

# Delivering Chronic Heart Failure Telemanagement via Multiple Interactive Platforms

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## Abstract

Existing telemonitoring systems provide limited support in implementing personalized treatment plans. We developed a Home Automated Telemanagement (HAT) system for patients with congestive heart failure (CHF) to provide support in following individualized treatment plans as well as to monitor symptoms, weight changes, and quality of life, while educating the patient on their disease. The system was developed for both a laptop computer and a Nintendo Wii. The system is designed to be placed in the patient's home and to communicate all patient data to a central server implementing real-time clinical decision support. The system questions the patient daily on their condition, monitors their weight, and provides the patient with instant feedback on their condition in the form of a 3-zone CHF action plan. Their medication regimen and suggested actions are determined by their care management team and integrated into the system, keeping a personalized approach to disease management while taking advantage of the technology available. The systems are designed to be as simple as possible, making it usable by patients with no prior computer or videogame experience. A feasibility assessment in African American patients with CHF and without prior computer or videogame experience demonstrated high level of acceptance of the CHF HAT laptop and Wii systems.

**Keywords:** *telemedicine, congestive heart failure, self-management*

## Introduction

Congestive heart failure (CHF) is a major public health problem which affects over 5 million Americans and costs \$33.2 billion annually [1]. CHF morbidity is reaching epidemic proportions

and African Americans are disproportionately affected [1-3]. Repeated emergency room visits and rehospitalizations for symptom relief contribute to CHF being the most costly cardiovascular illness in the US [1, 4-5]. Common reasons for CHF rehospitalization include delays in symptom recognition, medication and dietary noncompliance, and lack of knowledge and skills for competent self management [6-8].

Telemedicine approaches will be useful in patients with CHF for several reasons. First, telemedicine will improve disease monitoring through more frequent assessment of symptoms. Second, use of patient self-management plans will accelerate treatment in the setting of CHF symptoms and thus decrease the utilization of health care resources [8]. Home Automated Telemanagement (HAT) is a telemedicine system designed to assist health care practitioners treat patients according to current clinical guidelines, to assist clinicians in educating patients, to assist providers in monitoring patients, and to assist patients in following individualized self-care plans [9-14].

Gaming platforms gain significant acceptance in different population sub-groups including elderly [16, 17]. However, the feasibility of such gaming platforms as Wii for chronic disease management has not been explored systematically.

The Nintendo Wii is a popular videogame console which uses a motion sensitive controller. Adobe Flash allows content to be created and viewed on the Wii console through the Wii Internet Channel. The simplified controls, popularity, and internet connectivity make the Wii a promising platform for the development of CHF telemanagement systems.

The CHF HAT Wii home unit was created for the Adobe Flash platform to be able to be accessed using the Nintendo Wii videogame console. We attempted to take advantage of the simplicity, popularity, and low cost of the Nintendo Wii to deliver a comprehensive telemanagement system capable of being placed in a patient's home.

The CHF HAT laptop home unit was designed to run on Windows XP laptops. The low system requirements of the application and the ability to connect it to a digital scale allows for an inexpensive and simple telemanagement solution.

Our aim was to design a low cost telemanagement system on a laptop computer and the Nintendo Wii for CHF patients and to perform an initial assessment of patient acceptance of such a system.

### **System Design**

The HAT system is based on Wagner's model of chronic disease care [15] and supports patient self-management, comprehensive patient-provider communication, and multidisciplinary care coordination. The CHF HAT system comprises a home unit (laptop or Wii), a decision support server and a web-based clinician portal. The HAT home unit consists of a notebook computer or a Nintendo Wii videogame console and an electronic weight scale. CHF patients answer questions regarding symptoms, side effects, adherence, and receive disease-specific education using the home unit. The home unit automatically transmits the results to the decision support server after each self-testing session. Data transmitted from patient's home are de-identified and encrypted. For the laptop home unit, the data transmission can be carried out via Internet or direct modem-to-modem communication. For subjects without an active phone line, a cell phone is provided to transmit self-testing results over a secure wireless network to the server in a similar manner. The Wii home unit transmits the information securely over the internet.

The web portal provides an interface for the collected patient data for both platforms. The web-based care management portal is used to set up customized clinical alerts and individualized action plans based on patient disease severity and

other individual factors. The care management team individualizes alerts and action plans for each patient on-line whenever warranted. The updated action plans are automatically transmitted to patient home units. If certain clinical conditions are met, email alerts are sent to the nurse coordinator. The coordinator reviews the information and if necessary consults the medical provider and the patient for management changes.

The HAT server runs Internet Information Services (IIS) which collects the patient's data and integrates it into a website which can be accessed by the patient's primary care management team. The web page was developed using Microsoft's .NET framework. This is a framework for developing dynamic websites which offers extensive built-in functionality and is supported by most browsers.

