Effect of Telehealth Interventions on Hospitalization Indicators: A Systematic Review

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Abstract

Background: Telehealth has been defined as the remote delivery of healthcare services using information and communication technology. Where resource-limited health systems face challenges caused by the increasing burden of chronic diseases and an aging global population, telehealth has been advocated as a solution for changing and improving the paradigm of healthcare delivery to cope with these issues. The aim of this systematic review is to investigate the effect of telehealth interventions on two indicators: hospitalization rate and length of stay.

Materials and Methods: The reviewers searched the PubMed, ScienceDirect, and Springer electronic databases from January 2005 to November 2013. A search strategy was developed using a combination of the following search keywords: *impact*, *effect*, *telehealth*, *telemedicine*, *telecare*, *hospitalization*, *length of stay*, and *resource utilization*. Both randomized controlled trials and observational studies were included in the review. To be included in the review, articles had to be written in English. The results of study were compiled, reviewed, and analyzed on the basis of the review aims.

Results: This systematic review examined 22 existing studies with a total population of 19,086 patients. The effect of telehealth on all-cause hospitalization was statistically significant in 40 percent of the related studies, whereas it was not statistically significant in 60 percent. Similarly, the effect of telehealth on the all-cause length of stay was statistically significant in 36 percent of the studies and nonsignificant in 64 percent.

Conclusion: Considering the fact that hospitalization rate and length of stay can be confounded by factors other than telehealth intervention, studies examining the effect of the intervention on these indicators must take into account all other factors influencing them. Otherwise any judgment on the effect of telehealth on these indicators cannot be valid.

Keywords: telehealth, telemedicine, impact, length of stay, hospital admission

Introduction

Telehealth has been defined as the remote delivery of healthcare services using information and communication technology.[1] The term is broader than *telemedicine* and covers a variety of physician and nonphysician services.[2] The wide availability of the Internet accompanied by the increasing pace of technological advances has provided new opportunities for telehealth.[3]

Where resource limited-health systems face challenges caused by an increasing burden of chronic diseases and the aging global population,[4,5] telehealth has been advocated as a solution for changing and improving the current paradigm of healthcare delivery to cope with these issues.[6,7] However, its opponents continue to criticize it.[8-12]

Several systematic reviews have investigated the effects of various telehealth interventions on aspects of healthcare and healthcare delivery, and they have infrequently found consistent results of those interventions.[13-19] Few systematic reviews of the effects of telehealth interventions on hospital indicators have been conducted. These reviews have been restricted to populations of patients with particular types of diseases, or they have investigated particular effects of telehealth, for instance the socioeconomic effect, and have reported that the positive effects of telehealth on those aspects could not be generalized beyond those particular studies.[20,21] To the best of our knowledge, no systematic review has been conducted to explore the effect of telehealth interventions on hospital indicators among different types of patients regardless of disease type.

In this analysis, studies of the effect of telehealth interventions on two main hospital indicators were reviewed. The outcome of the studies reviewed could be positive, negative, or neutral. Therefore, conflicting results are to be expected. This article presents the reported evidence on the effect of telehealth and the characteristics of those reports. The intention of this article is not to assess or pass judgment on the value of telehealth.

