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Development and implementation of a national telehealth project for long-term care: A preliminary study

Min-Huei Hsu^{a,b}, Tu-Bin Chu^c, Ju-Chuan Yen^d, Wen-Ta Chiu^{e,*}, Geng-Chang Yeh^f,
Tzay-Jinn Chen^g, Yen-Jen Sung^h, Jack Hsiaoⁱ, Yu-Chuan (Jack) Li^{b,j,**}

^a Graduate Institute of Medical Sciences, College of Medicine, Taipei Medical University, Taipei, Taiwan

^b Graduate Institute of Biomedical Informatics, College of Medicine, Taipei Medical University, Taipei, Taiwan

^c Department and Graduate Institute of Business Administration, National Taiwan University, Taipei, Taiwan

^d Graduate Institute of Humanities in Medicine, College of Medicine, Taipei Medical University, Taipei, Taiwan

^e School of Medicine, Taipei Medical University, Taipei, Taiwan

^f Department of Pediatrics, Taipei Medical University, Taipei, Taiwan

^g Department of Health, Executive Yuan, Taipei, Taiwan

^h Institute of Hospital and Health Care Administration, National Yang-Ming University, Taipei, Taiwan

ⁱ Hsiao Chung-Cheng Hospital, Taipei, Taiwan

^j Department of Dermatology, Taipei Medical University - Wan Fang Hospital, Taipei, Taiwan

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ABSTRACT

The aging population is a global phenomenon. The skyrocketing costs of healthcare and the shortage of healthcare providers will soon become a crucial issue all over the world. Taiwan's government executed the Taiwan's Telehealth Pilot Project (TTPP) from July 1, 2008 to December 31, 2008, using healthcare information technology to tackle these problems. The system has three different models, the home-care, the community-care, and the residential-care model to assist the elderly in the pursuit of better healthcare and improved quality of life. The results revealed both the home-care and community-care models facilitated timely medical responses if the enrolled patients had emergent conditions. In the home-care model, the hospital readmission rate was reduced from 8.19% to 3.17%, and the hospital visit rate was decreased from 2.95% to 2.90%. In community-care model, the medication non-adherence rate was reduced from 38.20% to 9.20%. In the residential-care model, reduced rates of readmission to the hospital, nosocomial infection and the adverse drug event were found. Telehealth enabled the aged with chronic illnesses to live independently and helped the institutionalized elderly get acute care more efficiently without increased manpower of healthcare organization.

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* Corresponding author at: 250 Wu-Hsing Street, Taipei City 110, Taiwan. Tel.: +886 2 27366485; fax: +886 2 23787795.

** Corresponding author at: 250 Wu-Hsing Street, Taipei City 110, Taiwan.

E-mail addresses: wchiu@tmu.edu.tw (W.-T. Chiu), jack@tmu.edu.tw (Y.-C. Li).

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1. Introduction

1.1. Aging population

Aging population is a global phenomenon, and the elderly impact illness trends and health care services simultaneously [1,2]. According to the World Health Organization (WHO), the aged in 2000 (individuals 60 years and above) comprised 650 million people, accounting for 10% of the global population. This group will increase up to 2 billion people in 2050 [3]. The costs of health care will soar because of this trend. Taiwan's government launched national insurance on March 1, 1995, and the healthcare system in Taiwan has been operated efficiently so far [4]. Taiwan's total health-related expenditure as a percentage of gross domestic product (GDP) is 6.2%, in contrast to 16% in the United States [5,6]. Taiwan's elderly population reached 10.21% in 2007 and is expected to rise to 15.85% by 2020 [7]. The sharp rise of expenditure for national health insurance and a shortage of caregiver manpower have become the two most critical issues for the coming decade. Taiwan's Department of Health initiated the Taiwan Telehealth Pilot Project (TTPP) in July 2008 to tackle the most critical issues through information technology and innovative service models.

