Sustainable Case Study on Remote Patient Monitoring Device BL Healthcare Access Tablet
Remote patient monitoring, as one of the telehealth care modes, is a home-based monitoring and support for helping patients with chronic conditions (Chiang, Chen et al. 2012) and for engaging older adults in self-care (Gellis, Kenaley et al. 2012). It has been proven to reduce costs, improve life-quality, reduce number of hospital visits, and improve the relationship between the patients and healthcare providers (Herbert and Medd 2012). Users are looking for devices that will connect them more readily with health-care providers (Fraser, Kwon et al. 2011). According to the United Nations, the elderly population of the world is growing at a very fast rate. It is expected that by 2050, there will be more than 2 billion people aged 60 or over (2012). About 80% of the older adults have one chronic condition, and 50% of them have two or more chronic conditions (Lee, Helal et al. 2012). The remote patient monitoring market yearly growth rate is expected to increase nearly 22% from 2012 to 2014 (Moorman 2012). Medical devices account for an enormous amount of the solid, industrial, and chemical waste in developed countries. Thus, sustainable design, a concept in which devices are evaluated in terms of financial, social, and environmental impact, could have a great benefit for medical-device industry (Kadamus 2008). Proactive design for sustainability at the concept level reduces waste, packaging, and shipping costs (Hede, Nunes et al. 2011). It also improves manufacturing efficiency and use of raw materials. The way to improve sustainability of medical devices is design of a product lifecycle, not just a product. The purpose of this project is to improve the user experience of the Healthcare Access Tablet, BL Healthcare, by improving the user interface, with a focus on sustainability as a major driver. The significance of this project is the proposal of recommendations for improving the sustainable impacts of the remote patient monitoring devices.
Literature Review

According to the United Nations, world’s elderly population is growing at its fastest rate ever. By 2050, there will be more than 2 billion people aged 60 or over (2012).

An Aging Population (2012)

Telehealth is a broad term of remote healthcare used to describe the use of electronic communications to deliver clinical services and other types of health information, according to the American Telemedicine Association (ATA) (2012). The Patient Protection and Affordable Care Act (Public Law 111–148) (PPACA), signed into law on March 23, 2010, describes the use of telehealth as a process to promote evidence-based medicine and patient engagement of delivering efficient and cost-effective health care in the United States (2012).

Remote patient monitoring is a home-based monitoring that provides improved quality of life and independence in chronic disease patients (Demiris, Thompson et al. 2012) (Herbert and Medd 2012). It is proven to be useful to homebound older adults who have difficulty accessing care due to disability, transportation, or isolation (Gellis, Kenaley et al. 2012). Remote patient monitoring targets reducing costs of hospitalization (Forducey, Glueckauf et al. 2012) (Herbert and Medd 2012), reducing the frequency of hospital admissions (Dinesen, Haesum et al. 2012), and increasing accessibility of interventions (Pratt 2012). Remote patient monitoring (RPM) devices are proven to be clinically effective in patients with diabetes (McFarland, Davis et al. 2012), general area of mental health (Pratt 2012), high risk pregnancy monitoring, heart failure (Radhakrishnan and Jacelon 2012), cardiac disease (Bensink, Hailey et al. 2006), and chronic obstructive pulmonary disease (COPD) (Gellis, Kenaley et al. 2012) (Dinesen, Haesum et al. 2012) (Rixon, Hirani et al. 2012).

Discharge planning with use of RPM device could reduce family caregiver burden, improve stress managing, and improve family function during the first 30 days at home after heart failure patients are discharged from the hospital (Chiang, Chen et al. 2012) RPM provides objective assessments, timely patient status information, a sense of security, and patient accountability (Radhakrishnan, Jacelon et al. 2012).

“People want to take a more active role in managing their health care - both to reduce costs and improve their quality of life,” said Katherine Holland, general manager of IBM Life Sciences. IBM
scientists and health-care experts state that a variety of new devices are coming on the market, including those that will focus on dieting, elder care, blood monitoring, independence and mobility, and enhanced nonverbal communication (Fraser, Kwon et al. 2011).

Medical products account for an enormous amount of the solid, industrial, and chemical waste. Medical-device industry could benefit from sustainable design, a concept in which products are evaluated in terms of financial, social, and environmental impact (Kadamus 2008). Proactive design for sustainability at the concept level reduces waste, packaging, and shipping costs (Hede, Nunes et al. 2011). It also improves manufacturing efficiency and use of raw materials. The way to improve sustainability of medical devices is design of a product lifecycle, not just a product. Lifecycle analysis tools such as manufacturing flowcharts, materials databases, environmental impact analysis tools such as Sustainable Minds, Ocala, and Eco-Indictor 99, and software programs such as Eco-it and Simapro are available for integrating sustainability into the early stage of design process (Kadamus 2008). The Sustainable Minds application attempts to connect design and environmental science by utilizing a process based on Okala, a comprehensive design education project of the Industrial Designers Society of America (2012). Sustainable concepts are most effective when introduced to design process during the conceptual phase (Kadamus 2008).

