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ORIGINAL ARTICLE

Development of a home-based telehealthcare model for improving the effectiveness of the chronic care of stroke patients

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Abstract This study describes the development of an information technology (IT)-mediated home-based healthcare model designed to improve the effectiveness of caring for stroke patients who require chronic, home care. This model was evaluated at Kaohsiung Medical Hospital in Taiwan between 2005 and 2008; 84 newly diagnosed stroke patients diagnosed as the chronic covalence stage were enrolled for preliminary testing of this model. These patients required 24-hour in-home monitoring of their health status and emergency call service. Over the course of the study, 15 emergency transfers were carried out, and the acute stroke patients were sent to the emergency care within 26 minutes, on average. This system helped physicians, patients, and their families to more efficiently detect the occurrence of recurrent stroke. In addition, we found a statistically significant finding ($p < 0.001$) that daily blood pressure (BP) monitoring increased from 45.5% in the initial month of the study to 76% after 3–10 months of intervention. Meanwhile, the proportion of patients with an abnormal BP rate decreased from 20.5% in the initial month of the study

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to 10.9% after 3—10 months of intervention. This suggests that this model helped to improve patient behavior and their ability to care for themselves. This is the first study to develop an IT-mediated, home-based healthcare model in Taiwan. This model integrates both healthcare and clinical services and is capable of enhancing the effectiveness of the care provided to patients with chronic diseases, especially those in situations where self-care is essential for disease management.

Introduction

Reflecting its status as an "aging society," chronic diseases have become a major concern in Taiwan [1]. Under these circumstances, the rate of hospitalization due to chronic diseases is three times more likely for the elderly than any other age group, and the costs of inpatient care among the has elderly accounts for 33.3% of the total inpatient costs in Taiwan [2]. In particular, stroke has been ranked as the top three causes of death in Taiwan since 1964, and how to improve chronic care for victims of strokes in home self-care situations continues to demand attention [3]. The development of a real-time healthcare service model that utilizes information technology (IT) has become a major field of research [4—7]. The application of real-time telehealthcare has generally been focused on home-based health monitoring, which is an extension of inhospital services [4].

In order to order to improve clinical outcomes following stroke and reduce the stress of patients' families, the Ministry of Economic Affairs and the Department of Health began to promote the telehealthcare program in 2006. Under the instruction and funding assistance of the Department of industrial technology, MOEA, Taiwan, and Kaohsiung Medical University (KMU), Taiwan established a home-based telehealthcare model that utilized real-time home health monitoring between 2005—2008. In 2009, this project was honored by the Ministry of Economic Affairs as the best technology research project of the year. Following this pattern, one purpose of this study is to establish an information system platform that could provide instant health monitoring and long-distant health consultation services. This article presents a preliminary study on the construction of this home-based telehealthcare system and healthcare model.

Materials and methods

Constructing a home-based telehealthcare model

This research project was carried out from January 2005 through August 2008. It is methodologically based on the project development life cycle [8] and the adoption of the waterfall model. Based on Wagner's model [7], we interviewed experts on how to develop an IT-mediated chronic care model as a guide for how to improve the care of patients with chronic illnesses. Regarding the healthcare framework, home self-care was regarded as the basic unit of telehealthcare, and the healthcare professionals would be used to bridge the six kinds of services included in this model, which will be individually described in the next section. A simplified service model is shown in Fig. 1.

Improving the perceptions and capabilities of patients to self-care is an important strategy that can enhance the effectiveness of healthcare [15,16], however regular home visits by trained health practitioners would provide the stroke patients with regular home care, health education, and health consultation. The associated tasks are described below.

