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The effects on rehospitalization rate of transitional care using information communication technology in patients with heart failure: A scoping review

KaiXin Qi [*], Tomoko Koike, Youko Yasuda, Satoko Tayama, Itsumi Wati

School of Keio University, Tokyo, Japan

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ABSTRACT

Background: The number of people with heart failure is increasing. These patients have a high readmission rate and need ongoing health care and follow-up after hospital discharge. However, face-to-face nursing care is expensive; therefore, remote care options are required.

Objective: To determine whether there are differences in the effects (rehospitalization rate and drug adherence) between face-to-face transitional care and remote technology, such as information and communication technologies, for transitional care in patients with heart failure within 30 days post-discharge.

Design: A scoping review.

Setting: Patients with heart failure who received an intervention using information and communication technologies within 30 days of discharge after being hospitalized for heart failure, based on published studies.

Methods: Eight English, Japanese, and Chinese databases were searched for research papers published between January 2000 and November 2021 that examined outcomes such as readmission rates in patients with heart failure who received transitional care using remote technologies. This study followed the screening criteria outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 guidelines.

Results: Seventeen studies were included in this review. Among them, 14 studies reported lower readmission rates in the transitional care group using information and communication technologies compared to the control group, and the difference was statistically significant in nine studies. In addition, one paper showed that the transitional care group experienced more significant improvements in patient satisfaction and quality of life.

Conclusions: Transitional care using information and communication technologies can provide necessary guidance according to the patient's schedule, regardless of the patient's location and time. Patients can share their self-monitored information with medical practitioners and receive timely feedback and guidance. With continuous follow-up support from medical practitioners, patients can adjust their care plans to ensure optimal execution, and the patient's doubts and anxieties can be quickly resolved, increasing the patient's self-confidence. As a result, patients' self-care ability was improved, and controlling symptoms and preventing deterioration became easier. We inferred that the transitional care group achieved a higher self-care ability compared with the control group. Transitional care using remote technologies, such as information and communication technologies following discharge for heart failure patients, can help to reduce

* Corresponding author at: Keio University Shonan Fujisawa, 4411 Endo Fujisawa, Kanagawa Prefecture, Japan.
E-mail addresses: qikaixin86@icloud.com, 50362634@qq.com (K. Qi).

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readmission rates within 30 days of discharge compared to face-to-face care. In addition, the study demonstrated that remote technologies may improve quality of life and patient satisfaction.

What is already known about the topic?

- Information and communication technology is becoming increasingly popular for the remote management of patients, including transitional care.
- There is a lack of studies comparing the effectiveness of face-to-face transitional care with that of information and communication technology transitional care.

What this paper adds

- We found that information and communication technology can enhance self-care ability in patients with heart failure.
- Transitional care using remote technologies, such as information and communication technology. can decrease readmission rates in heart failure patients.
- Information and communication technology may also improve patients' satisfaction and quality of life.

1. Background

1.1. Causes of heart failure patient rehospitalization

Japan is a hyper-aged society, and the number of patients with chronic diseases is increasing, especially among older adults, as 86% have some form of chronic disease (Terai and Miyamoto, 2007). The number of patients with chronic heart failure, including hypertension and ischemic heart disease, continues to rise and is estimated to reach 1.3 million by 2030 (Okura et al., 2008). This represents approximately 1% of Japan's population. The growing number of patients with heart failure is not particular to Japan, but rather a global health challenge. Globally, the number of patients with heart failure in 2017 was 26 million, and those with heart failure over the age of 18 are on track to reach 30 million by 2030 (GBD 2017 Disease and Injury Incidence and Prevalence Collaborators 2018; Andersen and Borlaug, 2014; Savarese and Lund, 2017). In China, the number of patients with heart failure is 8.9 million (GBD 2017 Disease and Injury Incidence and Prevalence Collaborators 2021), approximately 1.3% of the Chinese population.

Furthermore, patients with heart failure are known to have a chronic course and a high rehospitalization rate. In the United States (U.S.), approximately 5 million patients have heart failure, and the readmission rate within 30 days of discharge is reported to be as high as 25% (Heidenreich et al., 2013); furthermore, in 2018, the 30-day readmission rate was 16.7% (Gangu et al., 2022). In China, the readmission rate within one month of discharge was the same (Li, 2017). In a Japanese study using its Heart Failure Registry, the rate of rehospitalization for heart failure after discharge among patients hospitalized for acute decompensated heart failure was 3.3% within 30 days and 8.0% within 90 days after discharge (Ishihara et al., 2020).

Readmissions are driving up healthcare costs for patients with heart failure. In 2012, healthcare costs for patients with heart failure in the U.S. were estimated at $31 billion, placing a significant burden on the healthcare system (Ishihara et al., 2020). Specifically, one of the most significant reasons driving up healthcare costs for heart failure patients was the high hospital readmission rate (Roger, 2013). In 2012, healthcare costs to treat heart failure in 197 countries worldwide were estimated at $108 billion, of which $ 140 million was spent on readmissions, accounting for approximately 10% of the total healthcare costs for patients with heart failure (Cook et al., 2014).

In Japan, the outpatient medical costs for patients with heart failure were approximately $620 million, and inpatient medical costs were approximately $970 million in 2017. Patients with heart failure over the age of 85, those between 75 and 84 years, and those between 65 and 74 years accounted for 62.8%, 36.4%, and 0.8% of the cost, respectively. (Ministry of Health, Labor, and Welfare 2017).

Nonetheless, the medical costs associated with rehospitalization are unknown. The medical costs for patients with heart failure in China in 2003 were estimated at over $48 billion; in 2011 and 2013, medical costs for patients with heart failure averaged $19,000 per person per year, showing a slight decrease (2.5%) (Li and Jian, 2017).

Benbassat and Taragin (2000) and Parry et al. (2008) indicated that the main reason for rehospitalization was the lack of health management after discharge. Specifically, upon discharge from the hospital, patients with heart failure often maintain a distinct perception of being under continuing treatment, potentially lacking sufficient awareness regarding the significance of home-based health management. Moreover, shorter hospital stays have resulted in patients being discharged sooner (Pryor, 2009).

