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The Efficacy of Telehealth Delivered Educational Approaches for Patients with Chronic Diseases: A Systematic Review

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Author Contributions

KLR, LH, RJ were responsible for the conception and design of the review. KLR led the entire review process. RJ lead the search process. MF and MT performed abstract review. LH assisted with initial abstract screening and quality monitoring. LB and MF participated in quality review of full-text papers. KLR and LB analyzed and interpreted the data. KLR drafted and revised the manuscript and LB assisted in its preparation. All authors have reviewed and approved the final revised manuscript.

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Abstract

Objective: The virtual delivery of patient education and other forms of telehealth have been proposed as alternatives to providing needed care for patients with chronic diseases. The purpose of this systematic review was to compare the efficacy of virtual education delivery on patient outcomes compared with usual care.

Methods: The review examined citations from 3 databases, MEDLINE, CINAHL, and EMBASE using search words telehealth, chronic disease, patient education, and related concepts. From 2447 records published between 2006 and 2017, 16 high to moderate quality studies were selected for review. Eligible papers compared virtual education to usual care using designs allowing for assessment of causality.

Results: Telehealth modalities included the web, telephone, videoconference, and television delivered to patients with diabetes, chronic obstructive pulmonary disease, irritable bowel syndrome and heart failure. In 11 of 16 studies, virtually delivered interventions significantly improved outcomes compared to control conditions. In the remaining 5 studies, virtual education showed comparable outcomes to the control conditions.

Conclusions: Findings demonstrated that virtual education delivered to patients with chronic diseases was comparable, or more effective, than usual care.

Research Implications: Despite its benefits, there is potential for further research into the individual components which improve effectiveness of virtually delivered interventions.

1. INTRODUCTION

Self-management and educational support are essential for those with chronic diseases [1]. Traditionally this support has occurred in face-to-face encounters but such access can be challenging due to competing demands, time, distance, and costs [2]. Barriers to accessing education for chronic disease management may lead patients to seek information from sources that are not always reliable. A study in the UK, found that up to 75% of the population goes online for health information [3]. Seventy percent of Canadians go online to search for medical or health-related information [4] and it has been reported that the Internet, rather than physicians, is the first source of information for many people [5,6]. One study reported that more than two-thirds of patients did not receive information about their illness while they were in their doctor's office, and many people did not receive information about their medications [7,8]. Clearly, ensuring adequate access to education for all patients is a challenge.

Virtual health care and telehealth options generally offer populations with chronic disease unprecedented access to services [9]. Virtual health care has become a burgeoning section of the health care market due to the advancement and broad adoption of telecommunication technologies, demand for consumer-driven health care where convenience and access are an expectation, and need for cost containment [10]. According to a 2012 United States (US) Survey, 40-67% of patient consumers were interested in using innovative health information technologies such as videoconference and apps [11]. Education, core to chronic disease management, can be delivered through a range of virtual options, such as websites, apps, videos, and text messaging or some combination of these tools [9]. However, a strong evidence base is needed to guide healthcare professionals in selecting from among many options available for delivering virtual education.

Despite a plethora of systematic reviews of virtual-based interventions in chronic disease prevention and control [12-14], only three previous systematic reviews could be found that specifically examined virtual educational interventions. Fredericks [9] found that web-based education, compared to printed education, significantly increased patients' self-care behaviors following post-operative cardiac surgery. Similarly, Kelly et al [15] reported that compared to usual care, telehealth delivered diet education for adults with chronic disease, improved dietary adherence and lipid profiles. In another review, remotely delivered education did not reduce the 3-month average blood glucose (A1C) to the same magnitude as observed with individual, group, and combined individual/group diabetes self-management education [16]. Two of the three reviews [9,15] described virtual educational interventions as one component of a larger intervention [15], or additionally included opportunities for accessing support (e.g., ask an expert) and functionalities (e.g., additional resources) [9]. These reviews were limited in addressing only a single virtual modality [9] not differentiating among collective modalities (e.g., telephone, online) [16], measuring only one patient outcome [9,16], targeting a specific educational focus (e.g., diet), [15], or including papers of moderate to low quality [9]. The current review expands on previous reviews by increasing the range of virtual modalities, outcomes, and educational foci under investigation and enhancing evidence quality.

2. METHODS

2.1 Design

A systematic review was conducted, synthesizing findings from studies that compared the efficacy of virtually delivered education with usual care on patient outcomes.

2.2 Sample

The search strategy for this review was developed in cooperation with a Health Sciences Librarian, taking into account published strategies used in similar systematic reviews [17,18]. The following databases were searched: Medline, Embase, and CINAHL. Given the scope and nature of the topic under investigation it was felt that these databases would provide exhaustive exposure to high quality data. Following guidelines from the *Cochrane Handbook of Systematic Reviews*, a combination of keyword and database-specific subject headings were used in the search to maximize the sensitivity of the strategy [19]. Keywords, relevant synonyms, and associated truncations used in the search revolved around three concepts—telehealth, chronic disease, and patient education. A full copy of the search history for Medline is included in Table 1 in accordance with the PRISMA guidelines [20]. The database searches were conducted from March 22nd to 24th, 2017 with results exported to RefWorks and organized into folders based on the names of the database searched. Duplicates were then removed before the citations were exported into Microsoft Excel for screening.

Initial search results yielded 4,531 papers across all databases. After duplicate citations were removed, a total of 2,447 relevant citations were screened. Title and abstract screening were undertaken by two trained Research Assistants (MF, MT) and quality checks completed by one member of the research team (KR). Disagreements about inclusion were discussed until agreement was reached. Those not meeting the inclusion and exclusion criteria outlined below were removed leaving 31 papers for full-text review.

2.3 Data Evaluation Inclusion/Exclusion Criteria

The full text of all eligible papers (n=31) were then evaluated to determine whether the article met all of the following criteria: (1) study design compared telehealth education interventions to usual care; (2) education was the key intervention and was explicitly identified

and described; and (3) the study was published in English between 2006 and 2017, to reflect the rise of virtual care. For purposes of this review, education was defined as activities that "impart knowledge and information about health, illness and well-being resulting in acquisition by the client of helpful behaviors, habits, and routines that may or may not require application" (pg. 592) [21]. A study was included only if knowledge and information giving were primary activities, and their applications (e.g., goal-setting, interactive communication) **were** identified in the paper as core to the educational intervention.

