

# EasyCare - The Management System for Chronic Heart Failure: A Case Study from Advanced Heart Failure Clinic at King Chulalongkorn Memorial Hospital

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**ABSTRACT** – Nowadays, chronic heart failure (CHF) is one paradigm of chronic diseases that is one of the most challenging health problems in many healthcare organizations. The management system called EasyCare was designed to improve the treatment of chronic heart failure by facilitating the patients to report their condition to care specialists at the hospital via telephone. The EasyCare system was developed to match with the requirements from the care specialists at Advanced Heart Failure Clinic at King Chulalongkorn Memorial Hospital for providing three telecommunication services; SMS, Website, and IVR system. The system aims to provide health care support for chronic heart failure patients from telephones that widely use today. This study has three objectives; first is to develop systematic long term care services for the elderly with the use of ICT, second is to study an effective intervention of telephones as a part of the management system for the elderly, and third is to provide home healthcare support with effective interface between home and clinic. This study is a preliminary study of the management system to show the possibility of using the ICT to support health care services for chronic diseases in Thailand in the future.

**KEY WORDS** – eHealth, telemedicine, management system, health care, chronic non-communicable diseases, heart failure, elderly, aging society

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## 1. Introduction

In 2005, chronic diseases had represented around 60 % of all deaths worldwide [1]. Cardiovascular diseases owned the largest group (30 %), followed by cancer (13 %), chronic respiratory diseases (7 %), and diabetes (2 %). The most common cause of mortality was Ischemic heart disease (reduced oxygen supply to the heart) which caused as many deaths as all types of cancer together [2]. In USA and Canada, chronic diseases accounted for 88 % of all deaths; CVD 38 %, cancer 23 %, respiratory diseases 8 %, and diabetes 3 % [2]. In European region, chronic diseases accounted for 86 % of all deaths; CVD 51 %, cancer 19 %, respiratory diseases 4 %, and diabetes 1 % [2]. In fact, these patterns are similar to most regions of the world, except for poverty where communicable diseases, maternal and perinatal conditions, and nutritional deficiencies are the major cause of death instead [1].

Elderly people were highly affected by the chronic diseases. As 77 % of all deaths from chronic diseases worldwide occurred in the age group 60 year old and

older [1]. In USA in 2007, 80 % of their population over 65 years old had one or more chronic diseases [3]. More than 60 % had two or more [4].

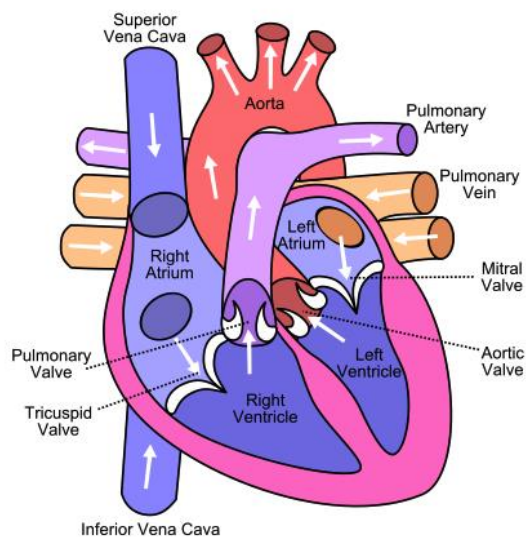
In Thailand, the burden of chronic diseases is rapidly increasing. The prevalence of hypertension was 51.1 percent among the elderly in Thailand, diabetes was 14.0 percent, and diabetes with hypertension was 8.0 percent in 2008 [5]. The Ministry of Public Health reported that there were 3 million Thais have diabetes and 10 million Thais with hypertension in 2009 [6]. Moreover, a high proportion of those elderly were also currently unaware of their condition (~90%) [5].

Chronic diseases are associated with high expenditure on health care. People with chronic diseases represent five times higher expense than normal [7]. In USA in 2005, about 80 % of total health care costs were related to the chronic diseases [4] [7]. A total cost due to morbidity and mortality for CVD alone was \$394 billion [7], cancer was \$210 billion, and diabetes was \$132 billion [6]. In Europe, a total cost for CVD in EU was e169 billion. In

Germany and UK was e54 billion and e37 billion respectively [8]. In Sweden had estimated e5 billion in the total costs on CVD, almost e3 billion were health care costs, representing 11.6 % of the total health care expenditures [8].