Kinugasa (2017) provided insight into the factors contributing to the readmission rate of patients with heart failure in Japan. Patients with more severe heart failure and comorbidities, such as renal dysfunction and anemia, were at an exceptionally high risk of rehospitalization due to inadequate guidance regarding patient self-care, including salt and fluid restriction, medications, and other self-care instructions before discharge, as well as inadequate guidance for preventing physical activity decline due to aging (Kinugasa, 2017). The causes of rehospitalization of patients with heart failure in China included inadequate management of salt and fluid restriction, fluid retention, inadequate weight control, poor control of hypertension, overwork, psychological factors (depression), and difficulty in taking medications due to different prescriptions received in different hospitals (Zhang, 2021).

Insufficient self-care worsens the symptoms of heart failure and decreases the quality of life (Alla et al., 2002). Moreover, patients more concerned about the recurrence or worsening of their heart disease at discharge from the hospital are more likely to have a lower overall score on the MacNew Heart Disease Health-Related Quality of Life Questionnaire (Shimada et al., 2018). Riegel et al. (2009) identified the following six causes of poor self-care in patients with heart failure:

(1) Comorbidities can be confusing, with many medications and complex dietary regimens, making it challenging to adhere to treatment after discharge.
(2) Depression leads to a decline in information processing, memory, cognitive abilities, and a stronger sense of social isolation.
(3) Anxiety symptoms are increased due to difficulties in accepting a new lifestyle.
(4) Sleep disturbance leads to decreased alertness and physical function.
(5) Low health literacy translates into difficulty understanding and implementing health-related information.
(6) Problems in the healthcare system arise due to insufficient time spent on self-care education and poor communication among healthcare professionals (Riegel et al., 2009). The first month after discharge from the hospital is a vulnerable time for the patient. This is because the self-monitoring of worsening disease symptoms and adherence to medications, exercise, and a care plan regarding salt, fluids, and nutrition, which were taught during hospitalization, must be implemented alone at home (Mika, 2009).

It is estimated that self-care behaviors take approximately one month to become habitual. Hence, the first month after discharge is a critical period in self-care habituation (Lee et al., 2023).

Furthermore, appropriate intervention during the so-called buffer period, when patients are discharged from the hospital after treatment and transition to life at home, is critical in promoting behavioral change. Interventions such as self-care guidance are necessary to enable patients to make self-care behaviors a habit during this period. However, many available healthcare professionals are required to provide face-to-face self-care guidance at home. While medical personnel can intervene intensively with patients in the hospital, providing frequent guidance at home is challenging, as it requires individual patient visits. Therefore, many patients with heart failure without adequate self-care education and guidance are readmitted to the hospital. In addition, chronic diseases like heart failure require long-term self-care at home. Moreover, patient engagement in health management requires knowledge, skills, and psychological support (Physiotherapy Science, 2008).

Self-care education and support using information and communication technology and other telehealth are becoming increasingly common, saving travel time and reducing costs for healthcare professionals. Patients can be supported through communication and monitoring at appropriate times. For this reason, many medical institutions are implementing these services.

1.2. Status of review articles on transitional care interventions with information communication technologies

Few review articles have examined the effectiveness of information and communication technology transitional care compared with face-to-face transitional care for patients with heart failure. Our literature search did not reveal any reviews on transitional care within 30 days of discharge, which is critical for patients with heart failure. Therefore, we conducted a scoping review to assess transitional care for patients with chronic heart failure within one month of discharge from the hospital and to determine whether there are differences in effectiveness between face-to-face transitional care and transitional care using remote technologies, such as information communication technologies.

Table 1
Framework of Items and search words.

	Items	Search words
Participants	Patients over 18 years of age with a diagnosis of heart failure within 30 days of discharge from the hospital.	"Heart failure," "cardiac failure," "myocardial failure," "heart decompensation"
Intervention	Transitional care using information and communication technology and other telemedicine equipment	"Telenursing," "telemonitoring," "remote monitoring," "telehealth," "telemedicine," "information technology," "information and communication technology," "monitoring," "cell phone," "mobile phone," "cellular phone," "text messaging," "short message," "smartphone"
Comparison	Transitional care is provided only face-to-face without the use of telemedicine equipment, such as information and communication technology	"Transitional care," "continuity of patient care," "patient transfer," "transition to adult care," "retention in care," "hospital discharge support in 30 days"
Outcome	Primary outcome: Readmission rate 30 days after discharge	Primary outcomes: "readmission," "readmission to the hospital," "hospital readmission," "hospitalization." Secondary outcomes: "activities of daily living," "quality of life," "SF-12 (12-item short-form health survey)," "health-related quality of life," "medication adherence," "body weight," "measures"
Study design	Randomized control trials, quasi-experimental studies, correlational studies, cross-sectional studies, and quantitative studies	

2. Methods

The details of the scoping review and the words used in the literature search are shown in Table 1.

2.1. Paper selection and exclusion criteria

Selection: Patients aged 18 years or older with a diagnosis of heart failure. The study was a transitional intervention using telemedicine technology, such as information communication technologies. The intervention period must be within 30 days of discharge from the hospital (transitional period). Even if the intervention period was longer than 30 days, studies that evaluated outcomes 30 days post-discharge from the hospital were included in this category. Only original articles published in English, Japanese, or Chinese were included.

Exclusion Criteria: Adults with an ejection fraction of 55% or less treated for heart failure and patients with cognitive impairment or psychiatric disorders were excluded. Reviews, conference summaries, letters, and journals were excluded. The search period was from January 2000 to November 2021.

Eight databases were used to search for articles in English, Japanese, and Chinese; PubMed was searched using Medical Subject Headings terms. The databases used were PUBMED, Google Scholar, CINAHL EBSCO, and EMBASE for English articles, CONGII and Medical Central Journal for Japanese articles, and China National Knowledge Infrastructure and Wan Fang Date for Chinese articles. Most English-language papers were searched in PUBMED, Japanese-language papers in Medical Journal, and Chinese-language papers in China National Knowledge Infrastructure. In addition, hand searches were conducted to retrieve relevant references from the target literature.