The CHF HAT laptop home unit was developed in Visual Basic 6.0 and runs on Microsoft Windows XP. The laptop home unit uses an active phone line or internet connection to send and receive data from the server.

The CHF HAT Wii home unit application was developed using Adobe CS3 with Flash 7.0 and runs on the Wii Internet Channel. Using the Wii Internet Channel with an active internet connection allows the user to access Adobe Flash 7.0 content through the internet. The system uses the Wii Remote for input and allows a patient to run a self-test which asks the patient a series of symptom questions, records their weight, sends the information to the server, informs and tests their CHF knowledge, then gives the patient instant feedback on their current condition based upon their symptoms and weight measurement.

### **Results**

The CHF HAT laptop home unit was successfully designed and implemented on an IBM T30 notebook computer running Windows 2000/XP connected to a Lifesource 321P digital scale through the serial port. Information was successfully sent and received from a remote location to the IIS server using an active landline and cell phone connection. The web portal was successfully launched and provides full functionality. The home unit runs the HAT program when it starts up and the user can navigate through the menu using the labeled arrow keys and the enter button. The text is

large and easy to read while all the instructions are kept as simple as possible.

The Wii HAT home unit was successfully designed and implemented on the Nintendo Wii videogame console a Lifesource CHF-321P digital scale was used for weight measurement.

The Nintendo Wii home unit allows the user to connect through the Wii Internet Channel to the site with the Adobe Flash application. The application can be navigated using the Wii Remote to select options and move between screens.

The home unit options are broken into six sections. The first section is self-testing. In this section the patient will begin with a self-testing portion where they answer a series of questions pertaining to their chronic condition. A symptom diary question screen is show in Figure 1.

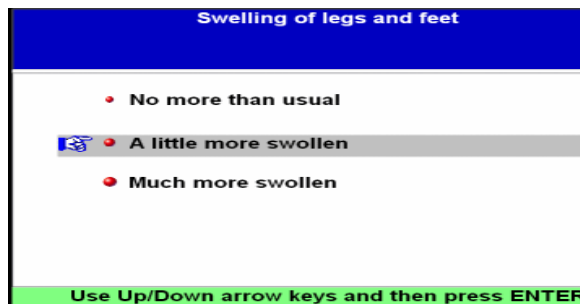


Figure 1. Symptom diary question

The responses are used to gauge the overall health of the patient, as well as to raise flags when the patient may be experiencing congestive heart failure symptoms that require immediate attention and treatment. After answering general symptom questions the patient is prompted by voice and text to correctly mount a weight scale. On the laptop home unit, the weight is automatically collected by the computer from the attached digital scale. On the Wii home unit, the patient uses a digital scale to weigh themselves, then enters the data through an on-screen interface. The scale instructions for the laptop home unit are shown in Figure 2.

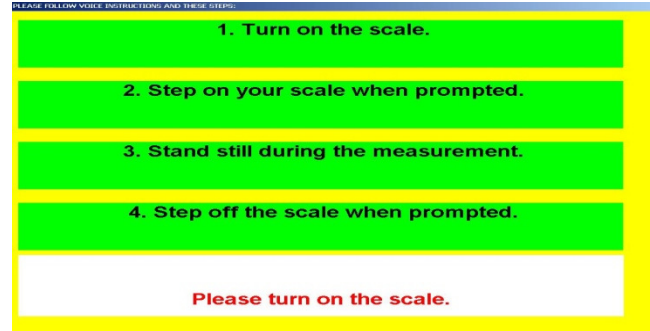


Figure 2. Weight scale instructions

The current patient's action zone is then immediately calculated and displayed. A screen displays weight and an absolute weight change from the previous day. The zone of the action plan is determined using the information provided earlier in the self-test. A sample action plan is seen in Figure 3.



Figure 3. Sample "Yellow Zone" action plan

After completion of the self-testing portion the patient is given an educational "Tip of the day." Each successive educational portion will end with a question about the previous day's tip. The question will be repeated each session until the patient is able to answer correctly. Then a new question is offered during the next self-testing session. At the end of an educational section, the patient will be asked several questions from the specific section. Upon completion of the educational portion, the symptom diary responses as well as the results of weight monitoring are stored for transmission. The system connects to the server using an active landline or wireless connection and relays all stored results/messages. This is shown on the laptop home unit in Figure 4. After transmission

the main menu is displayed.

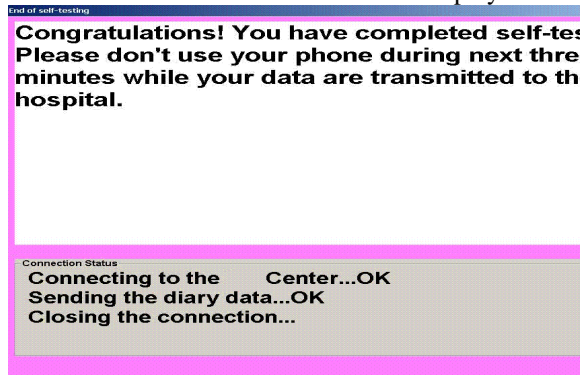


Figure 4. Data transmission screen

The HAT system also allows the patient to access their Action Plan. The patient can view their current action plan and their other plans for different zones. They can also view a graph of their recorded weights or action plan zones and the medications currently prescribed to them. The patient can also send either a personal or pre-written message to the care management team.