Design for Remanufacturing offers a business model for sustainable growth, with reputed double profit margins, a significant reduction in carbon emissions (OHL, 2004), and 15% of the energy required in manufacture (Steinhilper, 2006). DfE diverts material from landfill and creates a market for skilled employment (Gray and Charter 2007).

Remanufacturing is a process of recapturing the value added to the material when a product was first manufactured (Gray and Charter 2007). Used components and spare parts can be considered remanufactured if they are brought to at least Original Equipment Manufacturer performance specification from the customer’s perspective and given a warranty equal to that of an equivalent new product (Iljomah, 2002).

Report Remanufacturing and Product Design Designing for the 7th Generation defines Design for Remanufacture as a combination of eco-design strategies including Design for Multiple Lifecycles, which leads to other design strategies such as Design for Upgrade (Gray and Charter 2007). Two leading global practitioners of Design for Remanufacture are Xerox and Perkins Engines (now owned by Caterpillar). Remanufacture is currently practiced in numerous industry sectors, namely the automotive and aerospace sectors, the imaging industry is involved in remanufacture e.g. copiers and ink cartridges. Through remanufacture Caterpillar and Xerox have generated ongoing revenue opportunities from 2nd, 3rd, nth life products.

**Existing Solutions and Selecting the Device**

Market offers many solutions that allow patients to collect their own health-related information and to store them on portable devices, PCs, and in online services (e.g. CapMed, WebMD, MedKey) (Herbert and Medd 2012). Remote patient monitoring devices offer interactive patient health sessions designed and scheduled by the patient’s health care professional. Patients can measure their vital signs, respond to health assessment questions, receive educational information and motivational messages, and complete surveys during these sessions (Cavoukian, Fisher et al. 2010). Philips’ Telestation automatically sends an Autochek survey to follow up on out-of-limit readings (2012). Some remote
patient monitoring devices, like Carefusion’s TeleAM system, provide graphical representation for health parameter such as blood glucose, blood pressure, and peak flow (Pau, Seoane et al. 2009). Intel Health Guide has an integrated camera and offers face-to-face communication (Pau, Seoane et al. 2009). This is the way for the health care professionals to observe patients perform specific tasks, provide advice and encouragement. RPM devices can communicate with a wide variety of medical devices that collect patient’s vital signs or other medical data and then transmit the data to an IP server for review. Some of the peripherals are blood pressure monitors, glucose meters, pulse oximeters, peak flow meters, and weight scales, measurements that can take patient’s vital sign measurements. They provide audio and visual notifications, as well as reminders of scheduled sessions (Cavoukian, Fisher et al. 2010). Some devices provide security for both the patient and health care provider using a four-digit personal identification number (PIN) before the device can be used. The device is prescribed by a physician to the patient and configured by the professional installer. Patient’s personal health information is accessible only to patient’s own health care provider. In a case of discontinuation of use of the device strict procedures are applied for deletion of the data (Cavoukian, Fisher et al. 2010).

Other examples of remote patient monitoring devices on the market are the TeleStation, the center of Philips Remote Patient Monitoring (2012), Intel Health Guide, made by Care Innovations, GE’s and INTEL’s joint venture (2012), BL Healthcare Access Tablet (2012), Cardiocom COMMANDER FLEX (2012), The Bosch Health Buddy System (2012), just to name a few.

Portable device for monitoring and reporting of medical information for the evidence-based management of patients with chronic respiratory is an example of patents that explore telehealth technology (Boschetti Sacco, Saltini et al. 2012). The second one is the device and user authentication, a method of obtaining a device ID for the device, performing a biometric measurement of the user, obtaining helper data for the user, and generating a key from the biometric measurement and helper data (Asim, Merchan et al. 2012).

The trend in the remote patient monitoring is to use portable devices for remote patient monitoring. The novel, compact, and portable VenaHub, by Cambridge Consultants, is a small pocket device to capture data from a user’s ecosystem of wireless medical devices, which it then integrates into a customizable online health information portal (2009). VA company AFrame Digital has been developing for the past three years a flat, sensor-based watch/monitor wristband/clip (MobileCare Monitor) that reports in-the-home activity, location and vital signs, and fall detection (2010). My Lifecare allows patients to send SMS and automatically transmit of their blood pressure and blood sugar readings to a secure online server. Patients need just their phone; no additional hardware or software is required to view all health related data from the phone (via sms) or PC or Smartphone (web connection) (2012). Cambridge Consultants recently announced a new mobile health device called Minder that connects patients and healthcare professionals anytime, anywhere. Minder acts as a dedicated hub for peripheral personal health devices (2012).