In this study, based on the review process (participants, intervention, comparison, outcome,) search keywords and search formulas

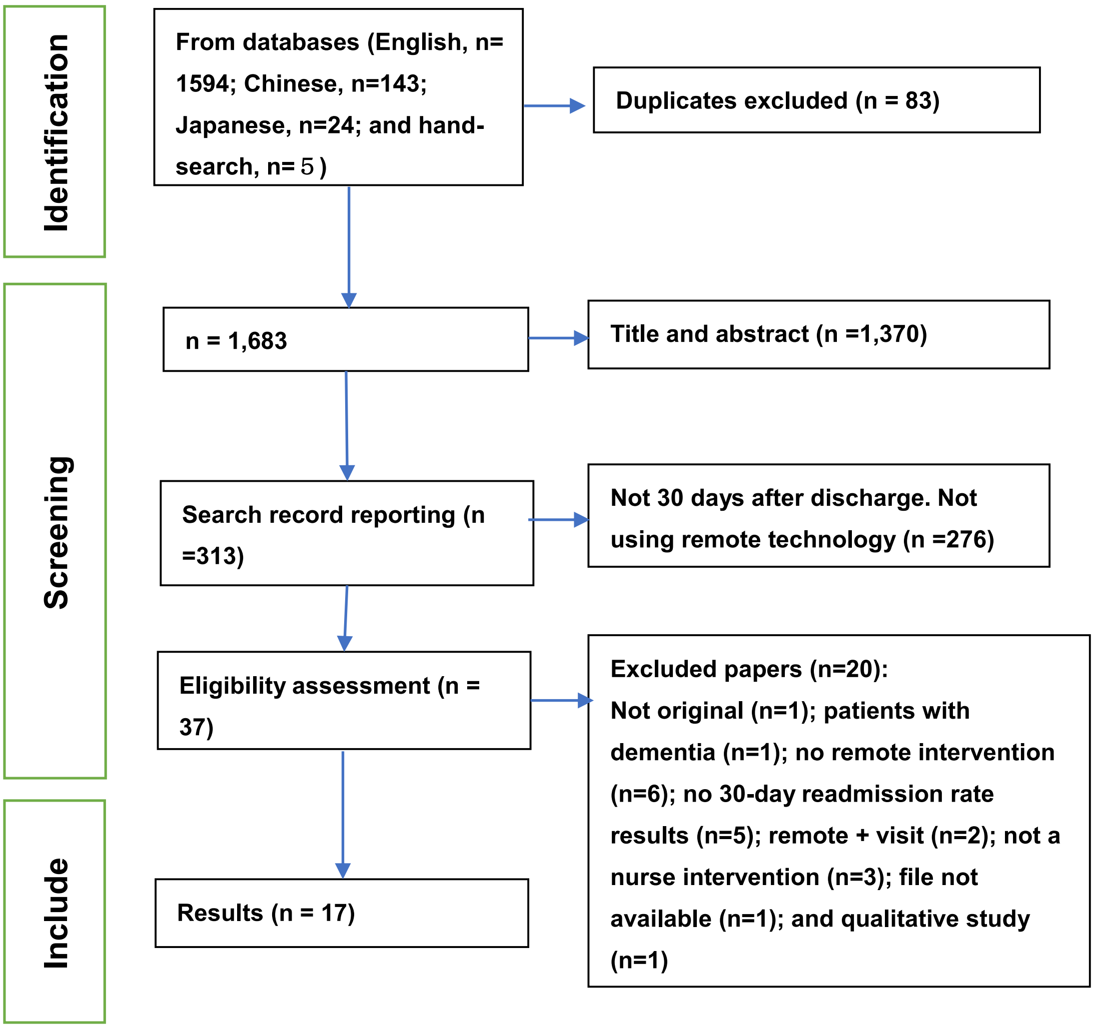

Fig. 1. Screening process.

were set, as shown in Table 1, with the cooperation of the university's librarian, to conduct an exhaustive search. Furthermore, keywords were searched alone and in combinations. When we searched the Chinese database, combinations of two keywords were used because of the small number of articles.

2.2. Paper screening process

A total of 1766 articles were extracted from the database, of which 1594 were in English, 143 in Chinese, and 24 in Japanese; additionally, five articles were hand-searched. The Mendeley Desktop literature management application excluded 84 duplicate papers retrieved from the database. Second, selected papers were screened for title and abstract based on the selection criteria, and those that were not applicable were excluded. Papers that could not be determined by title and abstract were judged by at least three researchers each, and the results were combined and discussed. In addition, the full text of the screened papers was carefully read, and several researchers jointly examined those that were difficult to judge. The process for selecting papers is illustrated in Fig. 1.

After screening titles and abstracts, 1370 articles were excluded, and 313 were provisionally included. Subsequently, we excluded 276 articles that did not use 30 days post-discharge or tele-technology. A full-text review excluded one article that was not original research, one that included patients with dementia, six that did not use tele-interventions, and five that did not have detailed data on readmission rates for 30-days post-discharge patients. We also excluded two papers that intervened remotely at the visit, had no control group, and for which the effectiveness of the remote technique was difficult to determine. In addition, we excluded three papers in which nurses did not intervene, one qualitative study, and one paper in which the files could not be downloaded. Following the above process, 17 papers were finally selected.

2.3. Evaluation of the quality of accepted papers

This study used the JBI paper Quality Evaluation Checklist (Moola et al., 2020; Tufanaru et al., 2020; Tufanaru et al., 2017) to evaluate the quality of the 17 papers. During each article's screening and quality assessment, two or more evaluators reviewed those that were difficult to determine if the criteria were met. Those articles that could not be agreed upon were reviewed and judged together with a third researcher. Six of the 17 articles were randomized control trials (Blum and Gottlieb, 2014; Finlayson et al., 2018; Haynes et al., 2020; Ong et al., 2016; Pekmezaris et al., 2012; Ritchie et al., 2016), eight were quasi-experimental (non-randomized control trials) (Arcilla et al., 2019; Austin et al., 2012; Davis et al., 2015; Dadosky et al., 2018; Kripalani et al., 2019; Liu, 2009; Kalista et al., 2015; Nakayama et al., 2020), one was a case-control, (Lee et al., 2016), and three were cohort studies (Harrison et al., 2011; O'Connor et al., 2016; Pekmezaris et al., 2012) One of these papers used two research methods: a randomized control trial and a cohort study.

