

Implementing Home Telemanagement of Congestive Heart Failure Using Xbox Gaming Platform

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Abstract — Gaming platforms have been recognized for user-friendly interface which does not require previous computer-related experience. Easy to use and wide availability of these platforms at patient households make them an attractive means to facilitate consumer health. The potential of such widely used platforms as Xbox for self-management of chronic health conditions has not yet been fully uncovered. We developed a Home Automated Telemanagement (HAT) system which utilizes Xbox to access personal health record, receive self-care support and exchange information with health care providers. The system questions patients with congestive heart failure (CHF) to monitor symptoms, weight changes, medication adherence and quality of life while educating the patient on their disease. The patients receive an instant feedback on their condition in the form of a 3-zone CHF action plan. The patient self-management information can be reviewed by a provider on a designated web site. The system is programmed to run on the Microsoft Xbox videogame console using an active internet connection and a connection to a computer running Windows Media Center. The system is designed to be as simple as possible making it usable by patients with no prior computer or videogame experience. The feasibility of this approach was tested in ten adults with no previous Xbox experience who completed attitudinal surveys and semi-structured qualitative interviews after using the system. All participants claimed that they did not have any problems in using the system and that they would use the system in the future if necessary. An Xbox-based telemanagement system has potential to optimize the care of patients with CHF and other chronic conditions.

I. INTRODUCTION

Congestive heart failure (CHF) is a major public health problem which affects over 5 million Americans and costs \$33.2 billion annually [1]. Repeated emergency room visits and rehospitalizations for symptom relief contribute to HF being the most costly cardiovascular illness in the US [1-3]. Common reasons for hospital readmission in patients with CHF include delays in symptom recognition, medication and dietary noncompliance, and lack of knowledge and skills for competent self management [4-6].

Home-based computer and telecommunication technologies supporting patient self-management have long been recognized to have enormous potential in improving quality of chronic care delivery [7]. 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].

The Xbox 360 is a popular videogame console. Connecting the console to a computer with Windows Media Center allows you to run a web browser through the console and navigate web pages. The simple controls, popularity, and internet connectivity make the Xbox 360 a promising platform for the development of telemanagement systems in patients with CHF and other chronic conditions..

Gaming platforms are widely used by individuals from different age groups. Seniors and individuals with limited computer skills have been shown to be able successfully use and enjoy various gaming platforms [9]. Previously, we demonstrated high acceptance of a Wii-based telecare platform for CHF telemanagement by seniors [10]. However, the potential of utilizing various gaming platforms including Xbox to enhance self-management of chronic health conditions has not yet been fully uncovered. The goal of this project was to explore whether it is possible to take advantage of the simplicity, popularity, and low cost of the Xbox 360 and to build a platform able to deliver a comprehensive disease management program directly to patient's home via this widespread gaming platform.

II. SYSTEM DESIGN

The conceptual design of the Home Automated Telemanagement (HAT) system is based on the principles of patient-centered care delivery model [11]. The HAT system supports the major components of this model including patient self-care, tailored education and counseling, individualized treatment plan, guideline-concordant decision support, comprehensive patient provider communication, and multidisciplinary care coordination [12]. Using this model, the HAT system has been successfully implemented and tested in various health conditions [13-17]. The HAT system consists of home unit, HAT server and clinician unit [18]. The previous applications utilized laptops, PDA, IVR, and cell phones for patient home units [19-22].

In this project the HAT home unit has been implemented using Xbox 360 gaming platform. A software application was developed using ASP.NET with Visual Basic .NET that is executed on a server running Windows 2003 Server. A connection to the Windows Media Center unit with the MCEBrowser 2.2 plug-in and an active internet connection allowed users access web content through the Xbox 360

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system. The HAT home unit uses the Xbox360 controller for input and allows a patient to complete a disease diary 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. The patient results are stored on the remote server and can be viewed by the physician using the CHF HAT provider website. The HAT server implements clinical decision support algorithms which allow alert provider if any ominous trend is detected in a timely fashion. Provider can contact patients when there is evidence that their disease is not controlled optimally thus averting potential hospitalization or emergency room visit.

The system is designed so that each patient has an “Action Plan” approved by their physician. The action plan defines what a patient’s actions should be based upon their self-test data. Prior to beginning home unit use, the patient has an action plan approved by their physician. The action plan accounts for the possible cases of good, fair, and poor health; respectively corresponding to a green, yellow, and red ‘zone’. The patient responses from the self testing portion and weight measurement are used as a gauge for determining the action plan zone in which the patient currently belongs. At any time the patient may view their current zone or review the other zones through the home unit website.