1.2. Experiences of developed countries

The aging population is even more profound in developed countries such as the United Kingdom and the United States. Therefore, they came up with resolves to tackle the long-term care of the elderly through telehealth. And some of them would be elaborated as follows:

In the UK, telecare is a public service that helps to protect and support people in their own homes. Brown [8] described telecare as a term given to the remote monitoring of patients through information and communications technologies. In Brown's definition telecare includes systems that incorporate electronic devices that can alert the occupant of a house or a care response system on the occurrence or non-occurrence of predetermined events. The UK has 1.75 million alarm support systems, using simple technology to provide support vulnerable people at home [9]. The alarm systems offer the certainty that there is always someone to help in times of an emergency. The UK's telecare network functions as a social care system; home safety is the major concern. In recent years, the UK government has added healthcare to the existing telecare system, in an attempt to bring telecare and telehealth together as a combined solution, and supports the national drive for a more flexible and integrated approach to health and social care delivery within the community setting, keeping people healthy, safe, and in control within their homes.

In the US, the Veterans Health Administration launched a large-scale telehealth system to reach 7.6 million veterans, and delivered healthcare services to 5.6 million veteran patients annually from 2003 to 2007 [10]. This project is based on the belief that the aging American population will cause healthcare costs (including non-institutional care needs) to soar. Therefore, the Veterans Health Administration devel-

oped a care coordination/home telehealth system, to allow aged veterans to choose to live independently at home with appropriate access to efficient care which having of chronic illnesses such as diabetes mellitus, hypertension, chronic obstructive pulmonary disease, and post-traumatic stress disorders.

In Hersh's 2001 report [11], telemedicine was classified into three patterns: store-and-forward, self-monitoring, and clinician-patient interaction telemedicine. But Hersh's update report on telemedicine in 2006 [12] changed the classifications to store-and-forward, home-based, and office/hospital-based telemedicine. In this study, the home-care model is similar to home-based telemedicine, while the residential and community-care models are similar to office/hospital-based telemedicine.

According to Hersh [11,12], telemedicine uses telecommunication technology for diagnostic, monitoring, and therapeutic purposes to meet the needs of long-distance healthcare. Information and communications technology can transmit textual, audio, and video information between healthcare providers and care recipients. Thus, there is an increasing need for telemedicine services to be part of the healthcare system. Telehealth is the delivery of health-related services and information via telecommunications technologies. Telehealth is an expansion of telemedicine, and unlike telemedicine which more narrowly focuses on the curative aspect. Telehealth encompasses preventive, promotive and curative aspects [13]. Healthcare information technology, including telehealth, might play a key role in helping resolve both skyrocketing healthcare costs and the increasing need of healthcare for an aging population [14]. But no evidence has been found to show that telehealth is cost-effective [11,12]. The purpose of this study was to propose functional models that provide integrated and ubiquitous long-term care (LTC) based on the application of information communication technology (ICT). ICT consists of the hardware, software, networks, and media for the collection, storage, processing, transmission and presentation of information (voice, data, text, images), as well as related services. Once proven effective, the models may be used in healthcare systems throughout Taiwan.

2. Development and implementation of a national telehealth project

In 1998, Taiwan developed local LTC management centers in 25 counties and cities existed in Taiwan. The LTC information network was established in 2003 using information technology to efficiently combine resources for LTC from both governmental and private institutions (Fig. 1). Based on the LTC information network and other established networks such as the National Health Informatics Project (NHIP), the TTPP was piloted from July 1, 2008 to December 31, 2008. The goal of the TTPP was to provide home care, residential care, and community care to deliver health and living services, health advice, emergency consultation services, and other needed healthcare services.

Fig. 2 shows the TTPP system. The project included four key elements: the residential-care model, the home-care model, the community-care model, and the telehealth central station

