Development and Cost Effectiveness of a Telenursing System for Homr Oxygen Therapy Patients and an educational Program for Telenurses

Development and Cost Effectiveness of a Telenursing System for Home Oxygen Therapy Patients and an Educational Program for Telenurses

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Abstract— **A life management telenursing system for home oxygen therapy (LMS-HOT) was developed for chronic respiratory failure patients for early detection and prevention of acute exacerbations of respiratory failure. LMS-HOT consists of four systems administered by the nursing monitoring center:(1) internet terminals in the patient's home;(2) telemonitoring with literature-based algorithms that trigger individualized response data;(3) the server supporting the interactions and care system; and(4) educational systems to guide patient compliance. LMS-HOT alleviated anxieties in daily life, resolved problems at an early stage, improved self-care awareness, and provided a sense of security. The cost of maintaining a patient at home using LMS-HOT was 23.4% of the usual readmission hospital stay. In 2006 and 2007, 146 health care professionals and others attended two telementoring seminars with the majority (87.5%) giving positive evaluations.**

Index Terms— **Chronic Respiratory Failure, Educational Program, Home Oxygen Therapy, Telenursing**

I. Introduction

In Japan Home Oxygen Therapy (HOT) for chronic respiratory failure began in 1985. HOT patients include those with pulmonary emphysema, lung cancer and chronic tuberculosis covered by health insurance.

The number of HOT patients' has shown a steady increase from its inception. By 2006 the number of patients reached 130 thousand [1] . HOT patients are becoming older and more chronic. In the last 20 years, the average age of the HOT patients was over 75 years and they had an extended period of time as a HOT patient. Acute exacerbations of respiratory failure and readmission to the hospital are common. Hospital stays reduce elderly HOT patients' Quality of Life (QOL) and interrupt daily home activities.

Kamei, et al. [2] found that the HOT patients' acute exacerbation had identifiable triggers, incidents that occurred prior to the diagnosed condition of acute exacerbation. A main event was upper respiratory infection and progressive respiratory failure. Typically they suffered from such symptoms as: dyspena, excessive sputum, and lethargy. These events are amenable to prevention by providing timely preventive nursing care at the patients' home using telenursing [3] .

Telenursing was developed in the late 1980's in Europe and the United States. The International Council of Nurses (ICN) defined telenursing as: the use of telecommunications technology in nursing to enhance patient care. It involves the use of electromagnetic channels (e.g. wire, radio and optical) to transmit voice, data and video communications signals. It is also defined as distance communications, using electrical or optical transmissions, between humans and/ or computers [4] .

Telenursing helps patients and families to be active participants in their care, particularly in the self-management of chronic illness [4] . Therefore telenursing reduces the use of higher cost health care services, provides effective limited health care for a wide range of people, reduces hospital stays, and is half the cost of visiting nurses [5] [6] [7] [8] .

Research regarding in-home respiratory care in Japan, including telemedicine for respiratory rehabilitation and daily life at home found that those activities resulted in an avoidance of acute exacerbations [9] [10] . Reports of the effects of long term use for home respiratory telemedicine/ telecare are limited because the medical fee doesn't cover the telecare cost.

Our previous study [11] [12] [13] focused on the development of the Life Management Telenursing System for Home Oxygen Therapy (LMS-HOT, Japanese patent pending 2007-182020) by nurses to manage comprehensive respiratory rehabilitation. The LMS-HOT consisted of four systems administered by the nursing monitoring center: internet terminals in the patient's home for physical and mental self-assessment; telemonitoring with literature-based algorithms that trigger individualized response data; the server supporting the interactions and care system; and educational systems to

guide patient compliance to conform comprehensive respiratory rehabilitation guidelines.

This telenursing system was accepted by elderly HOT patients because of its easy operation. Therefore beginning in 2005 we created a telementoring educational program for health professionals and others such as the Japanese Telemedicine and Telecare Association (JTTA). Although there was wide-scale acceptance of the HOT program, the relationship between patients outcome and cost effectiveness had not been established. Furthermore given the importance of health provider and patient supporters' actions the educational seminars needed to be evaluated.

The purpose of this study was two-fold: (1) clarify patient outcomes and the cost effectiveness when identifying the early stage of acute exacerbation by using LMS-HOT, especially patients' readmission, self management, health related QOL, subjective narratives and medical cost and (2) evaluate educational program for telementoring for advanced professionals.

II. METHODS

A. Development of LMS-HOT

LMS-HOT consisted of four systems administered by the telenursing monitoring center: (a) internet terminals in the patient's home; (b) telemonitoring with literature- based algorithms that trigger individualized response data; (c) the server supporting the interactions and care system; (d)and educational systems to guide patient compliance.