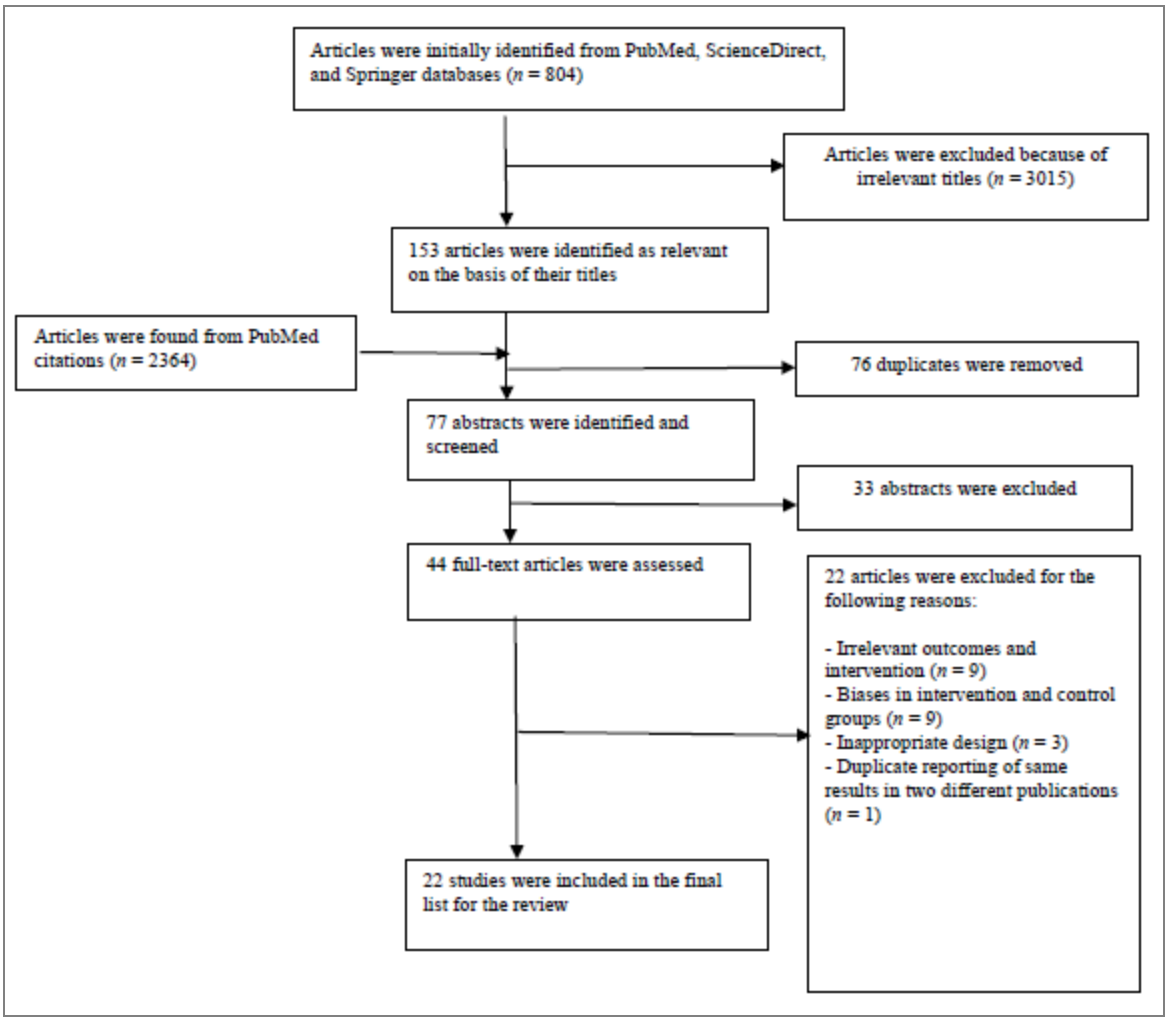
Methodology

Criteria for Considering Studies for the Review

Both randomized controlled trials and observational studies were included in the review. Systematic reviews or other types of studies were excluded. All forms of telehealth interventions ranging from telephone to two-way videoconferencing (either asynchronous or real-time technologies) were included in this review. In the studies, patients receiving any type of telehealth interventions were compared with those receiving usual face-to-face care. No limitation was set for the participants or the country of the study.

Studies were included if they reported objective measures of hospitalization or length of stay. Studies in which outcomes were related to any institution other than hospital, such as home care facilities or correctional facilities, were excluded from this review. Papers had to be written in English to be included. Articles with any bias toward possible influencing effects on the outcomes were also excluded. For instance, if the severity of disease differed between the intervention group and the control group in a study, the study was excluded. Figure 1 illustrates the process of selecting studies for the detailed review.

Figure 1: Flowchart Representing the Selection of Studies for the Systematic Review of the Effects of Telehealth on Hospitalization Indicators



Search Methods for Identification of Studies

The reviewers searched the PubMed, ScienceDirect, and Springer electronic databases for articles published from January 2005 to November 2013. A search strategy was developed using a combination of the following keywords: *impact*, *effect*, *telehealth*, *telemedicine*, *telecare*, *hospitalization*, *length of stay*, and *resource utilization*.

Data Extraction

Eligible papers were reviewed independently by the reviewers using a data extraction form that was developed for the purpose of this review and contained the following data elements:

- Name of the author
- Year of publication
- Size of population in both the intervention and control groups
- The country in which the study took place
- Title of the study
- Design type of the study
- Devices used for the telehealth intervention
- The specified aim of the telehealth intervention
- The type of intervention (i.e., real-time vs. asynchronous)
- Participants' type of illness
- Indicators on hospitalization rate or length of stay
- The statistical significance of the effect of the telehealth intervention on each of the indicators

In the process of the review and the data extraction, any disagreement among the investigators was resolved utilizing team discussion to achieve consensus.