Papers were excluded if: (1) education was not a major focus of the study; (2) study population was children and/or youth; (3) educational intervention was described only and not tested; (4) studies were qualitative; (5) reported a research protocol only. Following the final selection of studies (n=16), a hand-search of each article's reference list was conducted to identify relevant literature not identified through the Medline, CINAHL and Embase databases, with one additional study identified. A flow chart summarizing the search, screening, and study selection process is included in Figure 1. The final number of articles included in this review was 16.

2.4 Data Extraction

Two trained Research Assistants extracted data from the selected papers (Table 2). The data included: author/year of publication, country in which the study was conducted, study design (quasi-experimental, experimental, observation, randomized control trial), sample size (total, and sub-groups, if relevant), number and types of study groups, relevant sample demographics (age, urban/rural, chronic disease), and drop-out rate. Additional data extraction included: virtual education modality, educational intervention description, duration, and frequency of intervention, comparator, outcome measures, and results. A quality rating was

derived for each paper using the quality assessment tool for quantitative studies developed by the National Collaborating Centre for Methods and Tools [22]. Studies were rated as strong, moderate, or weak according to six components: selection bias, study design, confounders, blinding, data collection method, and withdrawals and dropouts. Component ratings were used to derive a global rating, of 1 (no weak ratings), 2 (one weak rating) or 3 (two or more weak ratings) [22], with lower scores of higher methodological quality. Two independent reviewers did all ratings, discussing any discrepancies until a consensus was reached. Any papers with a global rating of weak were excluded from the review.

3. RESULTS

3.1 Overview of Studies

The 16 studies that met the inclusion criteria for this systematic review included 2870 participants from seven countries: Canada (2), Netherlands (3), Iran (1), Korea (3), Singapore (1), Taiwan (1), and US (5). Designs included: randomized control trial (n=12) [8,23-33], quasi-experimental (n=1) [34], parallel group non-inferiority trial (n=1) [35], and cohort case control (n=2) [36,37]. Of the studies, 11 (68.8%) were of high methodological quality [8,24-26,28-30,33-35,37], with the remaining five (31.2%) of moderate quality [23,27,31,32,36]. Twelve studies used random assignment to intervention or usual care groups [8,23-33], one study used alternate assignment to intervention or usual care group [34], two studies used non-random assignment by physician referral to intervention and usual care groups [35,36], and one study used patients that were not contactable or refused to join the program as the usual care group [37]. Drop-out rates were reported across studies; 12 had rates $\leq$ 25%, three had rates between 33% [23] and 68% [35], and one study, a case control design, did not report a drop-out rate. Without analyses to accommodate drop-outs it is difficult to determine the extent of bias [38].

Two studies [8,28] identified blinding of data collectors and/or analysts but no studies blinded patients, a particular challenge given the technological nature of the studies. Four studies [23,25,33,35] used an intention-to-treat analysis, and two used per-protocol analysis [35,37].

3.1.1 Description of Patient Populations: Study populations were patients with chronic diseases, including diabetes mellitus (DM) [8,24,26,27,29-31,34,36,37], chronic obstructive pulmonary disease (COPD) [28,32,35], inflammatory bowel disease (IBD) [25], and heart failure [23]. The average age of patients was 54 (±13.36).

3.1.2 Description of Usual Care: The most common forms of usual care were routine physician care [23,25,33,34,37] and face to face education [24,30,32,35,36]. Four studies provided the same education in the usual care group as in the intervention group, except participants received paper copies of materials compared to electronic versions [8,28,29,31]. In two studies involving shorter durations (2 weeks to 3 months) [26,27], usual care participants received no education.

3.2 Virtual Education Modalities

Analysis revealed four delivery modalities in which education was a key component of the intervention: web-based [8,25,27-30,32-34], telephone [26,31,37], videoconference [24,35,36], and secure television [23]. These approaches varied in terms of the educational resource/material types, content, amount, sources, delivery frequency and length, and degree of interaction and communication support. In three studies the intervention included a face-to-face component, as part of the virtual education [24,32,33]. It was not appropriate to conduct a meta-analysis, because of intervention heterogeneity.

3.21 Web-based education: Web-based education was the primary approach used in nine studies, five with diabetic patients, two with patients with COPD, and one with patients with

ulcerative colitis. The educational materials varied in their sources, development, amount, type, and usage. Content sources were not clearly identified in five studies [28-30,32,33]; in two studies materials were explicitly identified as investigator developed with input from potential users (e.g., doctors, educators) [27,34]; and in only two studies were materials based on existing national guidelines (e.g., National Guidelines for Diabetes Care in the Netherlands) [27] or national associations hosting patient education sites (e.g., American Diabetes Association) [8]. Web-based disease specific educational materials ranged from four to 13 content categories [8,34], and included diverse types and amounts of educational materials and methods from a single educational method in one study (e.g., instructional video) [28] up to seven in two studies (e.g., printed sheets, lecture notes, videos, books/manuals, pictures, question-and-answer section, educational films) [8,34]. Web-based education ranged from 2 weeks to 12 months. Two studies included face-to-face sessions, one for initial training, orientation, and consultation [32] and the other for two group sessions that explored patients' knowledge, gave feedback, and provided education [33]. One study provided basic and advanced levels of their type 2 diabetes web-based self-management education program [27]. Only one study included theory, incorporating concepts from social cognitive, self-management, and pathophysiological theories in the educational program [32].