Six research articles with randomized control trials met 10 or more of the 13 JBI items, and the article by Finlayson et al. (2018) met all criteria. The studies by Haynes et al. (2020) and Blum and Gottlieb (2014) did not meet the following criteria: "1. Were participants blind to treatment assignment?" "2. Were those delivering treatment blind to treatment assignment?", and "3. Were outcomes assessors blind to treatment assignment?" The Ong et al. (2016) and Ritchie et al. (2016) papers did not meet one of these items. The study by Pekmezaris et al. (2012) did not include the item "Was follow-up complete, and if not, were the differences between the groups adequately described and analyzed in terms of their follow-up?"

Eight quasi-experimental studies, including Kripalani et al. (2019), Davis et al. (2015), Dadosky et al. (2018), and Liu (2009) and four other studies, met all the items. However, the study by Austin et al. (2012). met fewer than half the items. Those items were "1. Was there a control group?" "2. Were there multiple measurements of the outcome pre- and post-intervention/exposure?" 3. "Was there a follow-up? And if not, were the differences between groups adequately described and analyzed in terms of their follow-up?" "4. Were outcomes measured reliably?" and "5. Was the statistical analysis appropriate?". The study did not have a control group but analyzed the results by comparing them to those of other studies. There were no issues with the intervention methods or the measurement and collection of data. Thus, we decided to select it anyway because we judged it to be of high quality for this review and the criteria for selection.

Further, the only case-control study met all the items, and all three cohort studies met at least eight of the 11 items. Three of these studies did not meet the item, "Were confounding factors identified?" (Davis et al., 2015; O'Connor et al., 2016; Pekmezaris et al., 2012); whereas the item, "Were strategies to address incomplete follow-up utilized?" was not met by Davis et al. (2015) and Harrison et al. (2011).

3. Results

3.1. Study characteristics and data synthesis

The mean age of patients included in the 17 papers accepted for the study was 77.3 years; in the randomized control trials, the mean age of participants in the study by Ritchie et al. (2016) was 63.25 years, while participants in the other five studies had a mean age of over 70 years. Among the cohort studies, the study by Harrison et al. had the largest number of intervention participants (6773).

In terms of the nationalities of the researchers, the U.S. had 13 articles (Arcilla et al. (2019); Austin et al. (2012); Blum and Gottlieb (2014); Dadosky et al. (2018); Davis et al. (2015); Harrison et al. (2011); Haynes et al. (2020); Kripalani et al. (2019); Lee et al. (2016); O'Connor et al. (2016); Ong et al. (2016); Pekmezaris et al. (2012); Ritchie et al. (2016)), and Australia, China, England, and Japan had one paper each.

Table 2
Details of transitional care interventions using tele-technology in each study.

Type of research	Author	Year	I: Interventions n (average age)	C: Control n (average age)	Intervention methods
Randomized control trial	Haynes et al. (2020) USA	2020/7	I: 722 I + C*:70.9 years	C: 715	A wireless remote monitoring system was used to measure and record the patient's blood pressure, heart rate, and weight, which were reported daily to the healthcare provider, and heart failure education was provided by telephone. Patients with heart failure were surveyed at 7-, 30-, and 180-days post-discharge regarding background information, health literacy, self-management, social support, depressive symptoms, and other complications.
	Ong et al. (2016) USA	2016/9	715 (73 years)	72 (74 years)	An electronic device (wireless Bluetooth transmitting pod) monitored daily weight, blood pressure, and heart rate and sent the data to the nurse. This information could be displayed as text, and the patient and nurse could ask and answer questions. The nurse provided health guidance by phone within 2 days of discharge, then once a week, within the first month after discharge, and once a month after that until the sixth month.
	Ritchie et al. (2016) USA	2016/6	233 (62.7 years)	245 (63.8 years)	E-Coach Intervention: Trained care transition nurses used telephone Interactive Voice Response systems to conduct the following three interventions. (1) Gathering of patient information: red flags (symptoms and signs that are more likely to occur, especially during the transition period) (2) Patient-specific education and motivation (3) Monitoring: Alerts were sent to the care transition nurses when patients experienced red flags. This intervention was provided for 7 days post-discharge and was offered either daily or every 3 days for a total of 28 times, depending on the patient.
	Blum and Gottlieb (2014) USA	2014/4	101 (73 years)	102 (72 years)	A heart failure specialist nurse followed up by phone to answer patient questions. The patient measured blood pressure, daily weight, heart rate, and 15-s heart rate on the Philips Electronik E-Care system and transmitted it to the specialist nurse via wireless hub.
	Pekmezaris et al. (2012) USA	2011	83 (81 years)	85 (83 years)	Intervention using the Video Patient Station allowed interactive communication between patient and caregiver via video and audio. The Video Patient Station had a stethoscope, blood pressure and pulse meter, pulse oximeter, digital scale, and other devices that measured and transmited data. After discharge, patients received one home nursing visit every two weeks and two interventions by Video Patient Station, followed by interventions depending on the patient's situation. Patients received 60 days of intervention and 30 days of follow-up.
	Finlayson et al. (2018) Australia	2018	167 (77.5 years)	55 (77.9 years)	Three interventions were conducted by combining an exercise program, nurse visits, and telephone follow-up. 1) E (exercise): an intervention group with only an exercise program of about 2 h per session, six times a week. 2) N—HaT: (nurse visit and telephone follow-up) a group with visits and telephone follow-up by a nurse specialized in geriatric nursing. 3) ExN—HaT (exercise and nurse visit and telephone follow-up): a group with exercise therapy and follow-up visits and phone calls made by a nurse. Visits were conducted within 48 h of discharge. These programs were offered for 24 weeks. Each telephone follow-up lasted approximately 30 min. One phone call was made each week for the first 4 weeks after discharge; then, one phone call every 4 weeks to coordinate the patients' needs.
Quasi-experimental	Kripalani et al. (2019) USA	2019	762 (64.0 years)	6276 (62.2 years)	Transition care coordinators: nurses assessed patient needs and set discharge plans; transition care coordinators, supplemented by physicians, explained and educated patients about their medications. After the patient was discharged, the transition care coordinator conducted structured assessments during ongoing phone calls, established anticipatory guidance and an emergency response plan, and conducted a follow-up.
	Austin et al. (2012) USA	2012	60 (64.5 years)		The study developed an application (LISTEN UP FOR HEALTH) that reminded patients by phone about salt restriction, daily weights, medication adherence, when to call the doctor, and smoking cessation. It sent 10 messages of 3 – 5 min, recorded daily on an Mp3 player, about salt restriction, daily weights, medication adherence, and smoking cessation for the patient to listen to. The messages also included information on the importance of daily weigh-ins and