Net terminals were put in patients' home. Each day patients used a 21 item of check consisting of respiratory , physical and mental characteristics to note their health status [13] . Items included blood pressure (BP), SpO_2, pulse rate, peak flow, body temperature, appetite, sleep condition, perceived dyspena(Borg scale 10), and sputum volume. Patients answered by selecting and then touching the visual analog scale (VAS) displayed on the LMS-HOT net terminal. The data was sent each day via an internet to the server by PHS card [Figure 1 LMS-HOT Properties] .

The server stored their data and analyzed the daily scores. Telenurse accessed the data. Based on logically determined trigger parameters for each patient, the telenurse would note the data as no-trigger, trigger-remark or trigger-urgent and initiate nursing action including telephone calls to the patient. We develop a textbook and website for patients' education, as well as a storage bag for the LMS-HOT net terminal PC, peak flow meter, thermometer, manometer, and progress notes.

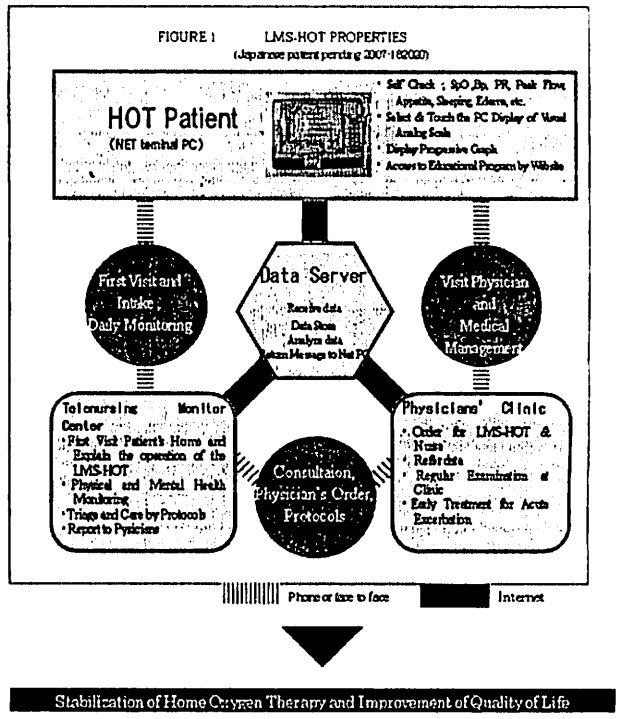

FIGURE 1 LMS-HOT PROPERTIES

B. Ethical Considerations

This research obtained approval from the ethics committee of St.Luke's College of Nursing. It was conducted in conformity to human research and health information privacy standards.

C. Telementoring educational program

We organized two telementoring seminars in 2006-2007 attended by 146 participants; 37.7% nurses; 29.5% other health professionals; and 32.9% others. We prepared a telementoring textbook and distributed it to each participant. The evaluation tool was to test participant's understanding and judgment related to telementoring situations, and a program satisfaction section consisting of six forced-choice items.

III. SUBJECTS

Agreeing to participate in the research was a convenience sample of five HOT patients with an average age 70.4(±13.0) who employed LMS-HOT between 77 days to 499 days. The average HOT period was 18.4 month (±3.0). Patients' age, sex, diagnosis, HOT period, data summary is shown in Table 1 [Table1 HOT Patients Properties] .

TABLE1 HOT PATIENTS PROPERTIES

	A	B	C	D	E
Sex / Age	F / 59yo	F / 55yo	F /78 yo	M /74 yo	M /86 yo
Diagnosis	Alveolar hypoventilation	Sarcoidosis	PE	OMI,PE	BA
HOT period*	22	18	20	18	14
LMTS-HOT period** a	77	173	499	288	139
Received data ** (b)	55(71.4)	172(99.4)	464(93.0)	278(96.5)	113(81.3)
Triggered data;** (c)	4(7.3)	164(95.3)	424(91.4)	48(17.3)	104(92.0)
Triggered cause	sputum volume↑ peak flow↓	bloody sputum body pain coughing	bloody sputum coughing peak flow↓ body pain	palpitation leg edema	peak flow↓

F=Female, M=male, Age=years old, PE=Pulmonary Emphysema, OMI=Old Myocardial Infraction, BA=Bronchial Athma.
*;month, **;day (b)=b / a ×100%, (C)=c / b ×100%

IV. MEASUREMENTS

A total of 1,176 days of the 21 item self- monitoring data, and patient responses to the previously established valid and reliable Japanese version of the Health-Related QOL (SF-36) [14] , and patients' statements about using LMS-HOT provided the data for analyses.