Information processing functionalities, integral to the web-based educational interventions, were used in six studies. Four studies used patient self-monitoring functions, in which patients input disease data (e.g., blood glucose, symptoms, medication, food intake) through a web portal [8,25,30,33], and received recommendations and feedback from health care providers through email, live chat, or Short Message Service (SMS) [8,30,32,33]. In other studies patients had access to electronic logbooks or bulletin boards [30], to a workbook to answer end of module

chapter questions, note questions or do goal-setting and planning [27], or had an online personalized action plan [32,33]. Heinrich et al. presented information primarily in spoken language, supported by headlines, images, video, and real patient experiences on different topics [27].

Web-site usage was monitored in several studies [8,27,29,30,34] but there was limited reporting of the use of functionalities and self-management tools. Heinrich et al [27] reported low use of functionalities, such as searching (41%) or examining additional information (60%). Of the few studies that obtained user input, satisfaction with information [27] and modality (VC) [36] were high, and system acceptance and ease of use good to very good [23]. In one study patients' preferences for the various technologies did not align with their group assignment which researchers suggested may have influenced findings [32] and in two studies lack of a user-friendly interface was noted to be problematic [29,34].

3.22 Telephone: Telephone was the primary modality for educational delivery in three studies, with one using a landline [37] and two using SMS [26,31]. Other studies used telephone but most often as a reminder in combination with other modalities and not for educational delivery [28,34]. Telephone education was delivered exclusively to patients with DM over three to six months, either as the sole modality [26], following intense lifestyle education, [31] or post-hospital discharge, [37] but details as to the follow up education were lacking. Short intervention timeframes limited observation of sustained outcomes. Only one of the three studies identified, but did not reference, the source of the educational content (e.g., developed with physicians according to disease management guidelines) [37]. Number of content areas (1-5) and frequency (weekly to monthly) varied across studies. SMS education ranged from weekly education tips for stress reduction [31] to four text messages/week over three months targeting knowledge,

attitudes, practice, and self-efficacy related to exercise, diet, diabetic medication, and blood glucose self-monitoring [26]. Landline education involved monthly 20-minute personalized education modules over three months on diabetes, cholesterol and blood pressure management, lifestyle modification, and diabetic complications [37].

3.23 Videoconference: Three studies used videoconference (VC) as the primary education modality directed at rural-living patients with DM [24,36] and COPD [35]. The VC education ranged from eight weeks [35] to 12 months [24] and varied in frequency and timing. In all studies the education was staggered over time including once per week for 8 weeks [35], once per month for 12 months [24] or given in a concentrated format (2-3 hour sessions) as a jump start with a 3- and 6-month follow-up [36]. One study [24] included a combination of face-to-face (n=3) and VC individual and group (n=10) sessions, a design feature potentially confounding observation of a true virtual effect. Education covered 7-12 chronic disease specific content areas with two of the three studies explicitly based on existing evidence-based guidelines, resources and curriculum [24,35] and one of the three studies implementing a theoretically-based (e.g., Health Belief Model and the Transtheoretical Model) intervention [24]. VC education generally involved group education by two or more health professionals (e.g., nurse educators, dietitian, physical therapist). In addition to education, VC patients kept self-monitoring logs in one study [24] and in another study had 2 hours of supervised group exercise [35].

3.24 Television: One study used a secure broadband home TV-channel to deliver education materials [23] but sources or content areas were not described. The personalized educational materials included medication reminders, health related surveys, and motivational messages specific to each participant's prescribed lifestyle regimen [23]. Patients had a

personalized plan created by their treating cardiologist and heart failure nurse specialist [23]. A highly selective heart failure patient population already being followed by specialists instead of a "clean group" was thought to reduce the true effects of the intervention [23].

3.3 Degree of personal interaction/communication support

Personal interaction and communication opportunities to support the education**al** interventions were common across the modalities. Web-based approaches generally included one or more types of support which were largely patient initiated [8,25,30,32,33]. Support differed across studies, from occasional (e.g., every 2-month physician visits) [29] to ongoing access as needed and involved contact with one (e.g., a respiratory nurse specialist, web-doctor) [25,33] or more health care professionals (HCPs) through various forms of communication (e.g., voice, SMS, web or regular e-mail) [8]. The communication was available synchronously and/or asynchronously [27,30], private or public [30], and was designed in some cases for meeting both immediate or routine needs (e.g., Question & Answer manned by physician, nurse, nutritionist; chat room with other diabetics) [8]. In contrast, in two of the telephone education studies providers initiated follow up telephone calls to monitor progress, support or counsel with frequency varying from every three weeks for three months [31] to one three-month follow-up [37]. Videoconference education had no interactive support built into the program beyond the intensive interaction occurring during the educational sessions.

3.4 Outcomes

Eight different categories of outcomes were measured across studies but only those outcomes reported in five or more studies (30%) have been included in this review. These outcomes, now synthesized across studies, include clinical indicators, knowledge, quality of life, self-care/compliance, and health care utilization.

3.41 Clinical Indicators

Clinical indicators, reported in studies of diabetic and asthmatic patients, showed comparable or significant improvements in virtually delivered educational groups compared to control groups. Compared to controls, diabetic intervention groups across modalities experienced significant improvements in clinical/metabolic indicators with decreases in fasting blood sugar [34], 3-month average glucose (A1C) [8,24,26,29,34,37], and post-prandial glucose levels [29]. In one telephone study DM patients in the intervention group, who were not well controlled (A1C$\geq$ 8.0%), had more significant reductions in adjusted mean A1C (0.38%) relative to the usual care group (p=0.022) [37]. In two web-based educational interventions, reductions in A1C were significantly related to the frequency diabetics accessed the website [29,30]. Noh et al [29] found in the web-based intervention group that access frequency by cell phone (r=0.766, p=0.03), but not the computer, improved A1C, with "dining out" (191 times) the most frequently accessed content [29]. Pacaud et al [30] found no significant between group (all groups had some web access) differences in A1C but regardless of group, the higher the website usage the lower A1C was at 12 months (r=0.271, p=0.026). Lee et al [34] reported consistent log ins from three to six months (9.6 ± 2.9 vs 8.5 ± 3.7 logins per patient per month) among diabetics in the web intervention. Although their better metabolic control was attributed to log in consistency, the relationship between log ins and metabolic indicators was not measured.