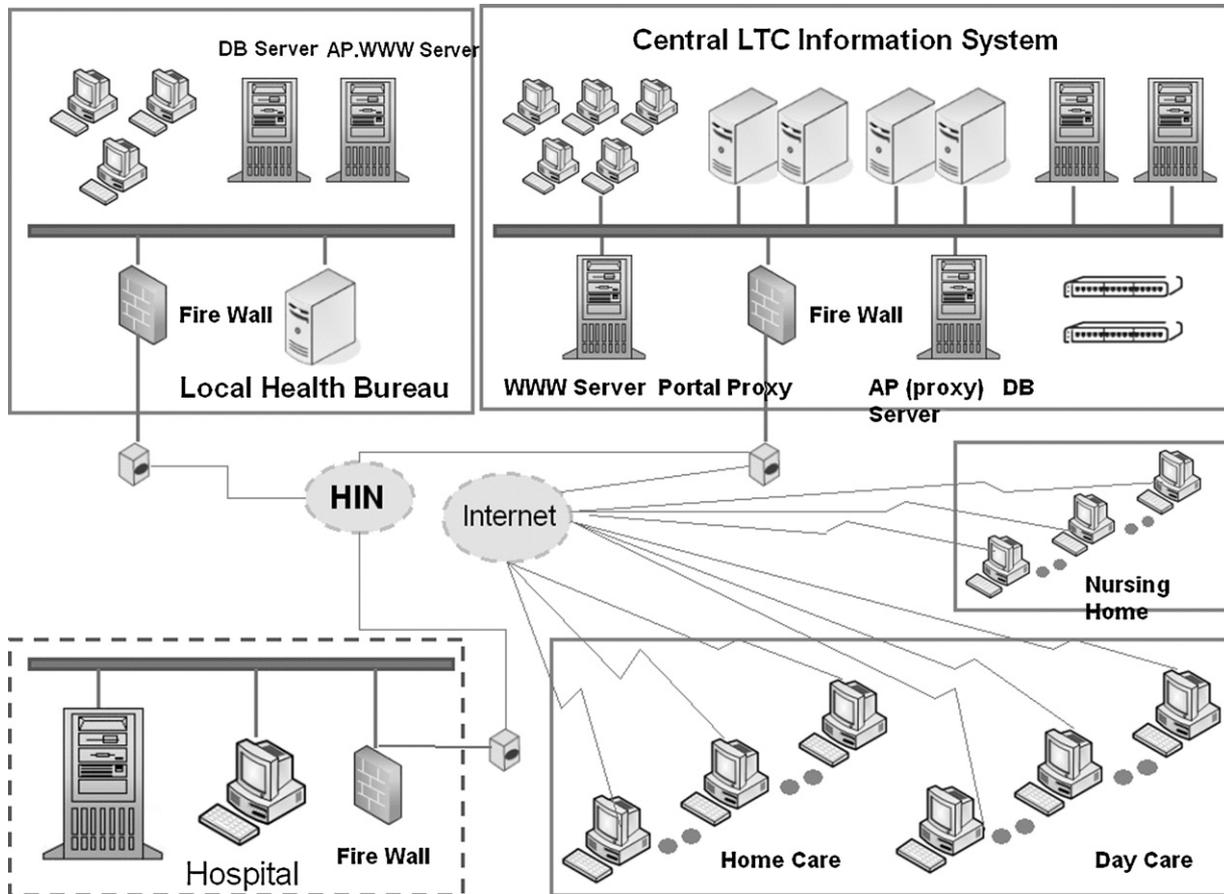


Fig. 1 – The long-term care information network in Taiwan.

(TCS), as well as an information platform to integrate all the relevant systems. The TCS was responsible for the administration, coordination, and management of health information to facilitate data and record archiving, exchange, and trans-

mission, it also served as a 24-h service call center that dealt with emergency consultations for daily health and lifestyle problems. Table 1 lists inclusion criteria and core services of the three (home care, community care and residential care)

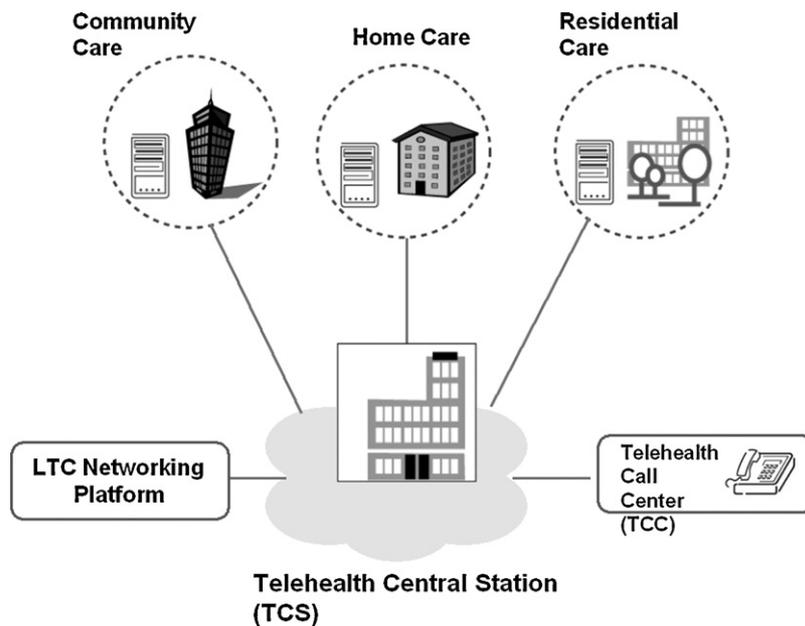


Fig. 2 – The functional structure of Taiwan’s Telehealth Pilot Project.