### 1.1 Chronic Heart Failure (CHF)

The heart and its circulatory system are responsible for distributing blood to flow throughout the body. A deoxygenized blood flows into a right ventricle by passing a superior vena cava and a right atrium, see *Figure 1*. The right ventricle then pushed the blood through a pulmonary artery into the lungs. From the lungs, where oxygen is collected, the oxygenized blood enters to a left ventricle through pulmonary veins and a left atrium. The left ventricle then finally pushes the blood to flow throughout the human body.



*Figure 1. A cross section sketch of the human heart [9].*

There are two types of chronic heart failure, diastolic and systolic dysfunctions [10]. In diastolic dysfunction refers to a compliance reduction of the ventricles, so it needs a higher filling pressure to be able to meet body’s metabolic needs. In the severe case, this process can lower a stroke volume and a cardiac output that results in less blood being pumped out into the body at each stroke. In systolic dysfunction refers to an impairment of ventricular contractibility of the heart due to a damage of cells or muscle weakening. In this case, the heart cannot pump all the blood from a ventricle that results in lowered stroke volume and cardiac output as well.

As described above, both diastolic and systolic dysfunctions lead to lowered stroke volume. The

body tries to compensate this condition by increasing heart rate, blood pressure, and swelling (edema). The edema that affected from the right side of the heart will occur in a peripheral system, leading to swelling of limbs; e.g., legs and feet. While the edema that affected from the left side of the heart will occur in a pulmonary system, leading to accumulate water in lungs. Therefore, CHF will force the heart to work harder and could lead to a completely loss of cardiac function.

The CHF patients can be classified into one of the four classes of New York Heart Association (NYHA) where class I is the least severe case and NYHA class IV is the most severe case, see *Table 1* [11].

*Table 1. A classification of heart failure according to the New York Heart Association.*

Class	Symptoms
I	No symptoms and no limitation in ordinary physical activity.
II	Mild symptoms and slight limitation during ordinary activity. Comfortable at rest.
III	Marked limitation in activity due to symptoms, even during less-than-ordinary activity. Comfortable only at rest.
IV	Severe limitations. Experiences symptoms even while at rest.

The most common symptoms of heart failure are breathlessness at rest or on exercise, fatigue, tiredness, and ankle swelling. The common signs of heart failure are tachycardia, tachypnea, pulmonary rales, pleural effusion, raised jugular venous pressure, peripheral edema, and hepatomegaly [12]. The worsening of HF symptoms could lead to a moribund health and a tediously persistent of hospitalization. Therefore, closely treatment from care specialist will help patients to stay healthier and out of hospital.

### 1.2 Treatment of CHF

More than 80% of the CHF patients are treated from the underlying causes with non-pharmacological and pharmacological treatments. A non-pharmacological treatment will monitor changes in the physical signs and heart failure symptoms. For example, sudden weight gain could lead to a fluid retention or body fluid buildup, while sudden weight loss could lead to a reduction in total body fat and lean body mass. The non-pharmacological techniques will only effective only if the patients are on diet, regularly exercise, reducing alcohol intake, and stop smoking. For many worsen cases will require a pharmacological

treatment, which has several drugs involved. The diuretics, angiotensin-converting enzyme (ACE) inhibitors, angiotensin receptor blockers, beta-blockers, aldosterone antagonists, and cardiac glycosides. A care specialist must closely monitor patient physical signs and heart failure symptoms to administrate new drug or changing its dose.

About 10% of CHF patients will require surgical treatment. This includes mitral valve surgery and implantable devices such as pacemakers and defibrillators (ICD). And less than 5 % of CHF patients will require heart transplantation. The heart replacement surgery can increase quality of life greatly. However, it will only apply to the patient at the end stage of CHF due to the risks of procedure like organ rejection and infection. The lack of donor hearts is also a major issue.

## 2. System Description

One of the most noticeable demographic changes among the elderly in Thailand is the increasing access to the telephones. According to the study of Impact of Population Change on Well-being of Elderly in Thailand [13], 2007, we have found that three fourths of the elderly have lived in households with a telephone compare to only 15% in 1994. This increase is due largely to the spread of mobile phones.

As described above, the elderly normally use phones to contact with children who live elsewhere which thus, they have important implications for the social well-being among the elderly in Thailand at this time [13]. The spread of phones has fundamentally supported the ability of older persons to access help in case of health emergencies. This eliminated a major concern for many older persons when they can immediately use phones to communicate with their children about the health conditions and get better coordinate assistance when needed.