Compared with controls, diabetic intervention groups also showed decreases in total [26,34] and low density lipoprotein cholesterol [8,24], and renal markers (e.g., BUN, micro-albumin, albumin-to-creatinine ratio) [24,26]. In one study, diabetics participating in the web-intervention showed decreases in different clinical metabolic indicators over time - fasting blood

sugar at 3months, A1C at 6 months, and total cholesterol at 9 months - compared to the usual care group [34].

Patients with COPD receiving virtually delivered education had comparable, or improved clinical indicators relative to patients receiving usual care. Asthmatics receiving web-based education [33] and patients with COPD participating in videoconference education [35] had non-significant improvements in asthma control (e.g., symptom free days) and exercise capacity (12 min walk test), respectively compared with usual care groups. However, compared to usual care, patients with COPD receiving a web-based instructional video as part of a 4-month breathing program had improved pulmonary function measures [28] while asthmatics participating in a web-based intervention had significantly less daily inhaled corticosteroid dose over the 9-month study period [33].

3.42 Knowledge: Knowledge was measured as an outcome in six studies: four web-based [25,27,30,33], one telephone [26], and one television [23]. Knowledge was measured as either disease specific knowledge (IBD, diabetes, heart failure), or psychomotor skill performance (inhaler technique). Four studies, using three different educational modalities (web, SMS, TV] reported significantly higher knowledge scores in the experimental compared to control groups [23,25-27] while knowledge in the remaining two web-based studies [30,33] was comparable between experiment and control groups. However, in their web-based study, Heinrich et al [27] found no significant correlation between total time (~1 hour) diabetic patients spent on the website and knowledge regardless of age, sex, or educational level ($p=0.42$). In contrast, Pacaud et al [30] found that higher total website usage for web based and control groups (who had access to web searching), was associated with higher diabetes knowledge scores ($r=0.265$, $p=0.029$). In one study, older diabetic participants had lower post-test

knowledge scores than younger participants regardless of group but there was no significant relationship between total time spent on the web and age, sex, or educational level [27].

3.43 Quality of Life: Quality of life (QoL) was measured as an outcome in six studies: five web-based [25,28,30,32,33] and one videoconference [35]. Valid and reliable disease specific QoL measures were used in all studies. Two studies, both web-based [25,28] found significant improvements in disease specific (ulcerative colitis, respiratory) QoL between intervention and control groups. Three studies, two web-based [32,33] and one VC [35] showed improved, but non-significant between group changes in disease-specific (diabetes, COPD) QoL. One web-based study found no significant difference in diabetes QoL between diabetic web-based and usual care groups with a trend towards a decrease in QoL over 12 months [30].

3.44 Self-care: Self-care, and related outcomes such as disease self-efficacy and compliance, were reported in five studies: four web-based [25,28,31,32] and one television [23]. Pacaud et al [30] and Balk et al [23] found no significant differences in self-care between diabetic web-based and HF television educational groups and control groups, respectively. Two web-based studies found improved, but non-significant between group differences in diabetes [30] and dyspnea management [32] efficacy. Two web-based studies found improved adherence/compliance in COPD patients' regular dyspnea breathing practice ($p=0.05$) [28] and ulcerative colitis patients' general self-management (73% web; 42% controls; $p=0.005$) [25] compared to controls but in one study the compliance was only sustained for the 4-week acute treatment [25].

3.45 Health Care Utilization: Utilization was measured in four studies across three modalities: two web-based, one telephone, and one television. There was no difference in hospitalizations for the three modalities compared to usual care for patients with diabetes, heart

failure or IBD [23,25,37]. Patients with IBD receiving web-based education had lower numbers of acute/routine visits to outpatients compared to controls, resulting in a cost saving of 189 euros per patient per year [25]. Van der Meer et al [33] reported fewer physician visits in asthmatics receiving web-based education compared to usual care group but the difference was not significant.

4. DISCUSSION AND CONCLUSION

4.1 Discussion.

Overall, findings from this review demonstrated that education, delivered through virtual modalities to patients with chronic diseases was comparable, or more, effective than conventional approaches. Even though studies were of moderate to high quality, it is not possible to conclude on the basis of review findings which of the four modalities was superior given the heterogeneity in studies and the greater prevalence of web-based education compared to the other modalities. In 11 of 16 studies, virtually delivered interventions improved outcomes; four compared to face-to-face [8,24,28,34], five compared to usual physician care [23,25-27,37], and two compared to paper-based education [29,31]. The superior performance of virtual educational approaches is significant as reliance on face-to-face and paper-based educational approaches have persisted as dominant approaches in chronic disease management [27] and yet are increasingly becoming less viable options [39]. Further in the few studies employing face-to-face components as part of virtual education [24,32,33] outcomes were consistent with those not including a hybrid approach.

Virtual educational interventions in the current study expanded applications of knowledge and information [21] that might be considered beyond the bounds of traditional education. In the current review this created the challenge of determining what interventional component(s)

accounted for the observed outcomes. For example, the contributions of support and/or functionalities (e.g., monitoring, reminders) to outcomes could not be determined. Evidence was conflicting as to the relationship between web usage and outcomes, such as knowledge and clinical indicators [27,30]. Relationships between support components and outcomes were not assessed in review studies but evidence suggests that good clinical outcomes can be obtained when internet-delivered programs involve very little or no clinical contact [40].

Changes in clinical outcomes are one of the most important quality indicators of chronic disease management [41]. This is reflected in the current review with clinical indicators the most common outcome measured across studies (n=12) and demonstrating improvements despite variations in the educational approaches, timeframes, and chronic diseases represented. This contrasts with a systematic review specific to diabetics, in which A1C improved as a result of self-management education for all except remote delivery modalities; however, the latter lacked description, including whether they were designed to impact clinical indicators [16]. Interventional timeframes must be adequate to observe changes in clinical indicators, such as a minimum of 3 months for A1C, that was used in all but one diabetic study in the current review.

