also with different study designs, where no restriction made. To ensure a broad scope, the search strategy included eight different databases. Furthermore, the broad scope allowed to give an estimation of the actual state of the art. Another

strength of this scoping review is that the analysis of the articles made it possible to map key features of the topic, which do not exist up to this point of time and to detect gaps of the research field. Additionally, this research is important, because the use of e-health technologies records a positive trend. However, there is no encompassing guiding principle of how e-health self-management for COPD patients looks like. Therefore, this scoping review tries to map key features of the e-health self-management technologies, the content aspects and the form of communication.

On the other hand, this scoping review has several limitations that have to be acknowledged. The main limitations of this scoping review result from the heterogeneity of the analyzed studies. They differed completely in kind of intervention, study population, presence of a control group, and outcomes. Nevertheless, this broad scope was necessary to scope all information available about e-health self-management interventions for COPD patients, but it makes comparison difficult. Furthermore, it was hard to identify studies addressing self-management via e-health technologies for COPD patients, which confirms the assumption that the research field is relatively new. But there were also many studies which had to be excluded, because they did not meet the inclusion criteria, for example they just analyzed the feasibility or usability of a study or they were ideas for future technologies and by that, not implemented yet. Due to the fact that only 14 studies could be found in total, the sample size is probably too small to generalize the results. This may have resulted from out the limited used search terms, because there might exist other terms, not known to the researcher, than the previously described. On the other hand, the research terms were checked again at the end of this study and there were no other search terms found. Finally, the effectiveness of the different content aspects, the levels of self-management and the forms of communication is not estimated in this study, because this would have exceeded the given timeframe of this study. This should be addressed in the future to ensure the deploy with effective e-health technologies.

A possibility to overcome the lack of the missing content aspect “smoking cessation”, is to provide a “smoking cessation application” which includes contact to a peer group of COPD patients who also want to stop smoking and where exchange of experience of daily cessation strategies is possible. A more detailed example is to transfer the concept of the “anonymous alcoholics” on e-health interventions for COPD patients. The main idea of the “anonymous alcoholics” is to support each other to stay sober. This is done by the help of role models, who already succeeded to quit drinking and share their experiences with their fellow sufferers. In regular meetings, group members tell each other their stories and empower each other in their

decision to quit. This could be transferred on COPD patients through providing an application or web-based platform that offers chatrooms, an option for video-conference and former smokers as role-models to adapt the concept of "anonymous alcoholics". Due to the fact that especially COPD patients of an advanced stage suffer from anxiety, depression and psychological tension, as mentioned above, such an e-health intervention could empower the patients by showing them, that other suffer from the same situation, too.

To enable COPD patients to make -health related decisions, it is important that future e-health interventions focus on the reduction of fear and depression, and by that reducing the fear to take a decision. This gap can be overcome for example by providing modules based on cognitive behavioral therapy, because internet-based cognitive behavioral therapy has shown to be effective for anxiety patients and patients with depression. Additionally, a collaborative relationship between healthcare professional and patient, which characterizes level 3 is found to increase patients' involvement and control in their disease and improve their well-being [83]. The same author also found, that changing patient behavior and ensuring maintenance are complex processes and require time. There are tools as activity monitor, communication tools, E-diary behavior change modules and self-management modules used. E-health technologies can support the development of self-management skills of level 3, because they have shown to promote the decision-making process of the patient, through a shift in the role of the patient from passive recipient to active consumer [82]. A problem is, that this is time consuming and that patients sometimes stop using the e-health interventions after a short time. To overcome this problem, it is important that e-health interventions include persuasive technology elements, such as motivating cues or personally tailored feedback [84]

In future e-health technologies it is important to offer a broad range of content aspects and to provide the patient the possibility to make his own disease-related autonomous decisions. By that and by the use of interactive two-way communication, higher levels of self-management can be reached. In the design of prospective e-health technologies, more content aspects of self-management should be included to ensure a comprehensive treatment of self-management for COPD patients. Besides, future e-health technologies should address level 3 of self-management [33] to concede more autonomy in decision-making to the patient. Hereby, it is necessary to accompany the patient and to guide the patient to a self-management level with higher activity of the patient. Apart from that, in future e-health design, the focus should lie on the more preferable two-way interaction in communication to make the intervention more efficient. Moreover, with the progression of symptoms, fear and depression increase. Therefore,

it is important that in future e-health interventions for COPD patients it is focused on "symptom management", so that patients learn to recognize and treat their symptoms and become less anxious. This could be done by the use of dyspnoea rating scales on the e-health technologies to compare daily values to intervene if the values get worse. Other possibilities would be to teach breathing techniques or body positioning the patient can use to breathe easier if dyspnea increases. Additionally, the e-health technology could identify environmental triggers of dyspnea, such as environmental pollution and give the patient the instruction to avoid this. In order to reach higher levels of self-management it is important to grant the patient more autonomy [33]. Therefore, the patient should become able to make disease-related decisions by himself, for example in giving the patient the opportunity to make changes in medication if daily symptoms increase. Next to that, the study of Verwey [70] can serve as an example for the design of higher level e-health self-management interventions for COPD patients. Even though this technology did not include the most content aspects, level 3 of activity in self-management could be reached. Therefore, the design of this study can provide information on how an intervention has to be created, so that higher levels of self-management can be achieved.

Future work on e-health self-management for COPD patients should also estimate how and under what circumstances higher levels of self-management can be offered and under which conditions patients become more likely to use those self-management technologies. It would also be interesting to examine which content aspects of self-management for COPD patients are most effective. This could be done with by a research with a fractional factorial design to compare the effects of different content aspects on health outcomes, for example. Future research should also focus on barriers and facilitators of self-management to tailor it optimal to the needs of care of the patient. Additionally, novel approaches to achieve a change in the behavior of the patient should be addressed. Those individual needs can be estimated through qualitative studies. Moreover, it is recommended to examine the effectiveness of the fourteen studies analyzed in this scoping review.