(*continued on next page*)

Table 2 (*continued*)

Type of research	Author	Year	I: Interventions n (average age)	C: Control n (average age)	Intervention methods
					contacting the physician if the patient gained more than 2 pounds in 24 h. The intervention was daily from discharge until 30 days after discharge.
	Kalista et al. (2015) England	2015	10 (81.3 years)		During the first week after discharge, a nurse made a 45–60 min visit to assess medication knowledge, education, and medication compliance. Weekly telephone follow-ups were conducted from 1 to 4 weeks after the visit to assess and provide guidance on medication. Each telephone follow-up visit lasted no longer than 10 min.
	Nakayama et al. (2020) Japan	2020	99 (64.5 years)	137 (69 years)	The study did not include a rehabilitation group. An outpatient cardiac rehabilitation group (following the Japanese Society of Cardiology rehabilitation program) and a remote cardiac rehabilitation group were included. In the remote group, patients were instructed to watch a DVD created by a cardiac rehabilitation physiotherapist, which included a physician's explanation of heart failure, preparatory exercises, indoor and outdoor aerobic exercises, and urgent visits. After hospital discharge, the cardiac rehab physiotherapist conducted phone follow-ups with the patient every 2 weeks for a continuous period of 5 months. During these follow-ups, the physiotherapist collected information such as weight, blood pressure, number of steps taken, and quality of life, and guided the patient.
	Dadosky et al. (2018) USA	2017	49 (78.6 years)	92 (80.55 years)	In the intervention arm, patients received 30 days of telehealth, point-of-care, and video telephone instruction by a physician. Before discharge, heart failure patients received education on heart failure, diet, medications, weight measurement, and activities. After discharge, patients measured their heart rate and respiration data at home with a Medtronic Zephyr BioModule (a wireless sensor that hangs on the chest wall) and connected a Nonin pulse oximeter, I Care blood pressure machine, and Littmann TeleSteth Bluetooth Stethoscope to a computer. The data measured was uploaded daily. The system automatically alerted the physician if the patient data was abnormal, and the home care nurse prioritized that patient for care. Each video call lasted approximately 30 min.
	Arcilla et al. (2019) USA	2019	102 (71.85 years)		Before discharge, the nurse taught the patient how to use the remote device and record data, assessed the patient's goals, and answered questions. Within 48 h of discharge, the nurse visited the patient's home to assess the patient's ability to manage medications, eat, and drink. Patients then recorded and uploaded their signs and symptoms, vital signs, blood pressure, and weight daily and sent the data to the visiting nurse. A 90-day follow-up was conducted.
	Liu (2009) China	2009	I: 81 (59.98 years)	C: 81 (58.06 years)	After the patients were discharged from the hospital, researchers (nurses and doctors) called patients by phone to ask questions and obtain physical information using a questionnaire, and when patients had problems, researchers and doctors guided them. Follow-up phone calls were scheduled as follows: once weekly phone calls for 1–4 weeks, once every 2 weeks for 5–10 weeks after discharge, and once every 4 weeks for 10–14 weeks. Questions: symptoms assessment (11 items), health education (3 items), emotional support issues (3 items), quality of life (l: Minnesota Living with Heart Failure Questionnaire assessment chart), and knowledge assessment.
	Davis et al. (2015) USA	2015	59 (63 years)	59 (65 years)	The patients were asked to report their information (medication, symptoms questions, nutrition, stress management, weight, and sudden changes in symptoms) using a remote monitoring device and by telephone. One nurse visit was made within one week of discharge to educate the patients on using the remote monitoring device, medication administration, self-management, symptom recognition management, nutrition, and stress management and to set up a health plan tailored to their needs. A response phone line was made available 24 h a day to answer questions. If a patient's symptoms suddenly changed, the remote monitoring device system immediately reported it to the nurse, and the remote monitoring device observer or physician determined the information and confirmed it by phone; otherwise, a physician or nurse visited the patient, depending on symptoms. The remote monitoring device observer also contacted the patient if he or she had not provided any medical information, such as

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Table 2 (*continued*)

Type of research	Author	Year	I: Interventions n (average age)	C: Control n (average age)	Intervention methods
					weight or medication management, in 3 days. The nurse was also informed and followed up with the patient.
Case-control	Lee et al. (2016) USA	2016	1,58 (76.4 years)	7935 (74.4 years)	There were two groups: an outpatient visit group and a telephone intervention + visit group. In the telephone intervention + visit group, a physician or a nurse trained in ambulatory heart failure care guided over the phone by asking about the patient's vital signs and symptoms, weight, and medication changes. The three groups were divided according to the time of the first call after discharge: a group within 7 days of discharge, a group within 8–30 days of discharge, and a no-call group. Intervention frequency was not noted, but the number of interventions was recorded as 2 or more times, 1–2 times, and 0 times.
Cohort	Harrison et al. (2011) USA	2011	6773 > 18 years 831 18–34 years 3059	23,499 35–49 years 6295 50–64 years 12,622	Phone calls (post-discharge exercise instructions, medications, and prevention of deterioration) were made. The intervention group received the first telephone intervention from a nurse specialist within 14 days of discharge. The control group consisted of patients who received the intervention by telephone 15 to 30 days after discharge and patients who did not receive a telephone call.
	O'Connor et al. (2016) USA	2016	80 (84 years)	80 (85 years)	Patients had their weight, heart rate, blood pressure, and blood oxygenation measured, and these data were sent daily to the medical team via a 4G-connected PC web system, along with answers to subjective questions related to heart failure and symptoms. Patients could also view tablet instructional videos related to heart failure diagnosis, medication management, and salt restriction.

* Notes; PC: personal computer. DVD: digital video disc.

The researchers' nationality and the institution's country were the same. Five of the six randomized control trials were conducted in the U.S.: Blum and Gottlieb (2014); Haynes et al. (2020); Ong et al. (2016); Pekmezaris et al. (2012); Ritchie et al. (2016), and one was from Australia (Finlayson et al. (2018). Of the seven quasi-experimental studies, four were from the U.S. (Arcilla et al. (2019); Austin et al. (2012); Dadosky et al. (2018); Kripalani et al. (2019)), while Japan, China, and England had one study each (Kalista et al. (2015), UK; Nakayama et al. (2020), Japan; Liu (2009), China).