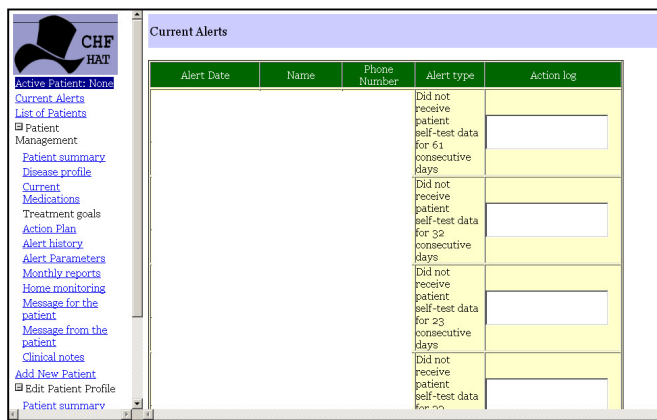


Fig. 1. CHF HAT Provider Website

The patient’s physician can access the CHF HAT website to review patient data, track progress, make changes to medications, and set alerts. Alerts can be set for the patient so that if the parameters are not met an email will be sent to the physician, notifying them which alert was triggered. Alert parameters include symptom diary score, self-testing compliance, entering a certain zone, and weight changes. The site is shown in Fig. 1.

The system also aids in medication adherence. The application displays a list of current medications with their dosages and frequencies. The computerized decision support

algorithms on the HAT server allow alert generation to inform providers about medication non-adherence or other clinically significant events.

The CHF HAT system features a progress chart which displays a graph of the patient’s weight measurements or action plan zones on the most recent self-tests.

There is a Frequently Asked Questions section on the laptop system for quick access to CHF information. Comprehensive questions about CHF and answers are available, providing an easy to use source of general information the patient may access at any time.

III. RESULTS

The HAT system was successfully designed and implemented on the Xbox 360 videogame console. A Lifesource CHF-321P digital scale was used for weight measurement. The main menu is shown in Fig. 2.

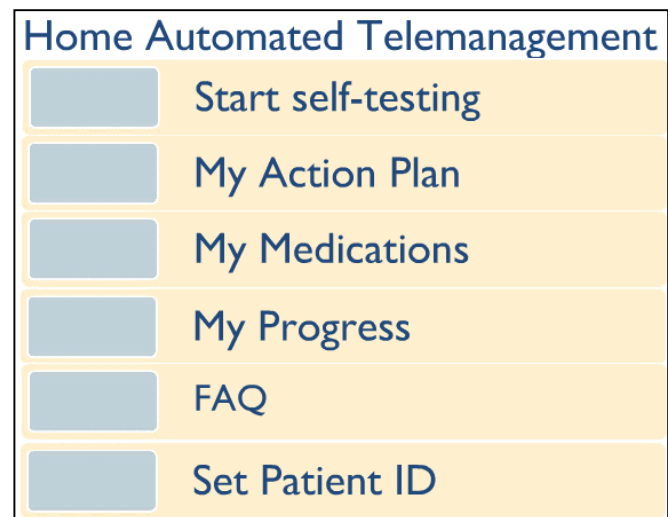


Fig. 2. Xbox HAT Home Unit: Main Menu

The Xbox360 system allows the user to connect through a computer running Windows Media Center to the site with the ASP.NET webpage. The application can be navigated using the Xbox 360 controller to select options and move between screens. The text is large and easy to read while all the instructions are kept as simple as possible.

The patient uses the controller to complete the daily self-testing portion of the program. When the “Start self-testing” option is selected the patient is asked a series of multiple choice questions about their symptoms that day (symptom diary). A sample symptom diary question is shown in Fig. 3.

Shortness of breath

- No more than usual
- More short of breath when active
- Shortness of breath that doesn't go away

Next

Fig. 3. Xbox HAT Home Unit: CHF Symptom Diary Question

After the symptom diary is completed the patient is shown a series of instructions for using the weight scale. The instructions are shown in Fig. 4.

- * Weigh yourself at the same time, on the same scale, and in the same way every day.
- * You should wear the same or similar clothing and take off your shoes when you use the scale.
- * Try to get on the scale the first thing in the morning after you urinate, but before you eat breakfast and have a bowel movement.
- * If you change the routine for weighing yourself, your weight may change by two or more pounds.

Fig. 4. Xbox HAT Home Unit: Weight Scale Instruction

After the instructions are shown and the patient weighs themselves, they are taken to an input screen where they can input their weight using the onscreen keyboard.