In this study, we developed the management system that based-on an intervention of the mobile phone called the EasyCare system to use among them. At the beginning, a prototype of the EasyCare system was developed from the most desirable features among the care specialists to support phone calls, so we decided to deliver the service with IVR. The prototype started from a few features and continuously added a new one once the current version had been reviewed by the care specialists. The design phase of an EasyCare system opened up a chance to remove the features or concepts that were non-beneficial. Therefore, the final features of the EasyCare system are short message service (SMS), website, and interactive voice response (IVR).

## 2.1 System Overview

The overview of the EasyCare system is described in *Figure 2*. The EasyCare system composes of three servers; VoIP server, web server, and database server. The VoIP server is connected with GSM gateway and VoIP Gateway. The CHF patient can access to the EasyCare system from the telephone, mobile phone, or computer at home to report the conditions of heart failure to the clinic. A confirmation message will be sent after patient has finished the activity via SMS and Email. The care specialist can access to the EasyCare system via website to review patient's conditions and give an advice back to patient via SMS and Email.

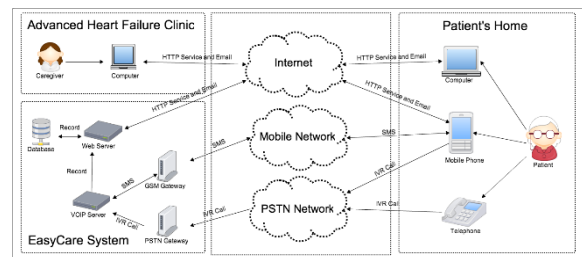


Figure 2. A schematic diagram of the EasyCare system.

## 2.2 System Architecture

The architecture of the EasyCare system composes of three servers; VoIP server, web server, and database server. The VOIP server is connected with GSM gateway and VoIP Gateway as described in *Figure 3*. The system flow is indexed by the number within the parentheses.

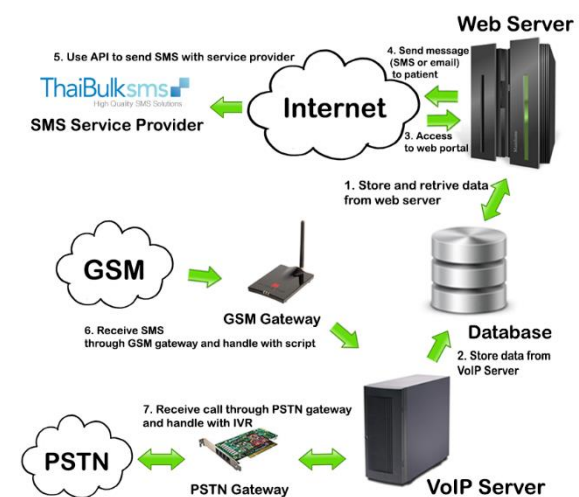


Figure 3. A system architecture of the EasyCare system.

The VoIP and web servers were connected to a single database server. The EasyCare system has two policies for managing the database. The web server has obtained Read/Write policy which will write the data to the database server when patient has submitted the conditions (1), and will read the data to display on the website when nurse has accessed to the patients' information. Unlikely, the VoIP server has obtained only Write policy that will only write the data to the database when patient has submitted the conditions through IVR (2).

The EasyCare system uses the web application server to provide the website for care specialists and CHF patients to access the system via Internet (3). The web server also calls the APIs of the SMS service provider to send the SMS to patients (4) (5).

The VoIP server used two gateways for connecting to two separate networks; GSM gateway for connecting mobile network and PSTN gateway for connecting landline telephone network. The GSM gateway receives SMS form the mobile network and then forwards the content to the Voice over IP (VoIP) network (6). Here, patients can send SMS from their mobile phone to the VoIP system to report their conditions. The PSTN gateway transfers voice calls form mobile networks and landline telephone networks to the IVR system (7). In this case, patients can use a mobile phone or home telephone to report their conditions to the IVR system.