Despite the educational focus of study interventions, knowledge was measured in only six studies [42]. Knowledge generally improved across modalities and in four of six studies was significantly greater than physician care [23,25] or no education [26,27]. Evidence from a recent systematic review indicated patients wanted personally relevant and applicable knowledge that did not always match with the disease-related knowledge they received from health professionals [43]. In contrast, virtually delivered approaches shift responsibility to patients, by providing access to, and self-selection of, available resources that may be more relevant and individually suited than conventional education. The generally large number of educational

resources characterizing current study interventions gave patient's a wide range of choices, perhaps better aligning with their personal learning needs.

Quality of life, an important outcome for patients with chronic disease, reflects how well the disease is being managed. Overall, virtual education effected QoL outcomes superior or comparable to usual care. The use of disease-specific QoL measures used in these studies provided greater comprehensiveness, precision, and sensitivity to detect clinically important changes [42]. However, changes in quality of life may have reflected the use of self-report measures, and resulting awareness, rather than the educational interventions that were web-based in five of the six studies.

Behavior change is often a key outcome of educational interventions but in the current review was examined in only five studies, four of which were web-based. Of all study outcomes, behavioral changes improved least with virtually delivered interventions; self-care and adherence/compliance were uniformly found to be comparable to usual care. Yet, a strength of all four web-based studies was their use of an unstructured approach, which has been shown to improve self-care [9]. However, only one web-based study [26] in the current review used theory to guide the intervention despite evidence that the integration of theory in internet-based interventions produces substantial behavior change [42]. Although behavior change was observed in the short term, the challenge is sustaining behavior change beyond the intervention period; for example, adherence was not sustained past 4-weeks in one of two web-based studies in the current review. Sustained behavioral change has been shown to require interventions with a minimum duration of 6 months [43,44].

Decreasing healthcare utilization is an important outcome of virtually delivered education, particularly from a cost perspective. Although hospital utilization was comparable between

virtual education and usual care, virtual delivery reduced primary and ambulatory services and in some cases resulted in cost savings. These are important findings as chronic diseases account for the greatest proportion of healthcare utilization and spending. Of the population with the highest health care costs, greater than 75% have one or more of seven chronic conditions, including 30% with diabetes and 30% with congestive heart failure [44], among the populations represented in the current review.

4.2 Conclusion

In conclusion, virtual education was as, or more, effective than usual care in improving outcomes including clinical indicators, knowledge, self-care, QoL, and health care utilization. Nearly 70% of the studies reported significant between group differences. This is encouraging for those looking to develop virtually delivered education programs for patients with chronic conditions who face barriers to accessing what they need for managing their conditions. Despite its demonstrated effectiveness, there is room to increase the benefits of virtual education by a closer examination of the individual components.

4. 3 Practice and Research Implications

Education is typically viewed as necessary but insufficient for chronic disease self-management. Yet the current review found virtual education had a significant impact on patient outcomes, with important implications for educators. Although traditional on-site (or face-to-face) education has had a long history, for many with chronic disease it is becoming a less viable and accessible option [39]. Virtual education offers a comparable, or more, effective alternative for many patients with chronic disease [8]. Tested, virtually delivered interventions offer practitioners a suite of options from which to choose. Although web-based options were by far the most common approach, no one modality emerged as superior. In the constantly changing

field of virtual education, practitioners need to stay current and replace ad hoc and outdated practices with more effective research based, virtual educational interventions. Further, as the body of evidence for virtual education grows and pushes the boundaries of traditional models, patient educators may need to re-visit their conceptualizations of education.

Findings from this review have the potential to direct future research aimed at improving virtual interventions. Future research should employ consistently rigorous designs including larger, randomized samples to reduce self-selection bias [37]. Across virtual modalities, education was highly variable yet it was not evident which components/features accounted for the positive outcomes. Giving patients choice and a range of educational resources to meet their varying needs and preferences must be balanced with isolating the components contributing to improved outcomes; this may mean initially implementing and testing only a limited number of components. The functionality features of web-based interventions, and their relationships to outcomes, would benefit from further study as would more in-depth investigation of the levels of support/contact needed for patients participating in virtual education. Direct comparisons of virtual modalities on patient outcomes would be beneficial in determining the effectiveness of modalities for specific sub-populations (e.g., age, chronic disease). Research that examines hybrid models (face-to-face + virtual) may be a worthwhile area of study. Including target groups and stakeholders in intervention designs but also in process evaluations to ensure ongoing user feedback is imperative to continually refine and improve quality and effectiveness of virtual education.

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Table

Appendix 1
Medline Search Strategy

Database: Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) <1946 to March 22nd, 2017>
Search Strategy:
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1 ((patient* or client* or consumer*) adj1 (educat* or instruct* or train* or taught)).tw. (19642)
2 Patient education/ (74725)
3 or/1-2 (86280)
4 Chronic.tw. (903021)
5 Degenerative disease*.tw. (8296)
6 Neurodegenerative.tw. (54801)
7 ((ongoing or persistent or long term) adj2 (illness or disease or condition)).tw. (11336)
8 Asthma.tw. (119140)
9 Pulmonary disease.tw. (42829)
10 Arthritis.tw. (139535)
11 Diabetes.tw. (380869)
12 Emphysema.tw. (19656)
13 Hypertension.tw. (306521)
14 Myocardial ischemia.tw. (22313)
15 Coronary disease.tw. (12369)
16 (Heart adj2 congestive).tw. (33876)
17 cerebrovascular accident.tw. (3403)
18 Stroke.tw. (169615)
19 Neoplasm*.tw. (110474)
20 Fibromyalgia.tw. (7678)
21 Osteoporosis.tw. (51285)
22 HIV infection*.tw. (58640)
23 Endometriosis.tw. (17891)
24 Menorrhagia.tw. (2807)
25 Chronic disease/ (235383)
26 Neurodegenerative disease/ (12550)
27 Asthma/ (110766)
28 exp Pulmonary Disease, Chronic Obstructive/ (42524)
29 Arthritis/ (33420)
30 Diabetes mellitus/ (101074)
31 Emphysema/ (6592)
32 Hypertension/ (209420)
33 Myocardial ischemia/ (34559)
34 exp Coronary disease/ (194008)
35 Fibromyalgia/ (6940)
36 Osteoporosis/ (37846)
37 exp HIV Infections/ (245859)
38 Endometriosis/ (18444)