V. ANALYSIS

The daily incidents of no-triggers, trigger-remark and the trigger-urgent of 21 items were compared by one-way ANOVA. The pre and post use of LMS-HOT changes in the SF36 scores were analyzed by means of an independent t-test. The significance level was set at 5%. Statistical analysis was performed using SPSS version 14.0 for windows (SPSS, Chicago, IL, USA). Patients' statements were content analyzed for themes. Percentages were used to analyze the telementoring education participant evaluation responses.

VI. RESULTS

A. Patients' physical and psychological daily conditions

Of the 1,082 reports submitted, the no-trigger data 223 reports (20.6%), the trigger- remark was 115reports (10.6%), and urgent- remark was 744 reports (68.8%). These reports suggested that exacerbation episodes identified when one or more parameters triggered the emergency alarm, yielded an over-all incidence rate of 79.4% (859/1082). Of the possible exacerbation episodes, 68.8% were judged to be emergencies; the number of emergencies per total reports per patient varied greatly: 7%(4/55), 95%(164/172), 91%(424/464), 17%(48 /278), and 92%(104/113).

On the day of triggering, parameters were significantly lower for pulse rate, blood pressure, SpO_2, peak flow, Borg scale 10 of perceived dyspena score, sleeping satisfaction, appetite, walking/moving conditions, leg edema, sputum volume, sore throat, palpitations, headache, subjective perceived condition (Visual Analogue Scale;VAS), and daily total points but, no significance in body temperature was found [Table 2 Comparison of parameters on triggered/ non triggered day] . Additionally, there were no occurrences of patients' hospital readmissions during the LMS-HOT period.

B Patients' effectiveness of LMS-HOT

a. Health Related Quality of Life (QOL)

SF36 was used to document patients' improvement of HR-QOL before and after employing LMS-HOT. Figure 2 shows the changes in HR-QOL responses [Figure 2 Changes of Health related QOL] . Improvement in function related to physical (RP), body pain (BP), and vitality (VT) were noted but did not reach statistical significance.

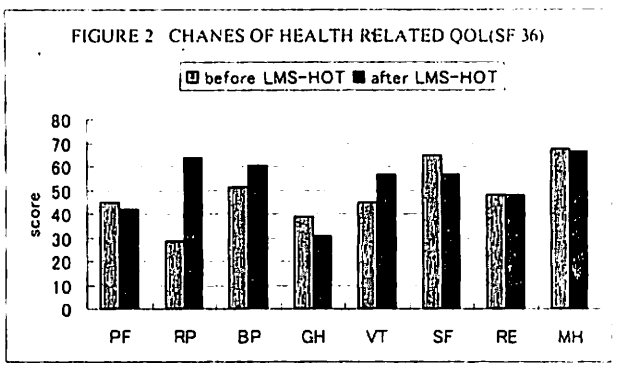

FIGURE 2 CHANGES OF HEALTH RELATED QOL

TABLE 2 COMPARISON OF PARAMETERS ON TRIGGERED/ NON TRIGGERED DAY(ONE -WAY ANOVA)

Parameter	Non Triggered day N=223	Triggered day (remark) N=115	Triggered day (urgent) N=744	p value
Body Temperature	35.4(2.5)	35.7(3.5)	35.7(3.3)	p=0.41
Pulse rate	72.8(7.1)	90.5(10.1)	87.8(13.1)	p<0.001**
Blood pressure	123.5(9.9)/ 73.8(7.9)	123.7(10.6)/ 76.6(8.6)	117.4(19.0)/ 69.5(10.8)	p<0.001**
SpO_2	99.1(0.5)	95.5(2.7)	95.9(7.9)	p<0.001**
Peak Flow	418.3(60.8)	206.8(107.9)	140.5(102.1)	p<0.001**
Borg scale score	1.42(0.74)	1.89(1.0)	2.42(1.0)	p<0.001**
Sleeping satisfaction point	4.5(0.8)	4.3(0.7)	4.2(0.7)	p<0.001**
Appetite point	4.0(0.1)	3.9(0.3)	3.7(0.6)	p<0.001**
Walking/ Moving condition point	2.4(0.5)	2.1(0.4)	2.1(0.4)	p<0.001**
Leg edema	-	0.2(0.4)	0.2(0.4)	p<0.001**
Sputum volume	0.05(0.24)	0.71(0.93)	0.88(0.49)	P<0.001**
Sore throat	-	0.03(0.2)	-	P<0.001**
Palpitation	-	0.04(0.2)	0.20(0.1)	P=0.009**
Headache	-	0.03(0.2)	0.01(0.1)	P=0.028*
Subjective perceived conditions	9.1(1.7)	7.4(1.8)	7.1(1.3)	P<0.001**
Daily total point	94.3(3.2)	83.6(5.1)	80.6(6.0)	P<0.001**