### 3. System Evaluation

Three evaluations; field trial, care specialist interview, and patient interview were begun in February-April of 2013 for answering three objectives. The evaluation for the effective intervention of telephones as a part of the management system for the elderly will conclude from the number of users of the EasyCare system during the field trial. The evaluation for the performance of long term health care services for the elderly with the use of ICT will conclude from patient interviews, nurse interview, and the healthiness of CHF patients. The evaluation for the effective interface between home and clinic from using the EasyCare system will conclude from patient's interval visit and frequent of use of the EasyCare system.

In field trial, thirteen CHF patients were initially chosen among group of NYHA class I and II. The EasyCare system was promoted to the CHF patients once at an initial meeting. The instruction was presented in both oral and giveaway pamphlet. During the presentation, patients were free to ask for questions regarding to technical or functional issues

about the EasyCare system. At the end of the meeting, thirteen patients were ready to use the EasyCare system from their mobile phone.

At the end of the field trial, the healthiness of each patient will be categorized the patients into one of the following groups; worse, stable, or better. If the CHF patient's conditions suit one of the following criteria then he or she can be classified into the group where that criteria belong to, see *Table 2*.

*Table 2. A group for classifying the CHF patients in the field trial.*

Group	Criteria
Worse	<ul style="list-style-type: none"> <li>- Body weight increases more than 2kg over a day</li> <li>- More amount of Lasix consumption</li> <li>- Interval visit less than or equal to 2 weeks</li> </ul>
Stable	<ul style="list-style-type: none"> <li>- Body weight increases more than 2kg over a month</li> <li>- Same amount of Lasix consumption</li> <li>- Interval visit higher than 1 month</li> </ul>
Better	<ul style="list-style-type: none"> <li>- Maintain body weight</li> <li>- Reduce the amount of Lasix consumption</li> <li>- Interval visit higher than 1 month</li> </ul>

### 3.1 Result from Evaluation

Over three months of the field trial, the result showed that eight CHF patients, especially the elderly, had hard time to change their behavior to the telephone approach solution. At the end, the number of users that using the EasyCare system was left to only three out of thirteen patients. This result was resulting from the difficulties from using SMS and IVR. Many elderly could not use the IVR because they owned the bad mobile phone. By letting patients use their own mobile phone, we're facing problems such as the keypad was too small, the IVR voice was hard to hear, the automated process was hard to follow when switching back and forth to listen and answer. The elderly could not use the SMS because the syntax was too complicated. They also complained about the cost from using both SMS and IVR services. From this reason, patients agreed that both IVR and SMS were too difficult to use and handle well in practice. The IVR service should be simpler, take no cost and take less time to complete the task and the SMS service will need more time to learn and understand. Therefore, the effective intervention of telephones as a part of the management system for the elderly was not successfully achieved by the number of users in this preliminary study.

Table 3. A comparison between an average usage of an EasyCare system and the frequency of Lasix's dose adjustment in one month.

Patient	System Usage (times/month)	Dose Adjusted (times/month)
P1	16	11
P2	9	0 (Disused)
P3	19	0 (Disused)

When compares an average usage of the EasyCare system and the frequency of Lasix's dose adjustment in one month from three patients who had been regularly using the website for over three months, Table 3. The result showed that patients had used the EasyCare system regardless to the condition of their health. Patient P1 used the EasyCare system for 16 times in one month, and 11 times were for adjusting Lasix's dose. Patient P2 and Patient P3 have used the EasyCare system for 9 times and 19 times respectively while they have already disused the Lasix consumption. So, the EasyCare system can be used to maintain the present of CHF patients with no additional cost. It can help care specialist to monitor patient's health and increase a chance to detect the early signs and symptoms of heart failure.

The healthiness of three patients was analyzed by the care specialist after the field trial has ended. Three participants were classified in a "better" group because they can maintain the body weight while continuing to reduce the Lasix consumption during the field trial. Patient P1 and Patient P2 had improved the NYHA score to class I (the least severe case). All patients can lengthen their interval visit while using the EasyCare system to maintain self-caring at home, see Table 4. Therefore, the effective interface between home and clinic from using the EasyCare system was successfully achieved by the patient's interval visit.

Table 4. A summary of each patient over three months.