39 Menorrhagia/ (3886)
40 or/4-39 (2737281)
41 Telehealth.tw. (2071)
42 Telemonitoring.tw. (850)
43 Telecare.tw. (500)
44 Teleconsultations.tw. (309)
45 (tele adj (health or monitoring or consult*)).tw. (176)
46 (eHealth or e-Health or internet or web).tw. (92371)
47 telemedicine/ (13623)
48 remote consultation/ (3920)
49 videoconferencing/ (991)
50 telephone/ (10021)
51 internet/ (56486)
52 ((cell* or mobile or smart) adj phone*).tw. (6558)
53 (smartphone* or iPhone* or telephone*).tw. (48730)
54 (tele adj (medicine or care)).tw. (92)
55 telemedicine.tw. (6977)
56 or/41-55 (185672)
57 3 and 40 and 56 (1834)
58 limit 57 to (abstracts and english language) (1600)

Table 2. Description of Studies

Author, Year	Design	Sample	Telehealth Educational Intervention	Intervention Length	Control Description	Measures	Results
Balk et al., 2008	RCT	Sample Size = 214 Age = 68 (33-87) Chronic Disease = Chronic Heart Failure Drop-out rate = 0.33	**Television:** A secured broad band home TV-channel with personalized educational material, medication reminders, health-related surveys, and motivational messages	Duration: 2-537 Days / 0-18 Months	**Usual Physician Care:** Routine appointments with cardiologists and heart failure nurses, participants kept records, in a diary, on their contacts with health care professionals and hospital admissions.	Primary outcomes = total days in hospital for all causes per year and days alive and out of hospital; Secondary outcomes = quality of life, knowledge of disease, and self care	**Improvement to control:** Knowledge of disease significantly higher in intervention group than in control group ($p<0.001$)
Davis et al., 2010	RCT	Sample Size = 165 Age = 59.9 (±9.4) Chronic Disease = Diabetes Drop-out rate = 0.19	**Videoconference:** Diabetes education delivered in 3 face to face group sessions, with 3 individual session via videoconference and 7 group session via videoconference with the assistance on an onsite nurse	Duration: 12 Months	**Disease Specific Face-to-Face Education**: One individual 20-min diabetes education session at the time of randomization by a nurse, as well as access to existing services at the community health centers continued.	Primary outcome = glycated hemoglobin (GHb); Secondary outcomes = LDL cholesterol, albumin-to-creatinine ratio, and blood pressure	**Improvement to control:** Improvement in GHb from baseline to 6 months ($p=0.003$), baseline to 12 months ($p=0.004$), and LDL cholesterol from baseline to 12 months ($p=0.02$) significantly greater in intervention group compared to control group
Elkjaer, 2010	RCT	Sample Size = 333 Age = 40 (21-69) Chronic Disease = Ulcerative Colitis (UC) Drop-out rate = 0.21	**Web-based:** 1.5 hour education session on disease plus website training. Online treatment program available 24 hrs/day, with information on signs & symptoms of UC and safety, a place to input disease and Qualify of Life (QoL) data, a	Duration: 12 Months	**Usual Physician Care:** Conventional treatment and follow-up at inflammatory bowel disease (IBD) out-patient clinic, including routine appointments and advance appointments for those with relapse symptoms.	faecal calprotectin, blood test values, compliance analysis, IBD knowledge, QoL	**Improvement to control**: 88% of patients preferred Constant-care web-based approach to conventional care. In Denmark, IBD knowledge ($p<0.05$) and QoL ($p=0.04$) were significantly greater in intervention group compared to control group.

			results section, recommendations for treatment, and the option to contact a doctor.				
Goodarzi et al., 2012	RCT	Sample Size = 81 Age = 50.98 (±10.32) Chronic Disease = Diabetes Drop-out rate = 0.19	**Telephone:** 4 text messages weekly containing information on exercise, diet, medication, self monitoring glucose levels	Duration: 3 Months / Frequency: Weekly	**No Education:** No educational content was provided by researchers	Diabetic knowledge, attitude, practice, and self-efficacy. Demographics, glucose, glycosylated hemoglobin (HbA1c), cholesterol, triglycerides, HDL cholesterol, LDL cholesterol, micro albumin, blood urea nitrogen (BUN), and creatinin	**Improvement to control:** Significant change from baseline in experiment group compared to control in HbA1c ($p=0.0024$), LDL ($p=0.019$), cholesterol ($p=0.002$), knowledge ($p<0.001$), practice ($p<0.001$), and self efficacy ($p<0.001$).

Heinrich et al., 2012	RCT	Sample Size = 99 Age = 56 (±7) Chronic Disease = Diabetes Drop-out rate = 0.07	**Web-based:** Web-based education program covering background information on diabetes, hyperglycemia, diabetes & lifestyle, treatment & management, hypoglycemia, blood glucose, and living with diabetes	Duration: 2 Weeks	**No Education:** No access to the webpage	Knowledge scores and time spent on website	**Improvement to control:** Compared to the control group, the intervention group had higher knowledge scores at post test (β = 0.18 $p<0.001$) with adjustment for knowledge at baseline. Older participants had a lower post-test knowledge score than younger participants.
Kearns et al., 2012	cohort case control	Sample Size = 66 Age = 49.8 (±11.5) Chronic Disease = Diabetes Drop-out rate = n/a	**Videoconference:** Living with diabetes education session via video conference with nurse educator, dietitian, and exercise physiologist	Duration: 3 Months	**Disease Specific Face-to-Face Education:** Living with diabetes education session in person with nurse educator, dietitian, and exercise physiologist	Glycosylated hemoglobin (HbA1c), treatment satisfaction, diabetes education, and Problem Areas in Diabetes (PAID) survey	**Comparable to control:** PAID scores increased in both groups. Diabetes treatment satisfaction increased in control group ($p<0.001$) but not in intervention.