There is an obvious trend in research towards designing portable RPM devices. Kalorama Information’s recently published report “Remote and Wireless Patient Monitoring Markets” states that in addition to the growing development of devices that monitor multiple vital signs, for example, a glucose monitor that can also track a patient's blood pressure, there is another trend: the increasing use of patient monitoring systems that come with data processing applications and equipment that use algorithms to evaluate monitoring measurements for a patient’s specific condition (Lewis 2012).
Map of RPM devices based on their portability and adoptability

After the completion of the competitor analysis, The Healthcare Access Tablet, BL Healthcare, is chosen for the purpose of this study.

The Healthcare Access Tablet is a standalone device with an interactive touchscreen and a foldable stand. It requires a power connection for set.

1. BL Healthcare Access Tablet
Specifications:

- 10.4” touch screen LCD display
- Built-in 3G/4G LTE wireless
- Built-in Webcam for video conferencing
- Wireless medical device connectivity
- Additional serial and USB connections
- Ethernet and telephone connection ports

The Tablet supports interactive health care activities including the monitoring and reporting of vital sign results, interactive health status and symptom assessments; health care-related messaging and reminders; video-based health education and video conferencing. (2012)

Methodology

The methodology of the project comprises of five phases: 1- analysis, 2- synthesis, 3-user experience, 4-evaluation and 5-conclusion. The following paragraphs describe in detail each one of these phases.

**Phase 1** is dedicated to the analysis of the remote patient monitoring devices on the market and choosing the specific one to be analyzed. The goal is to create taxonomy of current RPM devices in the market. Specific goals include:

- Sorting current RPM devices by the means of portability and adoptability.
- Choosing the adopted and adequate RPM device on the market for the purpose of this study.

**Phase 2** is dedicated to developing a synthesis of the material analysis results, literature review on usability of the RPM devices, literature review on sustainable impacts of medical devices and sustainable practices in medical industry, Sustainable Design Methods results, and cost analysis. The goal is to develop a complete anatomy of a chosen device. Specific goals include:

- Complete material analysis of all its components.
- Conduct literature review on usability of the selected RPM device, and literature review on sustainable impacts of medical devices and sustainable practices in medical industry.
• Application of Sustainable Design Methods (DfE Methods) by using the most applicable of the Sustainable Design Tools.
• Analysis of the results retrieved from the application of the Sustainable Design Tools and settling on one solution that satisfies the objectives of the sustainability.
• Proposing recommendations for improving the sustainable impacts of the remote patient monitoring devices.

Phase 3 will be dedicated to user experience with the goal of improving the user interface, conducting usability studies. Specific goals include:

• Usability testing: one hour-long observation with older adults using the chosen RPM device.
• Analysis of the results retrieved from the observation.
• Application of the observation results to the user interface of the RPM device.
• Explanation of the influences on the final solution from a variety of perspectives (the role of the manufacturer, the role of the government, the role of the designer, and the role of the consumer).

Phase 4 will be dedicated to the evaluation of the recommended sustainable practices applicable to the remote patient monitoring device, with the evaluation of the improved user interface. Evaluation tool Sustainable Minds will be used for the purpose of conducting the LCA comparative analysis of both devices (the original device and the new concept) with the cost analysis of the redesigned device. Additional usability testing will be conducted with the purpose of evaluating the improved user interface. Specific goals include:

• Using the evaluation tool Sustainable Minds conduct LCA comparative analysis of both devices (the original device and the new concept).
• Cost analysis of redesigned RPM device.
• Compare selected and improved RPM devices.
• Usability testing: one hour-long observation with older adults testing the improved user interface of the RPM device.
• Analysis of the observation.

Phase 5 will be dedicated to the conclusion and summary. Specific goals include:

• Explanation of the ways the final solution improves its environmental performance.
• Explanation of the ways the final solution improves its user experience.
• Future design considerations.

Refer to the Methodology Map which summarizes the whole process and activities involved.

Timeline lists all the activities that are taking place from the beginning of the process in April 2012, to the Final Review in May 2013.
Remote patient monitoring, as a home-based monitoring, provides improved quality of life and independence in chronic disease patients. It is useful to homebound older adults who have difficulty accessing care due to disability, transportation, or isolation. This project aims to identify and solve specific problems pertinent to this target market through observations and redesign of The Healthcare Access Tablet’s user interface. Using an optimal combination of Sustainable Design Methods (DfE Methods) and the objectives of the sustainability, the author proposes to write recommendations for improving the sustainable impacts of the remote patient monitoring devices.
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