The CHF HAT website is hosted on our servers and can be accessed securely by the care management team using any computer with a web browser and an internet connection. The care management team can also view a monthly report which displays graphs and statistics of the patient's information collected over the past month. A section of a sample report is seen in Figure 5.



Figure 5. Sample monthly report data

The website also shows any current alerts for the patient and allows the care management team to log their response to the alert as shown in Figure 6.

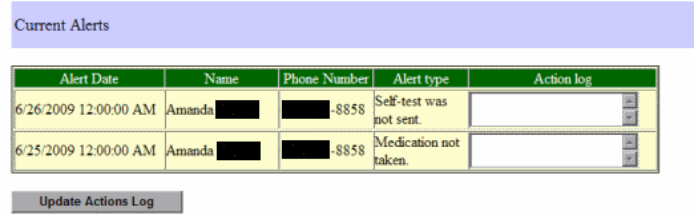


Figure 6. Current Alerts

The care manager can change their alert parameters for the patient, send a message to a patient, or view a list of the messages sent from the home unit to the server as seen in Figure 7.



Figure 7. Messages from the patient

### Pilot study

Pilot studies of both systems were conducted with ten African American CHF patients. Patients were given a demonstration of either the laptop or Wii home unit and then asked to perform a self-test by themselves.

After successfully using the laptop home unit, patients were asked to complete demographics, attitudinal survey and qualitative interview. Average age of patients was 56 years, and they completed an average of 13 years of education. 60% of subjects were females, and 100% were African Americans. About 50% reported that they had moderate heart failure symptoms, and 50% answered that their heart failure had been about the same during the last 12 months. 60% and 70% never used the computer and internet respectively, and 30% reported that they never used ATM machine.

After successfully using the Wii home unit, patient response overall has been positive. Patients commented, "I like the way it feels," "...the Wii makes it more interesting," and "Making me use a device that may be more fun in a way could make me pay attention more." 60% (6) of the patients had no prior computer use while 40% (4) used a computer once a month or less. 90% (9) of patients stated that the answering the symptom diary questions was "Not difficult at all," while 10% (1) reported that it was "Slightly difficult." Overall we have

concluded that the interface is sufficient for people with no history of computer or videogame use.

All patients were able to complete the self-testing procedure by themselves with little or no difficulty. 100% of subjects responded that they didn't have any difficulty working with the computer and answering the symptom diary questions. Also patients reported that length of self-testing was appropriate that it would not interfere with their usual activities. All the patients we have interviewed did not consider themselves computer literate and did not own a computer. Patients responded favorably to the educational portion of the self-test, indicating a desire to learn more about their condition. The content and interface also received positive feedback in patient responses. Patients commented that they believed the CHF HAT system would help them better manage their congestive heart failure and reduce their amount of hospital visits. 70% (7) of patients preferred the Wii version to the laptop version, commenting that "...the Wii makes it more interesting," and "Once you get used to it this one is easier to use."

### Discussion

The CHF HAT system's ease of use and convenience can provide reluctant patients with an easy way for care management teams to receive daily feedback from the patient. While care management team visits would still be important to the patient's care, allowing the patient to monitor their health frequently and educating them on their condition will hopefully increase their condition awareness, self management, and quality of life. The CHF HAT system can successfully provide support to patients in following their CHF action plans and to aid them in being adherent to their treatment regimens. Providing the system on different platforms can help to reach as many patients as possible. We are also looking toward expanding the HAT system to other computer platforms. Mobile computing is becoming smaller, faster, and cheaper, creating more potential environments for the HAT disease management system. Systems such as the Apple iPhone, iPod Touch, Blackberry, and mobile phones are becoming viable options for the CHF HAT platform.

The system can be adapted for other chronic diseases such as hypertension [18], asthma [19], chronic obstructive pulmonary disease [20], ulcerative colitis [21], multiple sclerosis [22] where the same principles can be applied to aid in patient care and adherence to treatment regimens [23]. The telemanagement platforms could be integrated into cyberinfrastructure to facilitate patient-centered chronic disease prevention and management [24].

### Conclusion

The CHF HAT laptop and Wii systems are viable systems to test in the management of CHF patients. These systems can be efficiently implemented for CHF, as well as other conditions, and is recommended for future use and expansion. A comprehensive evaluation using a clinical trial design is warranted for the CHF HAT systems.

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