3.2. Overview of the intervention methods

Telephones were the most common type of information and communication technology or other remote technology used in transitional care and were used as a communication tool in all studies except for that by Pekmezaris et al. (2012) Details of the intervention methods are presented in Table 2.

Among wireless technologies, Wi-Fi and 4 G were used to connect the phone and the blood pressure monitor or the phone and the computer. Ritchie et al. (2016) used an interactive voice response system. Specifically, the authors wanted to provide customized instructions or remote monitoring after retrieving information. Blum and Gottlieb (2014) used the Philips Electronic E-Care system: daily weight, blood pressure, heart rate, and 15-s heart rate were remotely monitored, and patients transmitted the measured data to their healthcare providers via a wireless hub. Furthermore, Pekmezaris et al. (2012) fabricated a new device combining a video phone with a vital sign measuring tool to transmit the measured data immediately. In the study by Dadosky et al. (2018), patients used a wearable wireless device, pulse oximeter, blood pressure cuff, and stethoscope at home and had their heart rate, respiration, and other information uploaded to a computer. Nurses and physicians used the transmitted data to instruct patients via video phone.

3.3. Primary outcome

3.3.1. Readmission rate 30 days post discharge

We analyzed the effect of transitional care using information and communication technology and other remote technologies. Seventeen articles measured readmission rates. In nine of the 17 articles, the readmission rate was significantly lower in the transitional care group using information and communication technology ($p < 0.05$) (Austin et al., 2012; Blum and Gottlieb, 2014; Finlayson et al., 2018; Haynes et al., 2020; Harrison et al., 2011; Kripalani et al., 2019; Kalista et al., 2015; Lee et al., 2016; Nakayama et al., 2020). The results of each type of research are described below and in Table 3.

(1) The results of randomized control trials 30 days after discharge

There were six randomized control trials, and the following three articles showed statistical significance in 30-day readmission rates after discharge in the group that received transitional care using information and communication technology and other

Table 3
Readmission rates within 30 days of discharge.

Type of research	Author	Readmission I: (Intervention) readmissions/n (readmission rate) C: (Control) readmissions/n (readmission rate)	Analysis
Randomized control trial	Haynes et al. (2020) 2020/7	I: 257/538 (48.7%) The number of readmissions and readmission rates for the target group (usual care) were not shown in the paper; only the statistical results of the comparisons were provided.	$p < 0.001$ Incidence rate ratios: 0.89;(95%CI 0.86–0.91.) 2-tailed tests
	Blum and Gottlieb (2014) 2014/4	I:29/64 (45.3%) C: 70/ 112 (62.5%)	$p < 0.05$ analysis of variance
	Finlayson et al. (2018) 2018/12	E group: 7/49 (14%) N—HaT group: 5/49(10%) ExN—HaT group: 4/53 (8%) C: 13/53 (25%)	$p = 0.01$ chi-square = 6.75
	Ong et al. (2016) 2016/9	I: 162/715 (22.7%) C: 156/722 (21.6%)	$p = 0.63$ logistic regression analysis
	Ritchie et al., (2016) 2016/6	I: 27/168(16.1%), C: 26/178(14.6%)	No significant Hazard ratio (95%CI) 1.14 (0.67, 1.96)
	Pekmezaris et al. (2012) 2012/3	Rct: I:25/83 (30%) C: 25/85 (29%) Cohort: I: 11/80 (14%) C: 12/80 (15%)	Not significant
Quasi-experimental	Kripalani et al. (2019) 2019/6	TCCA:72/762 (9.4%) The two intervention groups TCCF:41/460 (8.9%) TCCP:31/302 (10.3%) C:1182/6276 (18.8%)	Comparison between the TCCA and Control groups $p < 0.001$ Wald Test
	Austin et al., (2012) 2012/9	I: 5/60 (8.3%) *The study compares and analyzes the readmission rate with the standard readmission rate (21%) for patients who received usual care in Roper's study.	$p = 0.05$ Fisher's exact 2-tailed test
	Kalista et al., (2015) 2015/7	I:1/10 (10%) *Another study compared and analyzed the readmission rate (38%) for patients who received usual care (Collaboration with the Visiting Nurse Services of Newport and Bristol Counties VNSRI).	Visiting Nurse Services of Newport and Bristol Counties (VNSRI) with lower readmission rates. Not stated whether the results of the statistical analysis were significantly different.
	Nakayama et al. (2020) 2020/9	I: 0/30 (0%) C: 16/137 (12%)	$p = 0.02$
	Dadosky et al. (2018) 2018/4	I: 8/49(117.39%) Patients with heart failure had multiple other symptoms, and only two patients were readmitted for worsening heart failure, resulting in a readmission rate of 4.35%. C: 22/92 (23.9%).	p-value not stated
	Arcilla et al. (2019) 2019/4	I:8/102 (7.8%) The intervention group had multiple illnesses; only 4 patients were readmitted for heart failure, and the readmission rate due to worsening heart failure was 3.9%. Control group data were not listed.	Not significant
	Liu (2009) 2009/11	I: 2/74 (2.7%), C: 4/73 (5.5%)	$p = 0.32$
	Davis et al., (2015) 2015/9	I: 5/59 (8.5%) C: 10/59 (17.0%)	Not significant
Case-control	Lee et al., (2016) 2016/4	*Surveyed post-discharge patients (11,985) with heart failure from 2006 to 2013; transitional care was analyzed in 1587 patients readmitted within 30 days and 7935 patients who were not readmitted (readmission rate: 13.2%). The readmission rate was significantly lower when transitional care was provided within 7 days of discharge. Early telephone intervention was as effective as outpatient care.	Intervention within 7 days of discharge (OR = 0.81, 95%CI, 0.70–0.94)
Cohort study	Harrison et al. (2011) 2011/11	I:420/6773 (6.2%) C: 2304/23,499 (9.8%). The intervention group was 23.1% less likely to be rehospitalized than the control group.	$p < 0.001$, Fisher's test
	O'Connor et al. (2016) 2016/5	2011–2012 intervention (19.3%) for 818 patients discharged with heart failure in 2011–2015, 2014–2015 (5.2%): 14% decrease. (*Control group not included)	Not significant

Abbreviations: C: control; I: intervention; CI, confidence interval; E: exercise; IRR, incidence rate ratio; N—HaT, nurse visit and telephone follow-up; ExN—HaT, Exercise, and nurse visit and telephone follow-up; TCCA, total intervention group; TCCF, full intervention group; TCCP: partial intervention group; VNSRI, Visiting Nurse Services of Newport and Bristol Counties.

telemonitoring devices.