Lee et al., 2007	quasi-experimental	Sample Size = 274 Age = 61.15 (±12.67) Chronic Disease = Diabetes Drop-out rate = 0.25	**Web-based:** Access to medical information and education materials online. Patients also received email and SMS alert before appointments	Duration: 9 Months / Frequency: Access to webpage 24/7, plus reminders for appointments every 3 months	**Disease Specific Face-to-Face Education:** No access to the webpage, traditional in person education sessions and appointments every 3 months	Fasting blood glucose, glycosylated hemoglobin (HbA1c), total cholesterol, triglyceride, HDL cholesterol	**Improvement to control:** Fasting blood glucose different between control and intervention groups in first follow up (F=5.079, p=0.025) second follow up (F=9.735, p=0.002) and third follow up (F=10.857, p=0.001). HbA1c different between control and intervention groups in second (F=8.459, p=0.004) and third follow up (F=10.784, p=0.001). Total cholesterol was different between control and intervention in third follow up (F=6.378, p=0.012).
Liu et al., 2013	RCT	Sample Size = 60 Age = 69.4 (±3.3) Chronic Disease = COPD Drop-out rate = 0.05	**Web-based:** Home-based video rehabilitation program with four stages of breathing exercises. Each stage lasting one month. Patients who had not logged in regularly would receive reminder phone call from respiratory nurse.	Duration: 4 Months	**Disease Specific Face-to-Face Education:** Instructed on the importance of exercise by a respiratory nurse at discharge from the hospital. Handouts with pictures of breathing exercises were also given, with advice to perform these exercises for four months.	Pulmonary function, exercise capacity, health related quality of life (SGRQ), six minute walking distance	**Improvement to control:** Six-minute walking distance increased by 74.6 m in the dyspnea breathing group and decreased by 5.8 m in the control group ($p < 0.05$). All other measurements increased from baseline to 4 month follow up in intervention group. No change in control group

Moattari et al., 2013	RCT	Sample Size = 48 Age = 23.35 (18-39) Chronic Disease = Diabetes Drop-out rate = 0.08	**Web-based:** Online education site where participants enter data for self regulation. Participants could also ask questions on the site and received answers within 24 hours and were given weekly feedback from their healthcare team	Duration: 3 Months / Frequency: Daily	**Disease Specific Face-to-Face Education:** Usual diabetes education provided in the research centre	Glycosylated hemoglobin (HbA1c), fasting blood sugar, triglycerides, total cholesterol, HDL cholesterol, and LDL cholesterol	**Improvement to control:** Intervention HbA1c significantly improved compared to control $p<0.001$ and intervention LDL cholesterol significantly decreased compared to control $p<0.02$
Nguyen et al., 2013	randomized repeated measures	Sample Size = 110 Age = 68.5(±11) Chronic Disease = COPD Drop-out rate = 0.13	**Web-based:** Face to face exercise consultation, website and smartphone training, smartphone diary entry, reinforcement e-mails, interactive web modules, and live group chat sessions	Duration: 12 Months / Frequency: Daily	**General Face-to-Face Education:** Monthly face-to-face education classes that focused on health topics of interest to middle and older-aged adults and unrelated to lung disease (e.g., nutrition and general safety with medications). Participants also received biweekly phone calls that provided general health information.	Chronic respiratory questionnaire, exercise performance, intervention exposure, and satisfaction	**Comparable to control:** dyspnea improved in both groups, not significantly different from each other
Noh et al., 2010	RCT	Sample Size = 40 Age = 42.5 (±10.6) Chronic Disease = Diabetes Drop-out rate = 0.09	**Web-based:** Online information system (eMOD) and doctors visits every two months	Duration: 6 Months	**Disease Specific Paper-based Education:** Diabetes educational books that have similar contents with the eMOD website as well as physician visits every 2 months	Glycosylated hemoglobin (HbA1c), blood pressure, body mass index, triglycerides, HDL cholesterol, LDL cholesterol,	**Comparable to control:** HbA1c significantly decreased in intervention group ($p=0.031$), but not in control group. No significant difference between control and intervention