Once their weight is input, the HAT system calculates their action plan zone and displays the appropriate actions to the patient. A sample action plan green zone is shown in Fig. 5.

Next

greenzone ACTIONS

Here's how to stay in this zone:

1. Keep all your medical appointments
2. Follow a low-salt diet
3. Weight yourself each day
4. Keep taking your medications as prescribed

Fig. 5. Xbox HAT Home Unit: CHF Action Plan Green Zone

Then the patient begins the educational portion of the program. They are first asked a multiple choice question about the educational tip they received on the previous day as seen in Fig. 6.

In the blood pressure reading "120/80", which number represents systolic pressure?

- 120 is systolic pressure
- 80 is systolic pressure
- Both answers are wrong

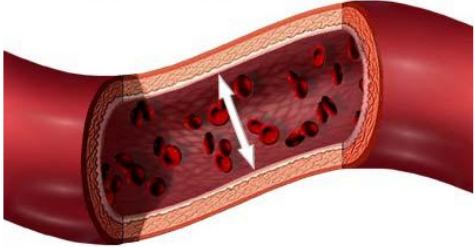
Next

Fig. 6. CHF Educational Question

If the question is answered correctly the patient is then shown the next tip in the section while the tip is also read aloud. If the question is answered incorrectly, the tip is repeated and the question is repeated the following day. A sample tip is seen in Fig. 7. Once all tips for a section have been answered correctly the patient is given a quiz where they must answer all section questions without receiving the educational tips. If all questions are answered correctly, they move on to the next section, otherwise they must repeat the section until the quiz is passed.

Blood pressure is the force of blood pushing against the walls of the blood vessels.

Blood pressure is the measurement of force applied to artery walls



Next

Fig. 7. Xbox HAT Home Unit: CHF Educational Message

IV. EVALUATION

A pilot study of the system with 10 subjects without prior experience in using gaming consoles has been conducted (60% females, average age 43±11). The study subjects were given a demonstration of the CHF HAT system and then were asked to perform a self-testing using the system by themselves while commenting aloud on anything that came to mind. After completion of self-testing, all subjects filled in attitudinal surveys and underwent semi-structured qualitative interviews about their experience with using Xbox for self-care and suggestions for improvement. The subject responses were transcribed and analyzed using qualitative research software (NVIVO 8).

TABLE I
RESULTS FROM THE ATTITUDINAL SURVEY

N=10 Questions	Score, %			
	1	2	3	4
1. How complicated was the self-testing process?				
Very complicated	0.0			
Moderately complicated		0.0		
Slightly complicated			40.0	
Not complicated at all				60.0
2. How difficult was it to use the weight scale?				
Very difficult	0.0			
Moderately difficult		10.0		
Slightly difficult			20.0	
Not difficult at all				70.0
3. How difficult was working with the CHF XBOX 360?				
Very difficult	0.0			
Moderately difficult		0.0		
Slightly difficult			50.0	
Not difficult at all				50.0
4. How difficult was answering the symptom diary?				
Very difficult	0.0			
Moderately difficult		0.0		
Slightly difficult			10.0	
Not difficult at all				90.0
5. Did you get all the necessary information about self-testing during the first introductory meeting?				
All information	80.0			
Almost all information		20.0		
Partial information			0.0	
Very limited information				0.0
6. How much of your time did the self-testing take?				
Very significant amount	0.0			
Considerable		0.0		
Little			30.0	
Very Little				70.0
7. Would the self-testing				

interfere with your usual activities?				
No	50.0			
Very Little		20.0		
Little			10.0	
A great deal				20.0
8. How often do you think you could commit to completing this self-testing?				
Once a day	60.0			
A few times a week		30.0		
Once a week			0.0	
A few times a month				10.0
9. Would you feel safer while monitored by the system?				
Significantly safer	40.0			
Moderately safer		10.0		
Slightly safer			30.0	
Same as usual				20.0
10. How important for you is it to know that that the results of your self-testing can be reviewed by the study staff immediately after the test?				
Extremely Important	40.0			
Very Important		60.0		
Uncertain			0.0	
Not Important at all				0.0
11. How often would you review the test results?				
Once a week	90.0			
Once a month		0.0		
Occasionally			10.0	
Never				0.0
12. Would you like to use this self-testing program in the future?				
Certainly Yes	80.0			
Maybe		20.0		
Unlikely			0.0	
No				0.0