Table 1 – Inclusion criteria and core services of the three care models of Taiwan's Telehealth Pilot Project.

	Home care	Community care	Residential care
Inclusion criteria	Current home care enrollees Caregivers with chronic disease Low to moderate-grade disability	Cardiovascular diseases Diabetes Dementia Low-grade disability Seniors living alone	Moderate to high-grade disability Intermediate care
Core services	Home visit using videoconference Physiological monitoring Living support Health education	Health promotion Dispensary Physiological monitoring Medication consultation Living support Health education	Regular and emergency consult Rehabilitation instruction Physiological monitoring Medication consultation Tele-learning Quality monitoring

models. An assessment and evaluation of the TTPP were done after a half-year implementation period.

The three telehealth models are elaborated below.

2.1. The home-care model

To be included for the home-care model were the elderly whose Barthel's index was equal or below 90 or who had diabetes mellitus or hypertension. The same family might have more than one patient because the care-recipients of the bed-ridden disabled elderly might be hypertensive or diabetic as well. The services in this model included (A) telemonitoring physiological parameters (blood pressure and/or blood sugar), (B) providing the relevant health information and medication instructions, and (C) offering consultations with healthcare professionals such as dieticians, therapists, pharmacists, and nursing professionals by videoconferences. In telemonitoring, the patients' physician determined the data upload frequency. All the data were uploaded to the central data base with an automatic alert system in telehealth service center. The on-duty staffs in the TSC would respond to any critical values and reminded patients or caregivers if they did not upload the data as the frequency set by the physicians. The data were also integrated into the hospital's computerized physician order entry (CPOE) system. And the clinicians might retrieve the data in the hospital information system (HIS) directly.

Relevant services were delivered through a set-top-box which was attached to a television. The set-top boxes in patients' homes were connected to the telehealth service center through asymmetric digital subscriber line (ADSL). ADSL is a high-speed digital telephone connection that operates over an existing copper telephone line, allowing the same line to be used for voice calls and data transmission. It is a popular broadband technology in Taiwan. The operating system of the set-top-box was Linux and all the applications were developed by Java with OSGi (Open Service Gateway Initiative) compliance. This type of set-top-box was used in the community-care and residential-care models as well.

2.2. The community-care model

To be included for the community-care model were the elderly who were living alone, or who had dementia, hypertension, or diabetes mellitus. The patients in this model could visit the community-care stations independently or with the assis-

tance of their caregivers. The goal of this model was to provide health and living services, including professional healthcare and local community services (such as laundry, haircut, and meal delivery services and so on). The goal of this model was to let the elderly be cared and supported in the community. This model was to allow the elderly to access convenient care services in a familiar context. The community-care stations were set up to offer the elderly the services such as telemonitoring as that of the home-care model and were using the same device, too. And the stations would offer healthcare information and medication instructions as well. Localization services for the elderly with dementia by a global positional system (GPS) were employed in this model. As aforementioned in home-care model, these physiological data were integrated to the hospital's CPOE system, and the physicians might retrieve the data directly in the HIS. The services delivered are similar to those of the home-care model, except that the operations of the telemonitoring were accomplished by the trained-staff in the community-care station instead of the elderly or their caregivers in their home.

2.3. The residential-care model

To be included for the residential-care model were the residents of the nursing home. The residential-care model involves a tele-consultation infrastructure to link the long-term care units and tertiary acute care hospitals with the assistance of the telehealth service center. If specialist consultations are indicated, the staff at long-term care units can employ this infrastructure to request help from the specialists from the corresponding tertiary acute care hospitals. These uploaded data such as the blood sugar or the blood pressure, were integrated to the hospital's CPOE system. Therefore, when physicians were using CPOE to prescribe medications, they might retrieve these recorded data directly from the HIS. The long-term care units can also make use of this infrastructure to seek consultations or support from dieticians, therapists, pharmacists, and nursing professionals. In this way, the residential-model helps to build the communications between the residents in the LTC units and medical professionals in the hospital.