Patient	Period of use	NYHA (class)	Body Weight (kg)	Diuretic Dose (mg)	Interval Visit (per month)	Heart Failure Group
P1	Pre	II	48.4±0.86	300±90	2	stable
	Post	I	47.3±1.16	190±75	4	better
P2	Pre	II	52.3±0.62	20	2	stable
	Post	I	51.7±0.5	Disused	4	better
P3	Pre	I	74.7±0.48	20	3	stable
	Post	I	72.3±0.67	Disused	5	better

The graphs show the summary of body weights and the Lasix consumptions of each patient during the trial period, see Figure 4. The first four months represents the values before patients have used the EasyCare system, following by the after four months

represents the values after patients have used the EasyCare system. In Figure 4, three patients were using the EasyCare system and they can maintain their body weights over three months.

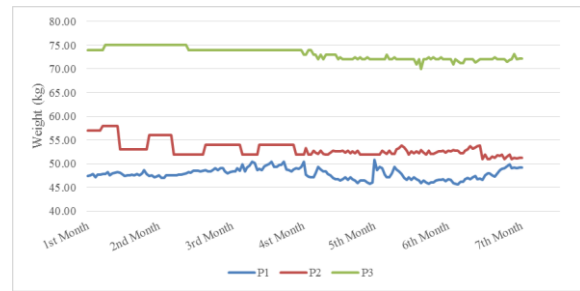


Figure 4. A summary of patients' weights over three months (in kilogram).

In Figure 5, three patients were using the EasyCare system. Patient P1 can reduce the Lasix consumption from 500 mg per day to 100 mg per day and Patient P2 and Patient P3 can reduce the Lasix consumption from 20 mg per day to 0 mg per day over three months.



Figure 5. A summary Lasix consumption of the patients over three months (in milligram).

At the end of the field trial, three patients were classified in a "better" group because they can lengthen their interval visit, maintained the body weight, and reduced the Lasix consumption. Therefore, the performance of long term health care services for the elderly with the use of ICT was successfully achieved by the healthiness of the patients in this preliminary study

### 3.2 Result from Patient Interview

According to the patient interview, the result showed that three patients were satisfied with the EasyCare system. Over three months, patients felt that they were being closer to care specialist. Patient P1 and Patient P3 gained more confident living with the disease. Patient P1 can reduce her treatment costs from using the website instead of regular phone call. Patient P2 took less time to complete a task and received a faster response from the care specialist.

The EasyCare system became a part of their living and they were willing to continue using the EasyCare system in the future. Therefore, the performance of long term health care services for the elderly with the use of ICT was successfully achieved by the patient interviews in this preliminary study.

### 3.2 Result from Care Specialist Interview

The result from the care specialist interview showed that she was very satisfied with the EasyCare system especially for the website. The nurse acknowledged that general idea of the web solution is noticeably easy to understand and easy to use among patients. The cost of web technology is also lesser than others. Over three months, she observed that the EasyCare system helped CHF to improve an ability to conduct self-caring at home, and helped care specialist to monitor patient's health and increase a chance to detect the early signs and symptoms of heart failure. So, care specialist believed that the internet-based management system and smartphone applications have the most potential to become the health care solution for CHF patients in the future. Therefore, the performance of long term health care services for the elderly with the use of ICT was successfully achieved by the care specialist interview in this preliminary study.

In care specialist interview, the care specialist has commented about the choices of measurement. The EasyCare system should be integrated with the social network such network such as LINE, Facebook, or WhatsApp. Therefore, the EasyCare system needs an improvement in the care specialist's perspective.

## 4. Conclusion

This study showed the evidence that the EasyCare system can be used to keeping the elderly cohort healthy. We have found the benefits from using the management system in heart failure clinic which are the community driven towards active and healthy life style, gain confident living with the chronic conditions, maintain patient's health, and help care specialist to monitor patient's health and increase a chance to detect the early signs and symptoms of heart failure. Therefore, the EasyCare system showed the possibility to become the systematic long term care services for the elderly in this preliminary study.

We observed that CHF patients and adult children are using both legacy phones and smartphone applications to contact with care specialists at the clinic. So, we suggested that an effective intervention of telephones as a part of the management system for the elderly may also be achieved by advances in communications technology such as smartphones and

home computers if the adequate supports were provided. Even though this methodology may seem to be impractical for Thailand due to cost and degree of sophistication to implement them, but it will change in the future as cost goes down and income and educational increase.

The trend of ongoing considerable progress in health care is being made on development of assistive technology to help adults monitor self's situation at home. According to the preliminary study of the EasyCare system, the CHF patients can lengthen their interval visit and continuously use the EasyCare system even they have good health. Therefore, the EasyCare system can provide the effective interface between home and clinic in this preliminary study.

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