Qualitative data analysis showed that response to the system overall was enthusiastic. All study subjects were able to complete self-testing including disease diary, weight reporting, and health education components. The Xbox users commented, "The text is big enough. It is easy to read," "Controls were simple," and "It is helpful to record your symptoms." They also commented, "I don't like it when it doesn't fit the screen and I have to scroll" and "I don't like the controller stick." Regarding the usefulness of the proposed approach one of subjects commented, "I think it'd be useful for realizing how I feel today. [It] asked very relevant questions for my illness". Other subjects acknowledged the comprehensive nature of the intervention, "I think it covers almost anything," and expressed confidence in the utility of such intervention for their daily self-management. Overall, we have concluded that the interface is sufficient for people with no history of computer

or videogame use. Further interface improvements may enhance user experience.

The results from the attitudinal survey (Table 1) correlated with information from the qualitative interviews. All study subjects claimed that the self-testing process was not complicated and it was easy using Xbox for disease self-management. The majority of respondents (70%) felt that the self-testing process would not interfere with their usual activities and that they would be able to use the system at least few times a week (90%). The study subjects expressed interest in potential use of the system in the future (100%). All study subjects felt that it is important that their self-testing information can be reviewed by their provider.

V. DISCUSSION

A comprehensive disease management platform for patients with CHF was implemented on the basis of Xbox gaming platform. Individuals with no previous Xbox experience were able to successfully complete self-testing using this platform. They expressed interest in using such a platform for self-management in the future and felt that the Xbox-based telecare program may potentially improve their medical care.

The Xbox 360 system's ease of use and convenience can provide reluctant patients with an easy way for physicians to receive daily feedback from the patient. While physician 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 and quality of life.

The aim of this paper was to introduce a technical solution of converting such a ubiquitous gaming platform as Xbox into a full-scale chronic disease management system as well as to provide preliminary data on potential acceptance of such a system by individuals with no previous Xbox experience. For further analysis, more elaborate usability studies involving comparisons across different platforms may be warranted. Investigation of clinical impact and cost-effectiveness of the proposed approach may require randomized clinical trial design.

Current technical solution is aimed at supporting patient self-report and interactive on-line communication however it does not provide for automated collection of physiological measurements from various sensors and webcam-based video communications. New features of Xbox SDK and introduction of Wi-Fi capable disease-specific sensors may help to address these issues in the future.

In the future we would like to take advantage of the Microsoft Kinect motion detection system for the Xbox 360 to allow the program to recognize gestures and movement for navigation. This functionality can further simplify user interface as well as enhance current solutions for telerehabilitation and exercise support.

The proposed system can be adapted for other chronic diseases such as chronic obstructive pulmonary disease [23],

asthma [24], ulcerative colitis [25], hypertension [26], Crohn's disease [27], and multiple sclerosis [28] where the same principles have been applied to aid in patient care and adherence to treatment regimens.

VI. CONCLUSION

The CHF HAT system utilizing Xbox gaming console as a home telecare unit is a viable platform to test in the management of CHF patients. This system can be efficiently implemented for CHF, as well as other conditions, and is recommended for future use and expansion. A formal clinical evaluation of the system with sufficient number of patients, appropriate clinical trial design, and sufficient time for patient follow-up is warranted.