Assessing Risk of Bias

The quality of studies was assessed using a mixed-method assessment tool. Depending on the study design, a range of criteria were used to assess the risk of bias. Criteria considered for assessing the studies included the following:

- A clear description of randomization
- Allocation concealment or blinding
- Completeness of outcome data
- Quality of outcome reporting
- Sampling and sample justification
- Control of confounding factors

Results

Basic Characteristics of the Studies

A summary of the basic characteristics of all 22 studies included in the review is provided in Table 1. As can be seen, 14 of the 22 studies were randomized controlled trials, and 8 studies used an observational method design. The age of the population in all studies ranged from 55 to 77 years except for one that was conducted on a population of infants. The purpose of the telehealth interventions in the studies included the following:

- Monitoring
- Education
- Supporting
- Measuring
- Managing
- Consultation

Table 1: Characteristics of Studies Included in the Systematic Review Examining the Effects of Telehealth on Hospitalization Indicators

Study Authors	Country	Type of Study	Mean Participant Age in Years	Type of Disease	Purpose of Intervention	Type of Outcome
Wakefield et al.[a]	United States	RCT	69	HF	To support patients after discharge	H, LOS
Morguet et al.[b]	Germany	Obs	61	HF	To educate and monitor patients' body weight, blood pressure, and pulse rate daily	H, LOS
Scherr et al.[c]	Austria	RCT	66	HF	To measure patients' vital parameters (blood pressure, heart rate, body weight) and send them to the monitoring center	H, LOS
Dinesen et al.[d]	Denmark	RCT	68	COPD	To assess the patient's data, monitor the patient's disease, and provide advice to the patient	H
Bowles et al.[e]	United States	RCT	75	DB, HF	To support patient care; to monitor and instruct patients on self-care and disease management	H
Steventon et al.[f]	England	Obs	66	CHD, DB, HF, COPD	To ask patients about current health status and encourage patients to better manage their health conditions	H, LOS
Dang et al.[g]	United States	Obs	72	DB, HF, COPD	To monitor and exchange disease-related information between patients and caregivers	H, LOS
Steventon et al.[h]	England	RCT	70	DB, HF, COPD	To monitor and educate patients	H, LOS
Soran et al.[i]	United States	RCT	76	HF	To monitor and detect early signs and symptoms of heart failure	H, LOS
Ferrante et al.[j]	Argentina	RCT	65	HF	To improve patients' diet and treatment, promote exercise, and regularly monitor symptoms, weight, and edema	H
Jia et al.[k]	United States	Obs	68	DB	To answer questions about patients' symptoms and monitor daily information	H
Chen et al.[l]	Taiwan	Obs	63	HF	To educate and communicate (two-way) with patients on diet therapy, fluid restriction, and adverse drug effects	H, LOS
Weintraub et al.[m]	United States	RCT	69	HF	To assess variables important to patient care management	H, LOS
Steventon et al.[n]	England	RCT	75	SCN	To monitor functions, security and environments of patients	H, LOS
Giordano et al.[o]	Italy	RCT	57	HF	To telemonitor and tele-assist	H
Webb et al.[p]	United States	Obs	0.67	CoHD	To send echocardiography studies from the community hospital to the tertiary hospital to be interpreted	LOS

Dendale et al.[q]	Belgium	RCT	76	HF	To measure body weight, blood pressure, and heart rate and send them to the central computer	H
Domingo et al.[r]	Spain	Obs	66	HF	To record weight, heart rate, and blood pressure and send them to the healthcare staff supporting patients via a dedicated web application	H, LOS
Schofield et al.[s]	United States	Obs	67	HF	To report and update patient symptoms and vital signs	H, LOS
Koehler et al.[t]	Germany	RCT	67	HF	To do daily self-assessment of blood pressure, body weight, and electrocardiography and send the results to the central server	H, LOS
Cleland et al.[u]	Holland Germany United Kingdom	RCT	67	HF	To assess patients' symptoms and medication; to measure weight, blood pressure, heart rate, and heart rhythm and communicate the information	LOS
Dansky et al.[v]	United States	RCT	77	HF	To take measurements of blood pressure, pulse, weight; to allow two-way, synchronous interaction between nurse and patient	H

Abbreviations: DB, diabetes; CHD, coronary heart disease; CoHD, congenital heart disease; COPD, chronic obstructive pulmonary disease; H, hospitalization; HF, heart failure; LOS, length of stay; Obs, observational; RCT, randomized controlled trial; SCN, social care needs.

Note: All studies in this table had usual care as the control.

[a] Wakefield, B., M. Ward, et al. "Evaluation of Home Telehealth Following Hospitalization for Heart Failure: A Randomized Trial." *Telemedicine and e-Health* 14, no. 8 (2008): 753–61.