1. A 24-hour real-time health status tracing and monitoring system. A machine for measuring several physiological parameters, including blood pressure, heart rate, blood sugar, and body temperature, was initially set up in each patient's home. Patient health status was be measured and monitored through the devices in the home, and the data was transmitted to a facility for data management. Once the services model is fully developed, an expansion of the equipment used to measure this physiological information will be considered. The physiological information of each patient will be recorded and turned into a continuous report and sent via the information system (IS) to healthcare professionals for monitoring purposes. If needed, home visits, prescription changes, return visits, and other tasks can be assigned.
2. Emergency care referral and health consultation care. The designed model is characterized by an emergency call system that is embedded into a health pad, and the staff managing this system can either clear out a false emergency call or help refer the patients to the appropriate care option. The services of this category can help patients cope with emergencies.
3. Home visits. Physicians will schedule home visits based on the patient's disease status, as determined by the real-time health monitoring devices.
4. Return visit scheduling. According to the physician's evaluation of the patient's health status, volunteers provide assistance and transportation services when notified through the system.
5. Prescription delivery. Through the system's coordination, patients no longer have to get the prescriptions on their own. In addition, patient scheduling of hospital visits would be managed by the system and could be further checked by healthcare workers who visit the patient at home.
6. Social welfare services application. By connecting to the hospital information system (HIS) and the social