Haynes et al. (2020) reported that a one-day increase in patient compliance with reporting vital sign readings in the previous week was associated with an 11% decrease in readmission rates in the following week (incidence rate ratio: 0.89; 95% CI: 0.86–0.91; $p < 0.001$).

In the study by Blum and Gottlieb (2014), the intervention group received telephone follow-up, and the readmission rate difference was statistically significant ($p < 0.05$).

Finlayson et al.'s study (Finlayson et al., 2018) consisted of three groups: the E group, the N—HaT group, and the ExN—HaT group. The 30-day readmission rates were 14%, 10%, and 8% for the E group, N—HaT group, and ExN—HaT group, respectively; in comparison, the control group had a rate of 25%, showing a statistically significant difference ($p < 0.01$).

(2) The results of quasi-experimental articles 30 days after discharge

There were eight quasi-experimental studies: the following four papers showed significantly lower 30-day post-discharge readmission rates in the intervention group.

Kripalani et al. (2019) interviewed the two groups by phone and continuously for 6 months. The group receiving the described intervention was the Transition Care Coordinators-Full (TCCF) group, while the group that did not assess individual needs but simply received telephone calls was the Transition Care Coordinators-Part (TCCP) group. Moreover, the Transition Care Coordinators-All encompassed both groups. The TCCF group had a readmission rate of 8.9%, and the TCCP group's readmission rate was 10.3%. In total, the TCCA group's readmission rate was 9.4%, compared to the readmission rate of the control group (18.8%). The difference in readmission rates between the Transition Care Coordinators-All and control group was significant ($p < 0.001$).

Austin et al. (2012) compared the baseline readmission rate of 21% for patients receiving usual care with the readmission rate for the intervention group(8.3%), which was significantly different ($p = 0.047$).

Kalista et al. (2015) assessed medication knowledge, education, and telephone follow-up. Since the authors did not include a control group, the readmission rate was analyzed by comparing it to that of usual care patients in other studies (38%). The authors reported a lower readmission rate with a statistically significant difference.

In a study by Nakayama et al. (2020) the intervention groups were divided into an outpatient cardiac rehabilitation group, a tele-cardiac rehabilitation group, and a no-rehabilitation group. By inquiring about weight, blood pressure, number of daily steps taken, and quality of life in a telephone follow-up post-discharge, the readmission rate was 3% among the 69 patients in the outpatient cardiac rehabilitation group; among the 30 patients in the information and communication technology-intervention cardiac rehabilitation group, no one was readmitted. In addition, 16 of the 137 patients in the control group were readmitted. There was a statistically significant difference in the readmission rate of Information and communication technology intervention cardiac rehabilitation patients ($p = 0.02$).

(3) The results of the case-control study 30 days after discharge

In the study by Lee et al. (2016), there was an outpatient visit group and a telephone intervention and visit group (telephone intervention plus visit). Any follow-up intervention, regardless of timing, frequency, and type, was associated with the risk of readmission ($p < 0.01$). However, outpatient teaching performed between 8 and 30 days post-discharge was not significantly associated with readmission. Initial contact by telephone showed lower adjusted odds of readmission within 30 days, but the association with readmission was not significant.

(4) The results of cohort studies 30 days post-discharge

There were two cohort studies, one of which reported significantly lower readmission rates in the group receiving transitional care (including information communication technology). Harrison et al. (2011) used telephone calls. The readmission rate in the intervention group was 6.2%. Of the 23,499 patients in the control group, 2304 were readmitted, with a readmission rate of 9.8%. The difference in the readmission rate in the intervention group compared with the control group was statistically significant ($p < 0.001$). In addition, the intervention group was 23.1% less likely to be readmitted than the control group.

4. Discussion

4.1. Reasons why transitional care with information and communication technology is so effective

(1) Patient self-monitoring information must be promptly reported to the health care provider.

Effective intervention requires information on patients' symptoms, level of adherence to their care plans, and medical treatment lifestyle. In the studies reviewed here, information and communication technology immediately captured this information by connecting electronic measurement tools (such as blood pressure machines, scales, and pedometers) with communication tools (such as non-technology-enabled telephones and smartphones) that reported the measured information.

The first important aspect is that patients can easily self-monitor. Specifically, the health information monitored by patients included weight, blood pressure, heart rate, edema, symptom changes, medication management (drug name and dosage), salt restriction, and daily activities (aerobic and anaerobic exercise time). For example, information measured by blood pressure monitors, scales, and pedometers is automatically stored on smartphones or personal computers using Bluetooth or other wireless devices, thus eliminating the need for patients to record and store the information themselves (Rector et al., 1987). The information is also automatically sent to the healthcare provider.

Data that cannot be automatically measured, such as dietary salt intake, rehabilitation specifics (e.g., method and frequency), medication status, and queries regarding the quality of life and patient satisfaction, can be documented as text and transmitted to healthcare providers through a reporting application. Alternatively, healthcare providers can gather this information through videophone or other accessible means. This approach is particularly beneficial for older individuals who may encounter challenges in text input. Thus, this remote technology facilitates patient monitoring and reporting to healthcare providers, reducing the likelihood of finding the measurements cumbersome or forgetting them; moreover, it makes it easier for the healthcare provider to understand the patient's daily information and to identify areas for improvement or enhancement in the patient's daily life. Additionally, the information sent by the patient can be immediately shared among the medical team.

The studies by Ritchie et al. (2016) and Dadosky et al. (2018) used an "alert system" that automatically sent information to the healthcare provider when a patient's symptoms worsened, which represents another important system for avoiding potentially dangerous situations due to sudden changes in clinical condition.

(1) Ease of education and support tailored to the patient's life and needs following discharge from the hospital

Merely instructing patients to monitor and report daily weight, blood pressure, heart rate, medication management, edema, vital signs, and other metrics is insufficient to deliver effective transitional care interventions using tele-technology; instead, the patient's reported symptoms and other information must be used to provide the education and support necessary for the patient (Austin et al., 2012; Dadosky et al., 2018; Haynes et al., 2020; Kripalani et al., 2019) by modifying the treatment and rehabilitation plans to meet individual care needs. In particular, rehabilitation guidance tailored to the patient's needs helps to prevent worsening symptoms and reduce readmission rates (Finlayson et al., 2018; Nakayama et al., 2020).