[b] Morguet, A., P. Kühnelt, et al. "Impact of Telemedical Care and Monitoring on Morbidity in Mild to Moderate Chronic Heart Failure." *Cardiology* 111, no. 2 (2008): 134–39.

[c] Scherr, D., P. Kastner, et al. "Effect of Home-based Telemonitoring Using Mobile Phone Technology on the Outcome of Heart Failure Patients after an Episode of Acute Decompensation: Randomized Controlled Trial." *Journal of Medical Internet Research* 11, no. 3 (2009): e34.

[d] Dinesen, B., L. Haesum, et al. "Using Preventive Home Monitoring to Reduce Hospital Admission Rates and Reduce Costs: A Case Study of Telehealth among Chronic Obstructive Pulmonary Disease Patients." *Journal of Telemedicine and Telecare* 18, no. 4 (2012): 221–25.

[e] Bowles, K., D. Holland, and D. A. Horowitz. "A Comparison of In-person Home Care, Home Care with Telephone Contact and Home Care with Telemonitoring for Disease Management." *Journal of Telemedicine and Telecare* 15, no. 7 (2009): 344–50.

[f] Steventon, A., S. Tunkel, et al. "Effect of Telephone Health Coaching (Birmingham OwnHealth) on Hospital Use and Associated Costs: Cohort Study with Matched Controls." *British Medical Journal* 347 (2013): f4585.

[g] Dang, S., F. Ma, et al. "Differential Resource Utilization Benefits with Internet-based Care Coordination in Elderly Veterans with Chronic Diseases Associated with High Resource Utilization." *Telemedicine and e-Health* 12, no. 1 (2006): 14–23.

[h] Steventon, A., M. Bardsley, et al. "Effect of Telehealth on Use of Secondary Care and Mortality: Findings from the Whole System Demonstrator Cluster Randomised Trial." *British Medical Journal* 344 (2012): e3874.

[i] Soran, O., I. Pina, et al. "A Randomized Clinical Trial of the Clinical Effects of Enhanced Heart Failure Monitoring Using a Computer-based Telephonic Monitoring System in Older Minorities and Women." *Journal of Cardiac Failure* 14, no. 9 (2008): 711–17.

[j] Ferrante, D., S. Varini, et al. "Long-Term Results after a Telephone Intervention in Chronic Heart Failure: DIAL (Randomized Trial of Phone Intervention in Chronic Heart Failure) Follow-up." *Journal of the American College of Cardiology* 56, no. 5 (2010): 372–78.

[k] Jia, H., H. Feng, et al. "A Longitudinal Study of Health Service Utilization for Diabetes Patients in a Care Coordination Home-Telehealth Programme." *Journal of Telemedicine and Telecare* 17, no. 3 (2011): 123–26.
[l] Chen, Y., Y. Ho, et al. "Assessment of the Clinical Outcomes and Cost-effectiveness of the Management of Systolic Heart Failure in Chinese Patients Using a Home-based Intervention." *Journal of International Medical Research* 38, no. 1 (2010): 242–52.
[m] Weintraub, A., D. Gregory, et al. "A Multicenter Randomized Controlled Evaluation of Automated Home Monitoring and Telephonic Disease Management in Patients Recently Hospitalized for Congestive Heart Failure: The SPAN-CHF II Trial." *Journal of Cardiac Failure* 16, no. 4 (2010): 285–92.
[n] Steventon, A., M. Bardsley, et al. "Effect of Telecare on Use of Health and Social Care Services: Findings from the Whole Systems Demonstrator Cluster Randomised Trial." *Age and Ageing* 42, no. 4 (2013): 501–8.
[o] Giordano, A., S. Scalvini, et al. "Multicenter Randomised Trial on Home-based Telemanagement to Prevent Hospital Readmission of Patients with Chronic Heart Failure." *International Journal of Cardiology* 131, no. 2 (2009): 192–99.
[p] Webb, C., C. Waugh, et al. "Impact of Telemedicine on Hospital Transport, Length of Stay, and Medical Outcomes in Infants with Suspected Heart Disease: A Multicenter Study." *Journal of the American Society of Echocardiography* 26 no. 9 (2013): 1090–98.
[q] Dendale, P., G. De Keulenaer, et al. "Effect of a Telemonitoring-facilitated Collaboration between General Practitioner and Heart Failure Clinic on Mortality and Rehospitalization Rates in Severe Heart Failure: The TEMA-HF 1 (TElemonitoring in the MAnagement of Heart Failure) Study." *European Journal of Heart Failure* 14, no. 3 (2012): 333–40.
[r] Domingo, M., J. Lupon, et al. "Noninvasive Remote Telemonitoring for Ambulatory Patients with Heart Failure: Effect on Number of Hospitalizations, Days in Hospital, and Quality of Life. CARME (CAtalan Remote Management Evaluation) Study." *Revista Espanola de Cardiologia* 64, no. 4 (2011): 277–85.
[s] Schofield, R., S. Kline, et al. "Early Outcomes of a Care Coordination-enhanced Telehome Care Program for Elderly Veterans with Chronic Heart Failure." *Telemedicine and e-Health* 11, no. 1 (2005): 20–27.
[t] Koehler, F., S. Winkler, et al. "Impact of Remote Telemedical Management on Mortality and Hospitalizations in Ambulatory Patients with Chronic Heart Failure: The Telemedical Interventional Monitoring in Heart Failure Study." *Circulation* 123, no. 17 (2011): 1873–80.
[u] Cleland, J., A. Louis, et al. "Noninvasive Home Telemonitoring for Patients with Heart Failure at High Risk of Recurrent Admission and Death: The Trans-European Network–Home-Care Management System (TEN-HMS) Study." *Journal of the American College of Cardiology* 45, no. 10 (2005): 1654–64.
[v] Dansky, K., J. Vasey, and K. Bowles. "Impact of Telehealth on Clinical Outcomes in Patients with Heart Failure." *Clinical Nursing Research* 17, no. 3 (2008): 182–99.