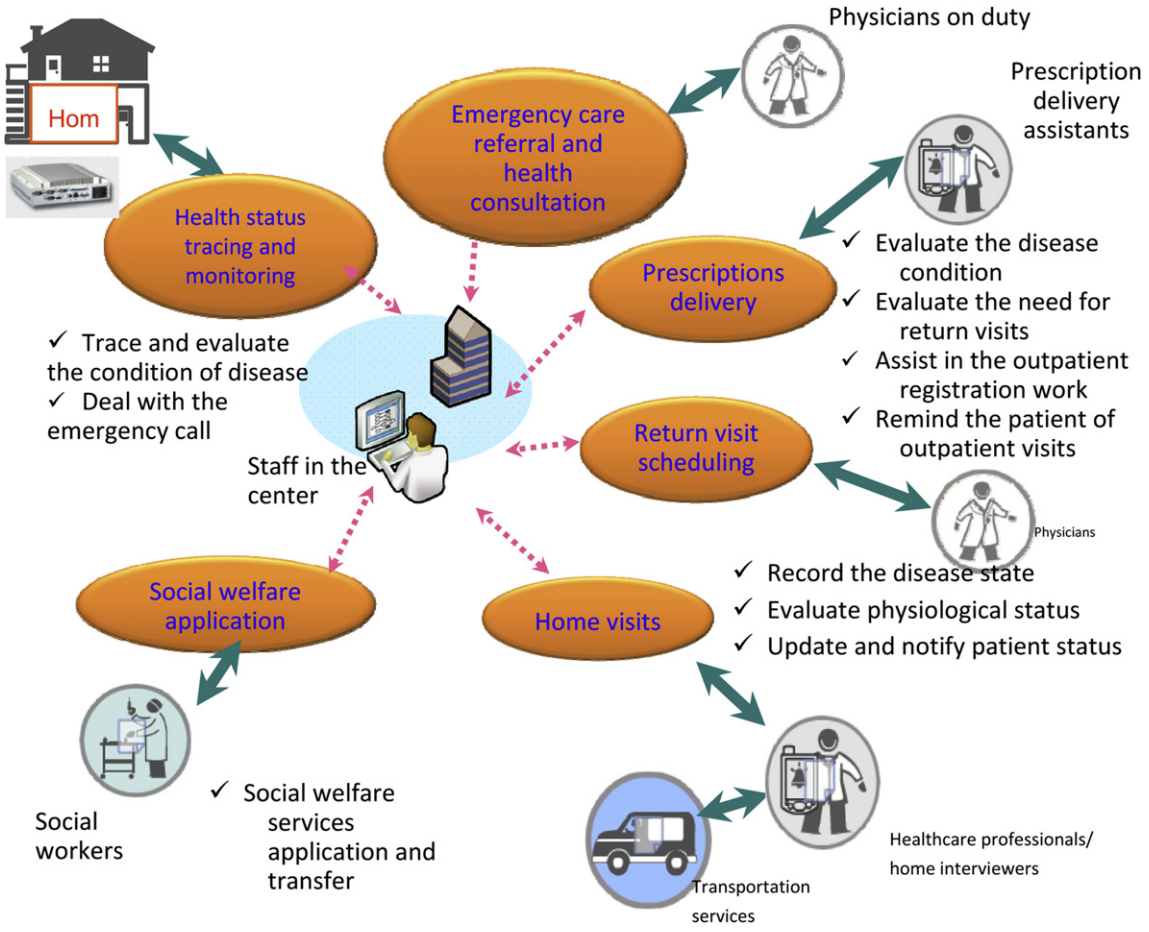

Figure 1. Home-based telehealthcare model.

welfare databases, the model can provide possible suggestions. Healthcare professionals will take charge of the application process, such as document preparation and transfers to government authorities.

Telehealthcare model test run

To examine the effectiveness of the service model, we simulated the model design for confirmation [17].

Enrolling patients for test run

Patients from the outpatient services department of the Neurology Department of KMU Hospital served as our study population. From October 2007 through February 2008, we recruited patients who lived in Kaohsiung city and who had been newly diagnosed with stroke within the past year to join the validating study. A pretest was given to each study patient within the first month after enrollment, and every participant was observed for at least 6 months. A valid participant was identified only if data was correctly collected through this period. In the end, there were 84 valid participants and 32 invalid participants. Invalid participants included three cases who passed away, 20 cases who withdrew due to personal time constraints or personal plans, and nine cases who were unable to be followed up due to disease conditions.

Data collection and analysis

Considering the characteristics of stroke home care, we focused on the efficiency of emergency delivery and enhancement of each patient's home self-management capabilities. Emergency care within 3 hours of an emergency call is considered one of the critical factors that affects the prognosis of a newly diagnosed stroke victim [18]. With respect to the efficiency of emergent delivery, we calculated the average time spent by the patient between triggering the emergency call at home to being sent to the hospital. In order to enhance each patient's home self-management capabilities, we cumulated the health behavior accuracy of blood pressure (BP) that was measured each day, as recorded by the information platform. Performing the measurement both in the morning and at night for a day is regarded as the proper behavior for self-monitoring BP [19,20]. Regarding daily measurements, we used the abnormal BP rate to represent compliance of daily health behavior instead of directly calculating the systolic and diastolic BP. Data was coded using Microsoft Excel 2007 and analyzed using SPSS

12.0. Statistical analyses, descriptive analyses, repeated-measured ANOVA, and trend charts were also conducted.

Results

Descriptive statistical data

Table 1 shows the demographics of the valid and invalid subjects. The mean age of the entire valid population was 66.4 years. The number differences between genders was small (males accounted for 54.8% of the study population). Most (94%) of the study samples reported receiving financial support from other members in the household. Very few (4%) of the study samples lived alone, and more than half (53%) did not finish elementary school. Based on the Barthel index for measuring the functional independence of the subjects, over half (59.5%) have total independence (Barthel index score of 100), while 13.1% have total dependence (Barthel index scores ranging from 0—19). The demographics of neither study group revealed statistical differences based on the goodness-of-fit test.

Time efficiency of emergent delivery

According to the records obtained by the IS platform, 24 person-times were triggered in the emergency call system among the study population. Of these cases, 15 needed emergency care transfer, and the average time spent on referral was 26 minutes. Compared to the results of the Taiwan Stroke Registry of 2007, the average time spent transferring stroke patients to emergency care was 14.4 hours while it took 8.9 hours for patients who were not enrolled in our study to visit KMU hospital. These results suggest that the average time spent in emergency care in our study was much shorter than these two previous studies. We found that the 24-hour continuous tracking of patient health status helped to detect the occurrence of a "recurrent stroke" and assisted when transferring patients to nearby healthcare facilities.