References

- [1] American Heart Association. Heart disease and stroke statistics: 2007 update. Dallas, Texas: American Heart Association; 2007.
- [2] O'Connell JB. The economic burden of heart failure. *Clin Cardiol* 2000;23(3S):III6-III10.
- [3] Massie BM, Shah NB. Evolving trends in the epidemiologic factors of heart failure: rationale for preventive strategies and comprehensive disease management. *American Heart Journal* 1997;133:703-12.
- [4] Babayan ZV, McNamara RL, Nagajothi N et al. Predictors of cause-specific hospital readmission in patients with heart failure. *Clinical Cardiology* 2003;26:411-8.
- [5] McAlister FA, Stewart S, Ferrua S, McMurray JJJV. Multidisciplinary strategies for the management of heart failure patients at high risk for admission. *Journal of the American College of Cardiology* 2004 August 18;44(4):810-9.
- [6] Grady KL, Dracup K, Kennedy G et al. Team management of patients with heart failure. *Circulation* 2000;102:2443-56.
- [7] Finkelstein J, Friedman RH. Potential role of telecommunication technologies in the management of chronic health conditions. *Dis Manage Health Outcomes* 2000;8(2):57-63.
- [8] Finkelstein J, Cha E, Dennison CR. Exploring Feasibility of Home Telemanagement in African Americans with Congestive Heart Failure. *Stud Health Technol Inform.* 2010;160(Pt 1):535-9.
- [9] Rosenberg D, Depp CA, Vahia IV, Reichstadt J, Palmer BW, Kerr J, Norman G, Jeste DV. Exergames for subsyndromal depression in older adults: a pilot study of a novel intervention. *Am J Geriatr Psychiatry.* 2010;18(3):221-6.
- [10] Finkelstein J, Wood J, Cha E, Orlov A, Dennison C. Feasibility of congestive heart failure telemanagement using a Wii-based telecare platform. *Conf Proc IEEE Eng Med Biol Soc.* 2010;2010:2211-4.
- [11] Finkelstein J, Barr MS, Kothari PP, Nace DK, Quinn M. Patient-centered medical home cyberinfrastructure: current and future landscape. *Am J Prev Med.* 2011;40(5 Suppl 2):S225-33.
- [12] Finkelstein J, Cha E. Hypertension telemanagement in blacks. *Circ Cardiovasc Qual Outcomes.* 2009;2(3):272-8.
- [13] Finkelstein J, Hripesak G, Cabrera M. Telematic system for monitoring of asthma severity in patients' homes. *Stud Health Technol Inform.* 1998;52 Pt 1:272-6.
- [14] Finkelstein J, Khare R, Ansell J. Feasibility and patients' acceptance of Home Automated Telemanagement of oral anticoagulation therapy. *AMIA Annu Symp Proc.* 2003:230-4.
- [15] Cross R, Cheevers N, Finkelstein J. Home Telemanagement for Patients with Ulcerative Colitis (UC HAT). *Digestive Diseases and Sciences* 2009;54(11):2463-72.
- [16] Finkelstein J, Wood J. Design and implementation of Home Automated Telemanagement system for patients with multiple sclerosis. *Conf Proc IEEE Eng Med Biol Soc.* 2009;2009:6091-4.

- [17] Cross RK, Arora M, Finkelstein J. Acceptance of telemanagement is high in patients with Inflammatory Bowel Disorder. *Journal of Clinical Gastroenterology* 2006;40:200-8.
- [18] Finkelstein J, Khare R, Vora D. Home Automated Telemanagement (HAT) system to facilitate self-care of patients with chronic diseases. *Journal of Systemics, Cybernetics and Informatics* 2003;1(3):78-82.
- [19] Farzanfar R, Finkelstein J, Friedman RH. Testing the usability of two automated home-based patient management systems. *J Medical Systems* 2004; 28(2): 143-153.
- [20] Samal L, Hutton HE, Erbeling EJ, Brandon ES, Finkelstein J, Chander G. Digital divide: variation in internet and cellular phone use among women attending an urban sexually transmitted infections clinic. *J Urban Health*. 2010;87(1):122-8.
- [21] Wood J, Yablochnikov I, Finkelstein J. Interactive asthma learning system utilizing a mobile phone platform. *AMIA Annu Symp Proc*. 2008 Nov 6:1181.
- [22] Skinner C, Finkelstein J. Using cell phones for chronic disease prevention and management. *AMIA Annu Symp Proc*. 2008 Nov 6:1137.
- [23] Finkelstein J, Khare R, Vora D, Arora M. Design and implementation of home automated telemanagement in chronic obstructive pulmonary disease. *Proceedings of the 16th IEEE Symposium Computer-Based Medical Systems (CBMS 2003)*, 2003:207 – 212.
- [24] Finkelstein J, Friedman RH. Telemedicine system to support asthma self-management. *Proc. of the 2000 IEEE EMBS International Conference on Information Technology Applications in Biomedicine (ITAB 2000)*, 2000:164 – 167.
- [25] Cross RK, Finkelstein J. Challenges in the design of a Home Telemanagement trial for patients with ulcerative colitis. *Clin Trials*. 2009;6(6):649-57.
- [26] Finkelstein J, Joshi A, Aurora, M. Home automated telemanagement in hypertension. *Proc. of the 17th IEEE Symposium on Computer-Based Medical Systems (CBMS 2004)*, 2004:452 – 459.
- [27] Cross RK, Finkelstein J. Feasibility and acceptance of a home telemanagement system in patients with inflammatory bowel disease: a 6-month pilot study. *Dig Dis Sci*. 2007;52(2):357-64.
- [28] Finkelstein J, Lapshin O, Castro H, Cha E, Provance PG. Home-Based Physical Telerehabilitation in Patients with Multiple Sclerosis: A Pilot Study. *Journal of Rehabilitation Research and Development* 2008;45(9):1361-1374.