Table 2 illustrates the different devices that were employed to perform the interventions. These include:

- Telephones
- Mobile phones
- Television sets (used as monitors)
- Computerized Internet-based devices
- Automated self-monitoring devices
- Telemeasuring devices
- Video cameras
- Personal digital assistants
- Wireless Bluetooth devices

Table 2: Summarization of the Effects of Telehealth on Hospitalization Indicators in Studies Included in the Systematic Review

Study Authors	Intervention Device (Modality)	Sample Size	Follow-up in Months	Statistically Significant Outcomes	
				Hospitalization	Length of Stay
Wakefield et al.[a]	1. Telephone (R) 2. Patient station consisting of television monitor	Intervention 1: 47	12	Intervention 3: all-cause, SD	None

	and video camera kit with a microphone (R) 3. Combined tools (R)	Intervention 2: 52 Intervention 3: 99 Control: 49			
Morguet et al.[b]	Telephone and the telemonitoring equipment (R)	Intervention: 32 Control: 96	11	All-cause, SD Other noncardiac reasons, SD	All-cause, SD Other cardiac reasons, SD
Scherr et al.[c]	Weight scale, sphygmomanometer, mobile phone, and client-server communication through Internet (A)	Intervention: 54 Control: 54	6	None	Heart failure, SD
Dinesen et al.[d]	Telehealth monitor system using wireless technology (A, R)	Intervention: 57 Control: 48	10	All-cause, SD	None
Bowles et al.[e]	1. Telephone (R) 2. Physiological monitor equipped with a blood pressure cuff, body weight scale, glucometer, pulse oximeter, digital stethoscope, and videoconferencing devices (R)	Intervention 1: 93 Intervention 2: 98 Control: 112	2	None	None
Steventon et al.[f]	Telephone (R)	Intervention: 2,698 Control: 2,698	12	None	None
Dang et al.[g]	Computerized, Internet-based, and in-home messaging and monitoring device for automating the daily monitoring of the enrolled patients by a care coordinator (A)	Congestive heart failure 17, control 17		Heart failure, SD	None
		Chronic obstructive pulmonary disease 17, control 17		None	None
		Diabetes mellitus 23, control 23		None	None
Steventon et al.[h]	Remote, automatic, and passive monitoring system in addition to peripheral devices including a pulse oximeter, a glucometer, and weighing scales (A)	Intervention: 1,570 Control: 1,584	12	All-cause, SD	All-cause, SD
Soran et al.[i]	Electronic scale and an individualized symptom response system linked via standard phone line to a computerized database (A)	Intervention: 160 Control: 155	6	None	None
Ferrante et al.[j]	Telephone (R)	Intervention: 760 Control: 758	12–48	Heart failure, SD	None
Jia et al.[k]	Home telehealth device (messaging device) and telephone (R)	Intervention: 387 Control: 387	48	None	None
Chen et al.[l]	Telephone (R)	Intervention: 275 Control: 275	6	All-cause, SD Heart failure, SD	All-cause, SD Heart failure, SD