Enhancement of patient home self-management capabilities

As shown in Fig. 2, the proportion of patients that adopted proper daily BP measuring behavior increased from 45.5% in the initial month of the study to 76% after 3—10 months of the intervention. Meanwhile, the proportion of patients with an abnormal BP rate decreased from 20.5% in the initial month of the study to 10.9% after 3—10 months of intervention.

Repeated-measured ANOVA was used to validate the statistical meaning of the abnormal BP rate, and patients were divided into three groups according to their follow-up times. T_1 was composed of those who had been discharged for longer than 1 month and joined this study within 3 months; T_2 consisted of those with a follow-up time between 3—6 months; and T_3 consisted of those who had joined the intervention model more than 6 months prior. A significant multivariate effect was found between the three groups (p-value < 0.001), and abnormal rates dropped significantly with follow-up time (p-value of each stage was lower than 0.001).

Discussion

The aim of the study is to present an IT-mediated healthcare model as an extension of ordinary chronic care. We further evaluated the effect of the model on two important

Table 1 Descriptive statistics of the study sample

Items	Valid sample	Invalid sample	p-value	Items	Valid sample	Invalid sample	p-value
N	84	32					
Age	66.4 ± 12.7	65.7 ± 10.2	0.533				
Gender				**Source of financial support**			
Female	38	12	0.923	Self	27	6	0.921
Male	46	20		Spouse	8	5	
Education level				Children	45	14	
Uneducated	21	3	0.411	Social support	4	4	
Elementary school	28	12		**Household members**			
Junior high school	15	7		Alone	4	1	0.920
High school	12	8		2—3 members	44	15	
College or above	8	2		4+ members	36	16	
Marital status				**Initial Barthel Index**[a]			
Unmarried	2	0	0.929	Total dependence	11	9	0.439
Married	72	31		Severe dependence	5	2	
Widowed	10	1		Moderate dependence	16	5	
				Slight dependence	2	0	
				Total Independence	50	15	

[a] The Barthel index (BI) is a commonly used scale used for evaluation purposes by physicians, nurses, and rehabilitation therapists. It is mainly used to measure severity and functional performance related to stroke rehabilitation [27,28]. The composite BI is scaled on a 100-point range, with 100 representing total independence, 60—99 representing slight dependence, 40—59 representing moderate dependence, 20—39 presenting severe dependence, and 0—19 representing total dependence.

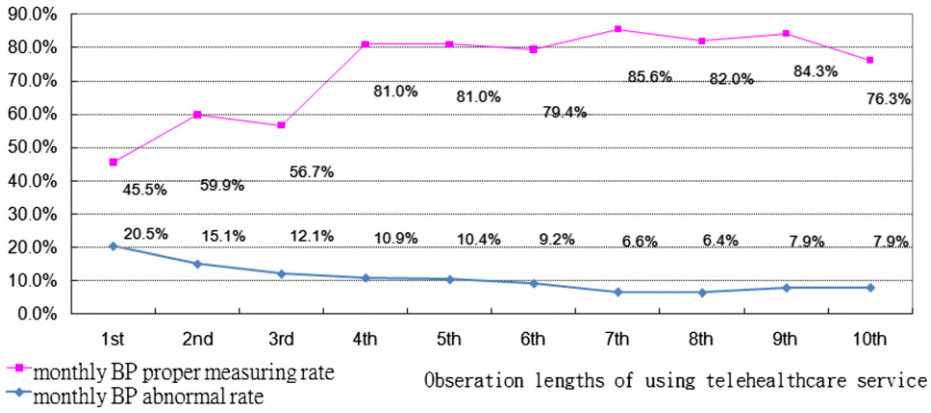

Figure 2. Effectiveness of proper and abnormal monthly BP measuring rates as determined by the telehealthcare service.

issues related to the home healthcare of stroke patients. First, prior studies have suggested that the prognosis of acute cerebral infarction could be greatly improved if a patient was diagnosed and treated in a timely manner [11,12]. The study results show that this model can dramatically improve the time efficiency of emergent delivery. Within the study period, 7 of the 15 person-time ER patients were diagnosed with recurrent stroke and were treated with tPA in time. The other cases were diagnosed with other acute conditions, such as diabetic coma, pneumonia, etc. In addition, this study found a relatively low ER revisit rate of 17.8% compared with the hospital-wide rate of 27.2%.