In this project, a computer on wheels with web-camera was built to enable the residents and their families to hold two-way videoconferences to allow "tele-visits." Many enrollees in this model were with the hurdle of ambulation; therefore a com-

puter on wheels could be moved to the site where the enrollees were to take part in the online meetings. Besides the bridging the residents and medical professionals aforementioned, this model also helps to create the communication platform between the resident and the family.

3. Results

3.1. The home-care model

Our home-care pilot study included 50 families, and 200 participants. The numbers of patients' Barthel's index were ranged between 0 and 60 (57%), 61 and 90 (4%), 91 and 99 (1%), and 100 (38%). The services in this model included tele-visits, which were conducted through 2456 telephone calls, 5009 telemonitorings of blood pressure and sugar, 25 emergency event management, 2 remote health instruction sessions, and 2 resource counseling initiatives. After the half-year period, the hospital readmission rate in the home-care model was reduced from 8.19% to 3.17%, and the hospital visit (visits to an emergency department) rate was decreased from 2.95% to 2.90%. The compliance rate for the patients or caregivers to upload the physiological data was 99.3%. We experienced three unwanted events reported in this period, i.e. the uploaded data of blood sugar were extremely high and responded as laboratory critical values. After recheck of the data at patients' homes, the values were still high so the patients were sent to the emergency department of the hospital. But their blood sugar data were turned out to be normal eventually. These false alarms caused "mistrust" from the patients and caregiver to the TTPP system. The reason for inaccuracy of the glucometer was proved to be caused by the adverse storage conditions on glucometer test strips.

3.2. The community-care model

The community-care model features a community-care station. The first community that joined this pilot study was the Cheng-Gung community, located in eastern Taipei. At the time of our study, this community consisted of 2384 families, with 7898 individuals. In this study, we included 152 participants (56% female). Services included 2569 physiological measurements, 94 participant visits, 166 on-site consultations, 48 remote healthcare instruction sessions, 51 remote consultations, 194 medication counselings, 50 hospitalizations of the demented elderly, and 7 referrals to other caregivers. In this model, we helped the aged access services in the familiar context of their own community. The medication nonadherence rate was reduced from 38.20% to 9.20% in this model.

3.3. Residential-care model

In this pilot study, three nursing homes (An-Tai Nursing Home in Keelung City, Chen-An Nursing Home in Taipei County, and Kung-Fu Nursing Home in Tao-Yuan County) and one hospital (Hsiao Chung-Cheng Hospital in Taipei County) joined the residential-care model. There were 95 people lived in these nursing homes, 82 residents (41 males) participated in our

research. From July 1, 2008 to December 31, 2008, there were 155 physician teleconsultations. Among all specialists, we called pulmonologists, nephrologists, orthopedic surgeons, and rehabilitation doctors more frequently than other specialists. This result reflects the importance of their roles for the elderly. Nursing home residents' monthly hospital visit frequency was declined over time (from 0.40% to 0.30%), while the nosocomial infection rate was dropped from 0.18% to 0.11%. In addition, medication safety was improved through pharmacist's efforts in reduction of potential drug interactions and duplications. Drug duplication rate decreased from 63.60% to 29.80%.

4. Discussion

In this study, three long-term-care models (home-care, community-care and residential-care model) were piloted in Taiwan. The results revealed both the home-care and community-care models facilitated timely medical responses if the enrolled patients had emergent conditions. In the home-care model, the hospital readmission rate was reduced from 8.19% to 3.17%, and the hospital visit rate was decreased from 2.95% to 2.90%. In community-care model, the medication nonadherence rate was reduced from 38.20% to 9.30%. In the residential-care model, reduced rates of readmission to the hospital, nosocomial infection and the adverse drug event were found.

4.1. Promotion of medication safety in TTPP

According to a 2006 report [15], the use of multiple medication treatment can increase the risk of adverse drug events in the long-term care facilities, due to the lack of the manpower of various medical professionals especially the staff of the clinical pharmacists and full-time physicians. Aging population is an inevitable global trend even in Taiwan. Polypharmacy which is the use of more than four medications at the same time in one patient will surely increase the likelihood in the future. In our study, through this IT infrastructure, we might ask clinical pharmacists to be a team member to reduce the risk of the adverse drug events and to promote medication safety (e.g. reduction of drug duplication rate decreased from 63.60% to 29.80% in this study).