Weintraub et al.[m]	Tele-measurement devices and an interactive communication device (A)	Intervention: 95 Control: 93	3	None	None
Steventon et al.[n]	Tele-care base unit along with a pendant alarm and up to 27 various peripheral devices (R)	Intervention: 1,236 Control: 1,190	12	None	None
Giordano et al.[o]	Portable measurement devices transferring data by a fixed or mobile telephone; one lead trace to a receiving station where health professional was available (A)	Intervention: 226 Control: 229	12	All-cause, SD Heart failure, SD	None
Webb et al.[p]	Interactive system along with store and forward system (A)	Intervention: 337 Control: 337	36	None	All-cause, SD
Dendale et al.[q]	Electronic weight scale, a blood pressure monitoring device along with a cell-phone, central computer (A)	Intervention: 80 Control: 80	6	None	None
Domingo et al.[r]	Interactive platform, automated self-monitoring equipment, Internet connection, and television used as monitor (A)	Intervention: 92 Control: 92	12	Heart failure, SD Other cardiac reasons, SD	Heart failure, SD Other cardiac reasons, SD
Schofield et al.[s]	In-home messaging device, a secure Internet site, and telephone (A)	Intervention: 73 Control: 73	6	All-cause, SD	All-cause, SD
Koehler et al.[t]	Portable measuring devices connected to a personal digital assistant for transferring information via cell phone to telemedicine centers (A)	Intervention: 354 Control: 356	26	None	None
Cleland et al.[u]	1. Telephone (A, R) 2. An electronic weighing scale, an automated sphygmomanometer, single-lead electrocardiogram using wristband electrodes, all communicated to a hub connected to patient's phone line and central web server and then workstations via secure Internet connection (A, R)	Intervention 1: 170 Intervention 2: 163 Control: 85	8	None	None
Dansky et al.[v]	Tele-home-care system: telephone-based communication system with medical peripherals (A, R)	Intervention: 174 Control: 112	2, 4	At 2 months: SD (not significant at 4 months)	None

Abbreviations: A, asynchronous; R, real-time; SD, significant decrease.

[a] Wakefield, B., M. Ward, et al. "Evaluation of Home Telehealth Following Hospitalization for Heart Failure: A Randomized Trial." *Telemedicine and e-Health* 14, no. 8 (2008): 753–61.

[b] Morguet, A., P. Kühnelt, et al. "Impact of Telemedical Care and Monitoring on Morbidity in Mild to Moderate Chronic Heart Failure." *Cardiology* 111, no. 2 (2008): 134–39.

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[g] Dang, S., F. Ma, et al. "Differential Resource Utilization Benefits with Internet-based Care Coordination in Elderly Veterans with Chronic Diseases Associated with High Resource Utilization." *Telemedicine and e-Health* 12, no. 1 (2006): 14–23.
[h] Steventon, A., M. Bardsley, et al. "Effect of Telehealth on Use of Secondary Care and Mortality: Findings from the Whole System Demonstrator Cluster Randomised Trial." *British Medical Journal* 344 (2012): e3874.
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[n] Steventon, A., M. Bardsley, et al. "Effect of Telecare on Use of Health and Social Care Services: Findings from the Whole Systems Demonstrator Cluster Randomised Trial." *Age and Ageing* 42, no. 4 (2013): 501–8.
[o] Giordano, A., S. Scalvini, et al. "Multicenter Randomised Trial on Home-based Telemanagement to Prevent Hospital Readmission of Patients with Chronic Heart Failure." *International Journal of Cardiology* 131, no. 2 (2009): 192–99.
[p] Webb, C., C. Waugh, et al. "Impact of Telemedicine on Hospital Transport, Length of Stay, and Medical Outcomes in Infants with Suspected Heart Disease: A Multicenter Study." *Journal of the American Society of Echocardiography* 26 no. 9 (2013): 1090–98.
[q] Dendale, P., G. De Keulenaer, et al. "Effect of a Telemonitoring-facilitated Collaboration between General Practitioner and Heart Failure Clinic on Mortality and Rehospitalization Rates in Severe Heart Failure: The TEMA-HF 1 (TElemonitoring in the MAnagement of Heart Failure) Study." *European Journal of Heart Failure* 14, no. 3 (2012): 333–40.
[r] Domingo, M., J. Lupon, et al. "Noninvasive Remote Telemonitoring for Ambulatory Patients with Heart Failure: Effect on Number of Hospitalizations, Days in Hospital, and Quality of Life. CARME (CAtalan Remote Management Evaluation) Study." *Revista Espanola de Cardiologia* 64, no. 4 (2011): 277–85.
[s] Schofield, R., S. Kline, et al. "Early Outcomes of a Care Coordination-enhanced Telehome Care Program for Elderly Veterans with Chronic Heart Failure." *Telemedicine and e-Health* 11, no. 1 (2005): 20–27.
[t] Koehler, F., S. Winkler, et al. "Impact of Remote Telemedical Management on Mortality and Hospitalizations in Ambulatory Patients with Chronic Heart Failure: The Telemedical Interventional Monitoring in Heart Failure Study." *Circulation* 123, no. 17 (2011): 1873–80.
[u] Cleland, J., A. Louis, et al. "Noninvasive Home Telemonitoring for Patients with Heart Failure at High Risk of Recurrent Admission and Death: The Trans-European Network–Home-Care Management System (TEN-HMS) Study." *Journal of the American College of Cardiology* 45, no. 10 (2005): 1654–64.
[v] Dansky, K., J. Vasey, and K. Bowles. "Impact of Telehealth on Clinical Outcomes in Patients with Heart Failure." *Clinical Nursing Research* 17, no. 3 (2008): 182–99.