( )=SD STANDARD DEVIATION, BODY TEMPERATURE= ℃, PULSE RATE=BPM, BLOOD PRESSURE=MMHG, SpO_2=%, PEAK FLOW=L/MIN, BORG SCALE SCORE=0～10 POINT, SLEEPING SATISFACTION POINT =1～5, APPETITE POINT =1～4, WALKING/ MOVING COMDITION POINT=0～3, LEG EDEMA POINT=0～1, SPUTUM VOLUME=0～4, , HEAD ACHE =0 ～1 , SUBJECTIVE PERCIEVED CONDITIONS= 0～10 POINT VISUAL ANALOGUE SCALE(VAS), DAILY TOTAL POINT= 0～100 POPINT. *;P<0.05, **P<0.01.

b. Patients' perceived narrative effectiveness.

The five patients reported that LMS-HOT alleviated anxieties in daily life, resolved problems at an early stage, improved self-care awareness, and provided a sense of security.

C. Cost Effectiveness for HOT patients

When COPD(chronic obstructive pulmonary disease) patients with acute exacerbations of chronic respiratory failure were admitted to the hospital, their average medical cost was almost 690 thousand yen (equivalent to approximately $5,750 USA) per admission [15] [16] .

HOT patients maintaining their physical and mental health by employing LMS-HOT in their own home, yielded medical, PHS, and nurses' cost of almost 162,000 yen (approximately $1,350 USA) per month. It costs 23.4% of the usual readmission hospital stay. If the 130,000 HOT patients in Japan received preventive care and avoid hospitalization for one year, the cost savings would be approximately 366 billion yen ($3 billion USA) in hospital fees per year. In this study, sample size was very small and limited; however despite their poor health which was typical of Japanese HOT patients, we determined that these patients had no hospitalization.

D. Evaluation of a Telementoring educational program.

Two telementoring seminars were offered in 2006-2007. Each participant received the telementoring textbook we prepared consisting of: I Telemedicine and Telementoring; II Methodology of Telementoring; III Practice of eHealth education; eHealth care by vital signs; Telenursing; Exercise and nutrition; and Non-smoking session [17] .

In 2006, 75 attendees and in 2007, 71 attendees participated in the program for a total of 146 attendees; 37.7% nurses; 29.5% other health professionals; 32.9% others. A questionnaire was given to the participants about the satisfaction of the each lecture sessions –Telenursing and Telementoring, Exercise and Telementoring, Nutritious Support and Telementoring, Non-smoking session and Telementoring, Health education and Video conference, Governmental approach for Life-style Disease by Ministry of Health, Welfare and Labor. And 87.5% gave positive evaluations for the telenursing and telementoring sessions.

VII. DISCUSSION

This research aimed to increase the effectiveness of telenursing's ability to respond to the triggers of HOT patients' exacerbations in the early stage; document the cost effectiveness of the HOT program, and evaluate an educational program for telementoring.

The parameters on the triggered day showed lower health conditions compared to the non-triggered day. When patients sent triggered data, the telenurse using a protocol telephoned the patient and asked about physical health and psychological condition or gave directions about medicine, meals, respiratory rehabilitation and other life consultations. Thus there were no occurrences of hospital readmissions.

Although it is important for patients to maintain their physical condition through monthly examinations by physicians, elderly HOT patients have difficulty discussing the daily small changes in their conditions or asking seemingly insignificant questions at the monthly outpatient visit. When HOT patients feel minor symptoms they do not consider the implication of the symptoms in all its aspects, therefore they finally visit the hospital when the situation has worsened. Our telenursing protocols effectively minimize the knowledge gap for patients and provide early detection and prevention of acute exacerbation of respiratory failure.

The previous report suggested that the COPD medical cost of Japan is 830 billion yen per year including HOT cost. It costs 180.6 billion yen during periods of patient stability, but 619.4 billion yen during the acute exacerbation period [16] . In our study, the cost showed a 23.4% savings of the readmission hospital stay. Our telenursing program has the potential to save medical cost by continually maintaining the health condition of those with severe respiratory conditions.

This research indicates that telenursing using LMS-HOT gave the patients a sense of relief and security, and improved vitality and function related to their physical condition; and also it provided an inexpensive cost for patients rather than the higher admission fee. The results suggested that preventive nursing care at the patients' home by telenursing effects improved the HOT patients' QOL.

The second aspect of our research was the related educational program. The telementoring educational program we created was positively received by a majority of the participating health professionals including nurses.

Telehealth guidance needs will increase in this era of preventive care; we think this educational program focused on telementoring was satisfying for the professionals and based on patient outcomes was effective in meeting the HOT program goals.

We strongly recommend follow up research on telenursing practice for large sample sizes and telementoring educational programs with the development of new types of nursing by using ICT.

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