5. Conclusion

The research field of e-health self-management for COPD patients via e-health is still very new and literature on this topic is scarce. As things stand now, e-health self-management technologies for COPD patients use “symptom management” most frequently as a content aspect. Some other important content aspects as “smoking cessation” are rarely used. The level of activity in self-management is found to be lower at this point of time, because the provided content aspects do not cease much autonomy to the patient in his health-related decision-making. However, one technology reached level 3 of activity in self-management and can therefore serve as a basis for future design of those technologies. For the design of future e-health technologies for COPD patients, it is important to achieve a higher level of activity of self-management, because it is found out that higher levels of self-management are associated with autonomy in decision-making, which leads to higher wellbeing of the patient. A comprehensive approach of active self-management for COPD patients does not exist yet, but this scoping review tried to map key features of this research field.

6. Competing Interests

The author of this study declares that there are no competing interests.

7. References

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8. Appendix

Appendix 1. Rating Sheme

eCOPD –Rating/coding scheme(02-02-2015)

Scoping Review MD	**Descriptives:**	***Explanation***
Nr.:		*Nr. (of Abs.)*
Author(s):		*Surnames author(s) (in Abs.)*
Year(of publ.)**:**		*Year (in Abs.)*
Country (study location)**:**		*Country (-ies) of researchers(optional: cities)*
Project name:		*Project name (when applicable + acronym)*
System name:		*System name (+ acronym)*
System objectives:		*System objectives*
(Opt.) **Project goal(s):**		*(Optional:) Project Goal (larger setting)*
Target Group		*1 or more of the following target groups :* *→ More target groups: + number in order of priority, e.G.: 1) C , 2) N)* C Clients/ patients I Informal caregivers (e.g. family) N Nurses N1 1 special nurse (e.g. care coordinator) P Physiotherapists S Specialists (e.g. physicians) O *Other care providers (name them →)*

Study design:		Study design (description of methodological approaches 1 Experimental studies (e.g., RCT with concealed allocation) 2 Quasi-experimental studies (e.g., exp. study with randomization) 3 Controlled observational studies 3a Cohort studies 3b Case control studies 4 Observational studies without control groups 5 Expert opinion based on bench research or consensus O *Other (name design type →)*
N =		*No. of participants in the study*
Instruments:		*Instruments used*
Selfmmt Instruments:		*Self-management-instruments (e.g. CCQ; name them →)*
Outcomes (type):		*1 or more of the following type of outcomes:* *→ More outcomes: + number in order of priority, e.G.: 1) Cp , 2) F)* F Financial • Reduction of costs / time • Reduction of time/services Cp Care-process • Improved transparency • Improved interaction • Satisfaction with care Cl Clinical • Improved clinical values • Improved quality of life B Behavioural • Improved self-care • Improved knowledge T Technical • Usability (and adoption) of technology • Satisfaction with technology

(A) Self-management levels& (B) Type of Content Aspects		**Remarks *(optional), on:***	Z.o.z.(!)
(A) Self-management levels &	**(B) Type of Content Aspects**	0 No self-mmt	• Disease management • Case management

(Levels of Schermer:) *0= no SM (disease-mmt or case-mmt)* *1: tasks CL (client): Delivery of values* *2: tasks CL.: Interpretative/decisional* *3:CL. Has own decisions & choices.*	A: Information	B: Symptom mmt.	C:Exacerbation mm	D: Medication mmt	E: Smoking cess.	F: Physical actiivit. (e.G. exercise)	G: Nutrition	H: Environmental m	I: Psychological mm (e.G.Emotions)	J: Social support	K: Communication (e.G.. assertiveness	L: Goals, problems, information	1 **Compliant / lower level**: •Cl. Takes over practical tasks from HCp • E.G.: measurements, values • **No autonomy - no decisions Cl**. 2 Compliant / lhigher level: • CL. Takes over interpretative / decisional tasks • Cl. Understands / interprets / takes action • E.G.: adapting medication / lifestyle aspects • **More (executive) autonomy - no own goals** 3 Concordant: • Cl. Makes own decisions & choices • Cl. Own views of life/values/goals count • Collaboration CL – HCp & concordance
SM0													
SM1													
SM2													
SM3													

(C) Technology Characteristics		A	B	C	D	E	F	G	H	I	J	K	L	**(D) Communication via eH:**	*(client)*	*(profess-sional)*	*(both, equally)*
C1. Media:	*(Clusters of devices, (online) instruments, etc)*													**D1. Initiative:** *(lead / main initiative)* *>>per Media-/ Technology-cluster):*	**CL:**	**HCp:**	2:
(No.1: ,,)	1)													**>>**			
(No.2: ,,)	2)													**>>**			
(No.3: ,,)	3)													**>>**			
(No.4: ,,)	4)													>>			

(No.5: ,,)	5)												>>				
C2. Subgoals ↓ *(of Media-/ Technology-clusters)↓:*	*- Of Form No.1 - No….* *- Etc.* ↓ *(Fill in the numbers)*												**D2.** **Interaction via eH:**	*human-human (synchro-nous)* **H >H**	*human > technology* (↑) **H > T**	*technology >human* (↓) **T > H**	*mediated by technology* *(a-synchro-nous)* **H <> H** **(T)**
(No.A: ,,)	(…-…) :												>>				
(No.B: ,,)	(…-…) :												>>				
(No.C: ,,)	…-…) :												>>				