In the randomized controlled trials, the follow-up duration for measuring the outcomes ranged from 2 to 26 months, whereas in the observational studies the follow-up duration ranged from 6 to 48 months.

Effect of Telehealth on Hospitalization and Length of Stay

The effect of telehealth on hospitalization and length of stay was categorized on the basis of the reason for admission including all-cause, heart failure, other cardiac conditions, and other noncardiac reasons (see Table 2).[22-43]

The effect of telehealth on all-cause hospitalization was statistically significant (significant decrease) in 40 percent of the studies that reported hospitalization outcomes, whereas it was not statistically significant in 60 percent of those studies. Similarly, the effect of telehealth on all-cause length of stay was statistically significant (significant decrease) in 36 percent of the studies that reported a length-of-stay outcome, and it was not significant in 64 percent of those studies.

Discussion

This systematic review included 22 existing studies with a total population of 19,086 patients. The basic characteristics of the studies are discussed first, and then more detail regarding the effects of telehealth on hospitalization rate and length of stay is provided.

Age and Diseases in the Population

Although telehealth can be utilized to provide services for different age groups,[44] the average age of the population in the included studies was found to be high (i.e., older) in this review. This finding can be attributed to the fact that most previous studies had been conducted on participants with chronic conditions, and about 75 percent of the elderly have at least one chronic disease and 50 percent have at least two chronic conditions.[45] The total population in the studies had chronic conditions, which may be a consequence of the realization that patients with chronic conditions impose heavy financial pressures on healthcare systems[46] and that these conditions can be managed less expensively and more effectively by using telehealth interventions. The cost savings and increased effectiveness therefore justify the focus of telehealth programs on chronic conditions.[47]

Moreover, a growing body of evidence supports the use of telehealth as an effective solution for the management and care of chronic conditions.[48] The chronic diseases for which telehealth intervention was applied in the studies are diabetes, heart failure, coronary heart disease, chronic obstructive pulmonary diseases, and congenital heart disease, and one study examined social care needs; this range of conditions is similar to the spectrum of diseases found in a study conducted on UK telehealth systems.[49]

Type of the Studies

More observational studies reported significant effects than randomized controlled trials did. This finding is consistent with those of the systematic review conducted by Louis et al.[50] and the results reported by Chaudhry et al.,[51] in which no significant effect was found in randomized controlled trial studies in contrast with observational studies. Other reports support this finding.[52,53]

Devices Used for the Telehealth Intervention

Different devices from various vendors were used for the telehealth interventions in the included studies. This pattern was consistent with the equipment listed in a study describing the model of information exchange in UK telehealth systems.[54] The devices with the highest range of usage were telemonitoring tools; this basic required measurement and communication equipment was ubiquitous. This finding is in accordance with the results of a systematic review emphasizing telemonitoring as a promising patient management mechanism in chronic diseases.[55] Telemonitoring has also been referred to as one of the common applications of information technology in the management of chronic diseases[56] and as a facilitating technology in care management of chronic conditions.[57] The telephone was the device with the second highest usage in the studies. This device was used not only for direct communication between healthcare providers and patients but also as a key component of telemonitoring equipment for transferring remote monitoring data. The prevalent usage of the telephone could be due to its wide availability, high level of acceptability to the majority of the population, and ease of use.