Previous studies have stated that BP control is significantly associated with the incidence and mortality rate of cardiovascular diseases [9,10]. In addition, how to assist stroke patients to develop the habit of regularly self-measuring their own BP is essential to self-care [13,14]. This study shows that this model can significantly reduce the daily abnormal BP rate by encouraging proper and daily BP measurement. The study results also suggest that a chronic care model, when integrated with home self-care, improves the effectiveness of care [21]. The study by Green et al. (2008) stated that a "web-based health monitoring with a pharmacy-intervened healthcare model" provides people with detailed information on self-care and helps them achieve the goal of proper BP control. Our study results also support the previous findings regarding the effectiveness of telehealthcare services [4,5,21]. In addition, this model could be used to effectively monitor the risk of stroke occurrence when patients are at home and instantly provide an emergency transfer. Moreover, compared with service models where only passive information is provided [20,22,23], we provided a telehealthcare service that allows healthcare professionals to intervene. This design can not only bring the motivation and resources of self-care to the service receivers, but also improve their self-care behaviors through active health education and real-time health monitoring by healthcare professionals.

The study possesses several notable strengths. First, our model design was based on the chronic care model proposed by Wagner et al. (1999) and suggestions from experts in various fields after evaluating practical healthcare needs. This will enable the expansion of this service model in the future. Second, we provided an IT intervention-based healthcare service, which could dramatically improve the efficiency and effectiveness of healthcare in the future. An analysis by the Rand Corporation indicates that the improvements in healthcare outcomes and efficiency will result mainly from the wide use of information technology [24]. The development and setup of the information platform is the core of this model: the health conditions of the patients at their home could be immediately seen on the platform, and healthcare providers and patients could interact through this system. In the future, with the further application of this model, the integration of available healthcare services will become easier and the elasticity and efficiency of innovative services will be increased.

This study has several limitations that should be addressed by future research. This study adopted a noncomparative before-after design, and therefore the observed model effects should be carefully regarded only as only preliminary results. Moreover, this study was limited to those who were discharged from a single hospital and had internet access from home and basic computer skills.

Given the high prevalence of chronic illnesses, self-management support appears to be an effective coping strategy and needs to be systematically integrated into clinical care [25,26]. To the best of our knowledge, this is the first study in Taiwan to develop a chronic care model with IT intervention that was integrated into the healthcare industry. This model is predicted to become an important approach for improving the effectiveness of self-care in chronic care, especially for BP control.

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References

[1] Ministry of the Interior, Republic of China. Bulletin of interior statistics. Taipei: Executive Yuan (in Chinese); 2010.

[2] Ministry of the Interior, Department of Social Affairs, Republic of China. Yearbook of social affairs. Taipei: Executive Yuan (in Chinese); 2005.

[3] Ofman JJ, Badamgarav E, Henning JM, Knight K, Gano ADJR, Levan RK, et al. Does disease management improve clinical and economic outcomes in patients with chronic diseases? A systematic review. Am J Med 2004;117:182—92.

[4] Yousef J, Lars AN. Validation of a real-time wireless telemedicine system, using bluetooth protocol and a mobile phone, for remote monitoring patient in medical practice. Eur J Med Res 2005;10(6):254.

[5] Marian PL, Mona NB, Peter H, Mohammed YP, Karen LY, Ruwani G, et al. Telemedicine for acute stroke: triumphs and pitfalls. Stroke 2003;34:725—8.

[6] Field MJ, Grigsb J. Telemedicine and remote patient monitoring. JAMA 2002;288:423—5.