Telephone and video communications were part of the transitional care intervention to assess post-discharge life and needs and provide patient education and support. Using technology that allows for two-way communication, interventions can provide ongoing health care education, health knowledge instruction, and supervision to patients (Davis et al., 2015; Haynes et al., 2020; Ritchie et al., 2016). With ongoing guidance from health care providers, appropriate patient-specific instructions, such as exercise, diet, and salt modification, can accumulate, resulting in improved health status (Dadosky et al., 2018; Haynes et al., 2020; Kripalani et al., 2019).

The outcomes of transitional care implemented through tele-technology encompassed patient self-monitoring and reporting, provider interviews, assessment of patient needs, and plan adjustments, as well as education, guidance, and support. Additionally, the 30-day readmission rates following discharge were examined. Provider interviews and education/guidance/support were identified as key components of remote transitional care interventions that showed a significant reduction in readmission rates when compared to face-to-face approaches. This suggests that simply having patients report measurement information is insufficient; appropriate education, guidance, and support must be provided.

(1) Whole-day intervention

During the post-discharge transition period, patients are expected to apply the self-monitoring techniques, oral therapies, salt restriction and dietary changes, and cardiac rehabilitation methods they acquired during their hospital stay to their home environments. Patients can understand and perform these activities during hospitalization under the supervision of nurses and other medical personnel. However, after discharge from the hospital, patients must prepare their meals and perform cardiac rehabilitation in between household chores and work and often make mistakes or fail to perform the patient-educated content, such as taking medications or measuring salt and weight, which worsens their symptoms and causes them to lose confidence.

In addition, before establishing self-care routines, patients often lose confidence and self-efficacy due to repeated errors and failures in what they are taught, making it difficult for them to continue the treatment. For this reason, it is crucial to provide appropriate instruction and emotional support, such as encouragement, so that patients can confidently continue their self-care routines. However, providing emotional support promptly during in-person visits or outpatient care is difficult.

In contrast, tele-technology lets patients receive immediate feedback and encouragement from their healthcare provider. This type of friendly support allows patients to check their questions each time they have them, making it easier to resolve problems and gain confidence in their self-care process. As a result, patients experience enhanced self-care capabilities and demonstrate improved compliance with medication adherence, cardiac rehabilitation, and other aspects of their treatment.

For some patients, such as older patients, transitional care using a mix of information and communication technology and home nursing has been reported to be effective in controlling symptoms and improving self-care (Pekmezaris et al., 2012). Moreover, it is important to choose the appropriate method of transitional care depending on the target population.

(1) An analysis of articles reporting no difference in effectiveness between tele-technology and face-to-face transitional care

Three articles reported no difference in 30-day readmission rates after discharge between tele-technology and traditional face-to-face transitional care. These three articles found no statistically significant difference, with a slightly higher 30-day post-discharge readmission rate for the tele-technology transitional care group.

An examination of the intervention methods used by Ong et al. (2016) revealed that the control group also received post-discharge telephone follow-up during the study period and accessed a readmission reduction prevention program and a chronic disease management program conducted by a physician. Since there were no significant differences in transitional care between the control and intervention groups, there were likely no differences in outcomes between them.

In the study by Ritchie et al. (2016), the intervention group was less likely to respond to telephone guidance from a healthcare provider (29.3%). This may have resulted in inadequate confirmation of medication management status and other instructions.

The intervention by Pekmezaris et al. (2012) implemented transitional care using tele-technology less frequently than did other studies, with only one visit every 2 weeks and two video communications. In addition, it took about a week after discharge for patients in the intervention group to receive the device for remote use, and they needed additional time to learn how to operate it. Therefore, there was likely no difference in readmission rates at 30 days post-discharge.

Based on the above, it can be inferred that the reason for the lack of difference in effectiveness between transitional care using tele-technology and face-to-face transitional care was the lack of significant differences between the patients' transitional care using tele-technology and that of the control group, poor participation in the intervention program, and infrequent interventions.

It is surmised that transitional care with appropriate tele-technology will have similar effects as in other studies. The results of this study suggest that transitional care methods using tele-technology may be effective in patients with other chronic diseases (Kamei, 2021; Van Spall et al., 2019; Yasuko, 2021), such as diabetes and chronic obstructive pulmonary disease.

4.2. Limitations

Although this review focused only on patients with heart failure, transitional care is also important for patients with other chronic diseases; therefore, the effects of transitional care using information and communication technology and other methods for patients with other chronic diseases should also be investigated.

There is a limited number of randomized control trials on transitional care using information communication technologies at this stage. Therefore, this study was conducted as a scoping review with a wide selection of research methods. In the future, information and communication technology will be applied in the healthcare field, not only in Europe and the U.S. but also in emerging economies, such as India and China, as information and communication technology is developing rapidly. We plan to continue to follow trends in transitional care using information and communication technology and other technologies and conduct systematic reviews and meta-analyses when randomized control trials increase to examine transitional care with lasting effects within 30 days post-discharge and over the long term.

5. Conclusions

Transitional care using tele-technology, such as information communication technologies, provided to patients with heart failure up to 30 days post-discharge from the hospital was found to have a positive effect compared with traditional transitional care. Readmission rates within 30 days were lower than in the control group in nine articles, and the difference was statistically significant. Moreover, weshowed that the system might improve quality of life and patient satisfaction. We conclude that transitional care using tele-technology may be effective in the care of patients with other chronic diseases.

To promote the use of tele-technology for transitional care, it is essential to provide training for medical personnel and support for patients. In the future, we intend to educate the public regarding the benefits of transitional care using information and communication technology.

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Data availability

The data supporting this study's findings are available from the corresponding author upon reasonable request.

CRediT authorship contribution statement

KaiXin Qi: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft. **Tomoko Koike:** Project administration, Supervision, Validation, Visualization, Writing – review & editing. **Youko Yasuda:** Supervision, Validation. **Satoko Tayama:** Validation. **Itsumi Wati:** Validation.

Declaration of Competing Interest

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