Type of Telehealth Modality

The modality of the technology used for interventions was asynchronous in most of the studies,[58-68] as was the case in a systematic review conducted on teleconsultations for diabetes care.[69] This finding may be due to the fact that implementation of real-time telehealth interventions can be much more expensive than implementation of asynchronous ones.[70,71] However,

different results have been reported regarding the outcomes of interventions using these two modalities. Although one study reported low clinical efficacy of the asynchronous modality compared to real-time interventions, other studies documented no difference in the outcomes of these two modalities.[72,73]

Studies of interventions using a hybrid modality (both real-time and asynchronous) were a minority among the included studies. No considerable difference could be observed between the real-time and asynchronous modality interventions in terms of their effects on the hospital indicators that are the subject of this review. The same trend was reported in the systematic review conducted on teleconsultation for diabetes care.[74]

Country and Place of the Intervention

Not a single study included in this review originated in developing countries. This finding is similar to the results of a systematic review on the use of telehealth in Asian countries, in which no study was found to have been conducted on telehealth interventions in Asia.[75] Most of the studies in this review originated in the United States. This finding is in line with existing evidence reported on telehealth trends[76,77] and can be attributed to the substantial investment made by the US federal government in telemedicine networks, technologies, and research.[78] In addition, no study was found to have been conducted on rural populations or in medically underserved communities despite the fact that telehealth intervention can provide opportunities to increase individuals' contact with healthcare services in those types of areas and communities.

Effect of the Intervention on the Hospital Indicators

This systematic review reveals conflicting effects of the telehealth interventions on hospitalization rates in different studies. About 60 percent of the interventions reported no significant effect on the hospitalization rate, and a significant decrease was observed in only 40 percent of the interventions. Although these findings are consistent with the findings of different reviews reporting the weak effect of telehealth on some aspects of healthcare and healthcare delivery,[79-84] they are contrary to other evidence reporting the positive effect of telehealth in different domains of healthcare.[85-89]

In terms of the effect of telehealth on length of stay, no significant effect was reported in 64 percent of the studies, and a significant decrease was observed in 36 percent of the studies.

In this review, the telehealth interventions aimed at the education of patients were found to significantly decrease both the hospitalization rate and the length of stay,[90-92] and existing evidence supports this result.[93] A study of the effect of electronic education on metabolic control indicators of diabetes confirms the positive effect of tele-education,[94] which can be considered to have a transforming effect on patients' behavior and thereby lead to better self-care management. In fact, patient education is a key element of self-management in chronic disease[95] because it enhances patients' ability to manage their own diseases,[96] and it has been discussed in literature as a critical factor for realizing patient-centered care.[97,98] Of course, healthcare professionals' own attitudes toward the benefit of telehealth is an important factor that influences the ultimate effectiveness of patient education and must not be ignored.[99]

The mixed outcomes observed in the studies can be attributed to the fact that an independent initiative rather than an integrated telehealth approach was used in each of the studies, and considerable differences exist among telehealth programs and devices in terms of their quality, reliability, and interoperability.[100] This variability may influence the intervention outcome, as has been highlighted in the literature.[101] In addition, no standard guideline or integrated framework has been established for implementation and evaluation of telehealth programs,[102] making their outcomes more difficult to compare. Moreover, the duration of the intervention and its effect on patients' familiarity with the technology[103] may also influence the outcome of telehealth interventions.

Possible Effects of Factors Other Than Telehealth

Differences observed in outcomes of telehealth interventions might be a consequence of various factors on which no information was provided in the included studies. Among these factors are the contextual conditions of a telehealth implementation that can influence the outcome.[104] It is important to bear in mind that neither technology nor patients act identically in all situations and contexts.[105]

Outcomes may also vary with the socioeconomic status of patients.[106-109] In some reports, longer length of stay has been attributed to the lack of family support and a significant distance between the hospital and the patient's home.[110,111] Individual patients' social problems have also been identified as predictors of hospitalization,[112] but despite such evidence, this factor has been ignored in most of the existing telehealth studies.[113]

Differences observed in the effects of telehealth can also be the result of differences in a patient's personal perception of the intervention; this perception affects the acceptability of the intervention,[114] and as a result, patients may be more inclined to use one particular type of telehealth intervention rather than other available types.[115] More importantly, the quality of the partnership between patients and care providers can also play a significant role in optimizing the potential of telehealth.[116]

Variation in the severity of illness on admission, the day of admission, and patient comorbidities have also been reported to be important factors influencing length of stay.[117-119] These same factors can influence patient discharge status, the quality of care in a previous hospital stay can influence the likelihood of future patient hospitalization, and the existing hospital bed occupancy rate can also have an effect on length of stay.[120-122]

Conclusion

Investigation of the effect of telehealth interventions should not be conducted in a vacuum. Considering the fact that hospitalization and length of stay can be confounded by factors other than telehealth intervention, any study examining the effect of telehealth interventions on these two indicators must be designed to take into account other factors that influence their effectiveness; otherwise, any judgment on the effect of telehealth based on these indicators will not be valid. The conflicting effects observed in telehealth studies could arise from factors other than the intervention itself.

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