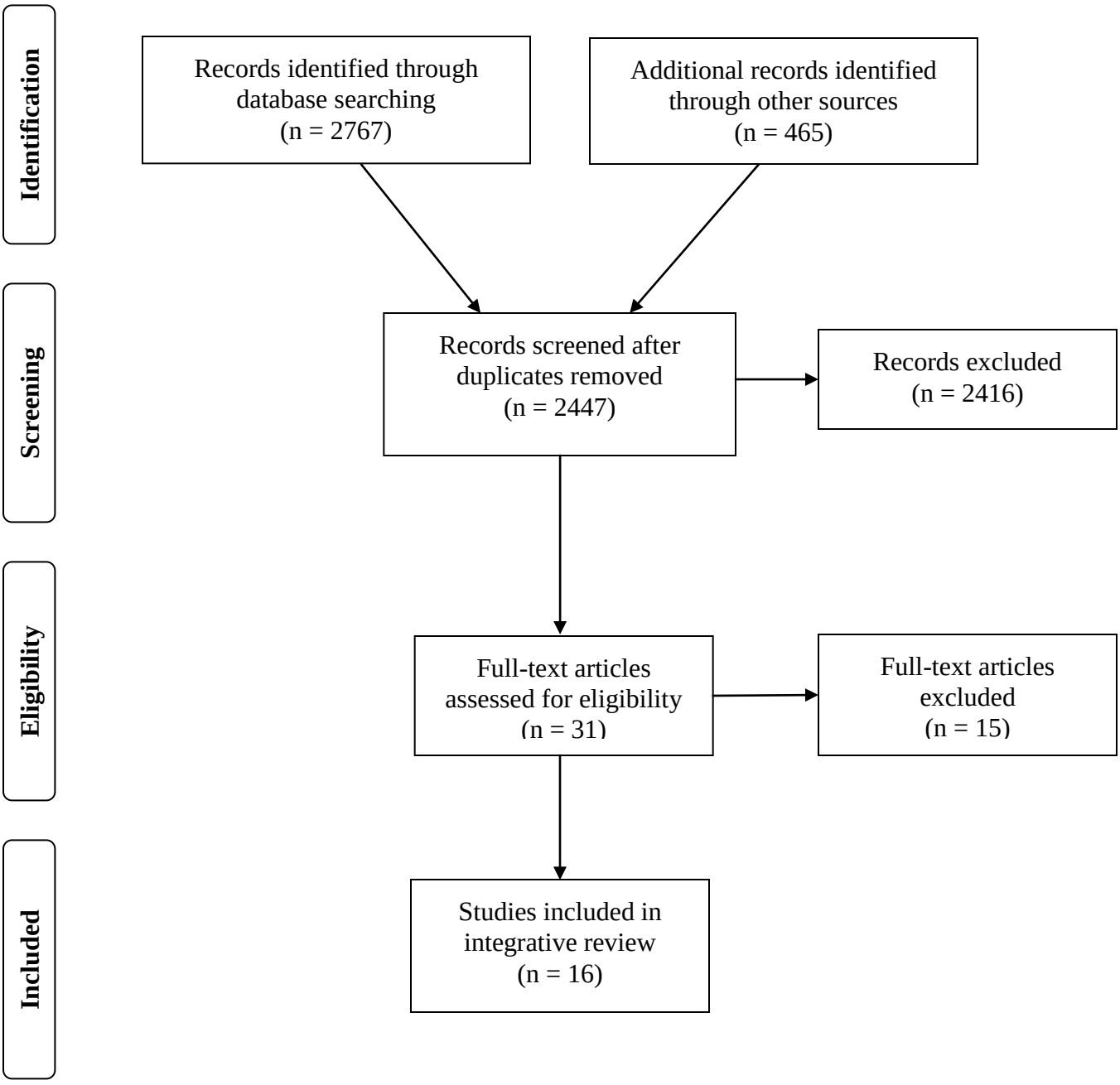
Pacaud et al. 2012	RCT	Sample Size = 79 Age = 54.0 (±9.3) Chronic Disease = Diabetes Drop-out rate = 0.14	**Web-based:** Online site where participants could enter data for self regulation. Participants also had medication updates, track your learning updates, virtual appointments over email with clinicians, and reminders.	Duration: 12 Months	**Disease Specific Paper-based Education and/or Disease Specific Face-to-Face Education:** Control group received paper-based educational materials and normal follow-up care through face-to-face educational meetings/seminars with their provider and/or attended group educational sessions.	A1C, diabetes knowledge, self efficacy, self care behaviour, satisfaction, and diabetes quality of life,	**Comparable to control:** all groups increase in diabetes knowledge (p=0.005), self efficacy (p=0.019), and self care (p=0.006). No significant between group differences in A1C
Patnaik, Joshi, & Sahu, 2015	RCT	Sample Size = 55 Age = 52 (±12) Chronic Disease = Diabetes Drop-out rate = 0.45	**Telephone:** Participants were counselled with lifestyle education using printed material and computers. SMS with educational tips and to decease stress were sent weekly and investigators call every three weeks	Duration: 3 Months / Frequency: Weekly	**Disease Specific Paper-based Education:** Printed educational materials	Perceived Stress	**Improvement to control:** Perceived stress significantly decreased in intervention group compared to control group (p=0.001)
Stickland et al., 2011	parallel group, noninferiority trial	Sample Size = 409 Age = 69.5 (±9.7) Chronic Disease = COPD Drop-out rate = 0.68	**Videoconference:** Patients were seen by a pulmonologist via Telehealth and participated in group exercise for 2 h and attended group education for 1 h per session via video conference.	Duration: 2 Months / Frequency: Weekly	**Disease Specific Face-to-Face Education:** Group education and exercise program, twice weekly for eight weeks, sessions comprised of group exercise for 2 h, and group education for 1 h.	Self administered St. Georges Respiratory Questionnaire (SGRQ), Self paced 12 minute walking test - distance recorded, and lung function	**Comparable to control:** significant improvement in SGRQ scores in both groups. Significant improvement in self paced 12 min walking distance in both groups. SGRQ scores were maintain at 6 month follow-up in both groups

van der Meer et al., 2009	RCT	Sample Size = 200 Age = 36 (18-50) Chronic Disease = Asthma Drop-out rate = 0.08	**Web-based:** Participants received weekly asthma control monitoring and treatment advice, online and group education, and remote Web communications with a specialized asthma nurse.	Duration: 12 Months / Frequency: Weekly	**Usual Physician Care:** Usual care followed Dutch general practice guidelines on asthma management in adults, which recommend a medical review and treatment adjustment every 2 to 4 weeks in unstable asthma and medical review once or twice yearly for patients whose asthma is under control.	Prebronchodilator FEV1, daily inhaled corticosteroid dose as fluticasone equivalents, quality of life, asthma knowledge, inhaler technique, and self-reported medication adherence	**Comparable to control:** Asthma knowledge and inhalation technique improved in both groups - no difference between groups.
Wai Leng et al., 2014	Observational Study	Sample Size = 633 Age = 63.0 (±12.5) Chronic Disease = Diabetes Drop-out rate = 0.21	**Telephone:** 20 minute phone call once every 3 months on personalized education, symptom, recognition, diabetes, cholesterol, blood pressure, and life style management. Patients were followed up 3 months after last phone appointment	Duration: 3 Months / Frequency: Monthly	**Usual Physician Care:** Usual care involved routine follow-up with physicians at intervals of 3–4 months, depending on the adequacy of the patient's glycaemic control.	Glycosylated hemoglobin (HbA1c) and diabetes related re-admission rate	**Improvement to control:** Patients with baseline HbA1c > 8% significant improvement in intervention group compared to control (p=0.022)

Table 2. Description of Studies

Figure

Figure 1.
Summary of literature search and study selection process.



Adapted from: Moher D., Liberati A., Tetzlaff J., Altman D. G., & The PRISMA Group, (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine, 6*(6), e1000097.