4.2. The point-of-care test in telehealth

In the home-care model, the improper storage of glucometer test strips, irregular periodic calibrations of glucometer and inadequate trainings of the patients or caregivers would cause the laboratory data of blood sugar inaccurate. These glucometer test strips are easily humidified under the high humidity weather in Taiwan, and resulted in extremely high blood sugar data and let the staffs respond to that critical value and send the patients to the hospital for recheck. The recheck data of blood sugar are reported to be resulting in causing "mistrust" from patients and caregivers towards staff. In this issue, we found it appropriate to disclose the possibility of inaccuracy of the data due to the humidification of glucometer test strips in advance to relieve the tension of misunderstanding. There-

fore, to train the patients or caregivers to store the glucometer strip tests properly and operate the glucometer with regular calibrations correctly under the supervision of staff is crucial [16].

4.3. The feature of the telehealth service center

One unique feature in this study is that the telehealth service center supported three different models simultaneously, making the implementation more cost effectively. Besides, this project was led by the acute care tertiary hospital, and thus providing manpower of various healthcare professionals was more feasible without increased costs.

4.4. The comparison of the three models

Traditional electronic commerce models include the business to business (B to B) model and the business to consumer (B to C) model. In telehealth, the provider to provider (P to P) model is analogous to the B to B model, while the provider to recipient model (P to R) is analogous to the B to C model. Thus, in our project, the residential-care and community-care models would be examples of P to P, while the home-care model would be a P to R approach. In the healthcare industry, it would be easier for the residential and community-care models (P to P models) to operate successfully because of the availability of healthcare personnel close to care recipients to help the delivery of services. No local assistance was available to the patients under the home-care model (P to R model). But both patients and caregivers under the home-care model should be familiar with practical operational principles. In TTPP, the same infrastructure was employed among the three models, yet the cost-effectiveness was the lowest in the home-care model. Since the home-care model could give relatively less patients than those of the other two models.

4.5. Comparison with other studies

The results of Darkins's study showed a 25% reduction in the number of days that patients remain in the hospital and a 19% drop in the number of hospital admissions. The Veterans Health Administration will expand and extend this program to meet the needs of 50% of patients in need of non-institutional care (25,000 patients annually). The results of our study are similar to those of Darkins's report [10] in terms of a decline in the number of hospital admissions (61.3%) in the home-care model and the decline in the nosocomial infection rate (32.5%) in the residential-care model.

4.6. Taiwan's future mandatory tax on long-term care

Taiwan's government has started to plan out a long-term care program, with the intent that citizens will pay extra fees (about 1% of their annual salaries) to cover future increased costs. The tremendous aging population and the prevalence of chronic illnesses facilitated the creation of this program, and telehealth will play a role.

4.7. Future directions

Telehealth offers many benefits that may help with the long-term care of our aging population. However, it has yet to overcome various barriers. First, the clients' willingness to pay for telehealth services is limited. Second, telehealth must produce more evidence for its effectiveness to convince the government or the Bureau National Health Insurance in Taiwan to continue investment in the technology. Under current national regulations, in-person visits are still necessary for most healthcare events. There is a need to develop more user-friendly electronic devices for at-home care. Existing equipment is still suboptimal, and more innovations are needed in the future. Telehealth still has a long way to go.

4.8. Limitations

This study has three limitations (A) the sampling of this study was not randomized. (B) Those three models were mostly piloted in northern Taiwan's urban areas. Therefore, generalizations of the study data to other geographical areas should be cautious. In addition, (C) the results of our study are still preliminary. More data in future studies needed to verify and support these conclusions.

5. Conclusion

Implementing this telehealth pilot study was tailored to meet the needs of the elderly because of aging population. Reduced rates of readmission to the hospital, adverse medication events and nosocomial infection were the major advantages. In spite of the targeted aims, we cannot conclude that the telehealth can be conducted in an economical/cost-efficient way.

Conflict of interest statement

There are no conflicts of interest that could inappropriately influence this research work.

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