[7] Wagner EH, Austin BT, Von Korff M. Organizing care for patients with chronic illness. Milbank Q 1996;74(4):511—44.

[8] McConnell S. Software estimation: demystifying the black art. WA: Microsoft Press; 2006.

[9] Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL, et al. Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of high blood pressure. Hypertension 2003;42(6):1206—52.

[10] Staessen JA, Wang JG, Thijs L. Cardiovascular protection and blood pressure reduction: a meta-analysis. Lancet 2001; 358(9290):1305—15.

[11] Jahan R, Duckwiler GR, Kidwell CS, Sayre JW, Gobin YP, Villablanca JP, et al. Intra-arterial thrombolysis for treatment of acute stroke: experience in 26 patients with long-term follow-up. Am J of Neuroradio 1999;20:1291—9.

[12] Proceedings of a National Symposium on Rapid Identification and Treatment of Acute Stroke. Washington, DC: National Institute of Neurological Disorders and Stroke; 1997.

[13] Ohkubo T, Asayama K, Kikuya M, Metoki H, Hoshi H, Hashimoto J, et al. How many times should blood pressure be measured at home for better prediction of stroke risk? Ten-year follow-up results from the Ohasama study. J Hypertens 2004;22(6):1099—104.

[14] Parati G, Stergiou G. Self blood pressure measurement at home: how many times? J Hypertens 2004;22(6):1075—9.

[15] Lorig KR, Ritter PL, Laurent DD, Plant K. Internet-based chronic disease self-management: a randomized trial. Med Care 2006;44(11):964—71.

[16] Porsche R. Hypertension: diagnosis, acute antihypertension therapy, and long-term management. AACN Clinical Issues 1995;6:515—25.

[17] Kerlinger FN, Lee HB. Foundations of behavioral research. New York: Thomson Learning; 2000.

[18] Kathleen D. Treatment-seeking behavior among those with signs and symptoms of acute myocardial infarction. Heart Lung 1991;20:570—5.

[19] Green BB, Ralston JD, Fishman PA, Catz SL, Cook AJ, Carlson J, et al. Electronic communications and home blood pressure monitoring (e-BP) study: design, delivery, and evaluation framework. Contemporary Clinical Trials 2008;29(3): 376—95.

[20] Fahey T, Schroeder K, Ebrahim S. Interventions used to improve control of blood pressure in patients with hypertension. Cochrane Database Syst Rev 2006;2:CD005182.

[21] Green BB, Cook AJ, Ralston JD, Fishman PA, Catz SL, Carlson J, et al. Effectiveness of home blood pressure monitoring, web communication, and pharmacist care on hypertension control: a randomized controlled trial. JAMA 2008; 299(24):2857—67.

[22] Walsh J, McDonald KM, Shojania K, Sundaram V, Nayak S, Lewis R, et al. Quality improvement strategies for hypertension management: a systematic review. Med Care 2006;44(7): 646—57.

[23] Cappuccio FP, Kerry SM, Forbes L, Donald A. Blood pressure control by home monitoring: meta-analysis of randomised trials. BMJ 2004;329(7458):145.

[24] Hillestad R, Bigelow JH. Health information technology: can HIT lower costs and improve quality? Santa Monica, CA: Rand Corporation; 2005.

[25] Lorig KR, Sobel DS, Ritter PL, Laurent D, Hobbs M. Effect of a self-management program on patients with chronic disease. Eff Clin Pract 2001;4(6):256—62.

[26] McCulloch DK, Price MJ, Hindmarsh M, Wagner EH. A population-based approach to diabetes management in a primary care setting: early results and lessons learned. Eff Clin Pract 1998; 1(1):12—22.

[27] Granger CV, Dewis LS, Peters NC, Sherwood CC, Barrett JE. Stroke rehabilitation: analysis of repeated Barthel index measures. Arch Phys Med Rehabil 1979;60:14—7.

[28] Mahoney FI, Barthel DW. Functional evaluation: the Barthel Index. Md State Med J 1965;14:61—5.