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Attitudes and Acceptability of Smart Wear Technology: Qualitative Analysis from the Perspective of Caregivers[†]

Smart wear integrates computing technology into fabric or a garment for additional functionality. This research explored the attitudes and opinions of the use of smart wear from the viewpoint of caregivers. Thirty two individuals including care providers of children and adult family members with health problems participated in focus group interviews. Participants reported being interested in smart wear because of the potential to detect the location (GPS) of a dependent (e.g., child, elderly) and to monitor vital signs. Participants indicated perceived advantages of smart wear such as identifying geographical location and effectiveness. Perceived concerns mentioned were privacy/security issues and accuracy of data. Participants taking care of dependents without a specific disease were hesitant to adopt and pay for smart wear. However, caregivers of elderly individuals expressed positive adoption intentions and willingness to reasonably pay for smart wear. They indicated expectations that potential insurance would provide coverage for cost savings. Caregivers expressed the need of specific requirements for future adoption such as customizability, and comfort/safety. Specific to smart wear clothing, most respondents preferred it be an undershirt or a jacket with a sensor located in the shoulder area. The findings from this study can be used in product development, promotion and marketing of smart wear.

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With the emphasis on high quality in daily life, various products with the label of "smart" are gaining a surging interest globally. Smart wear can be defined as innovative clothing that is integrated with digital equipment. It provides the "smart" or "intelligent" ability to sense stimuli from the environment, and then react or adapt behavior to the circumstances in a controlled or predicted manner (Baurley, 2004). The stimulus and response can have an electrical, thermal, chemical, magnetic or other origin (Tao, 2001, Langenhove & Hertleer, 2004). For this research, the concept of smart wear is defined as innovative clothing that integrates computing/digital technology into fabric or a garment

for additional functionality such as monitoring location (e.g., Global Positioning System, referred to as GPS hereafter) or health functions (e.g. vital signs). Smart wear in its early stages began to find application in fields where the need for monitoring and actuation can be of vital importance, such as a medical environment, and with vulnerable population groups (e.g., space travel/military) (Langenhove & Hertleer, 2004). Ariyatum and Hollands (2003) identified the major applications of smart wear into military, medical, communication, entertainment, and sports/recreation. Suh, Carroll, and Cassill (2012) stated that according to the U.S. Smart Clothing Market share, application of smart wear varies dramatically by application segments with 41% for consumer entertainment, 27% for safety, 22% for biomedical, and 10% for military segment respectively.

Care recipient population groups encompassing geriatric, frail, and children need the help of caregivers. Although studies have focused on the design direction and technology of smart wear to realize specific performances for particular situations (Noury *et al.*, 2004; Paradiso *et al.*, 2005; Paek & Ashdown, 2009; Lee, 2011; Kim *et al.*, 2011) and acceptance/purchase intention of the wearers (Kang & Jin, 2007; Ko *et al.*, 2009; Park & Noh, 2011; Noh & Park, 2011), few have attempted to understand the value of smart wear use from care providers' perspectives. Since at risk individuals (e.g. diseased, elderly, mentally and physically challenged individuals) sometimes are unable to express their thoughts and make a reasonable decision, it might be more feasible to listen to the opinion of their caregivers. Moreover, the concept of smart wear technology is still in the early stages of development and it is not popularly known among customers. Thus, this research, through focus group interviews, provided an investigation of the attitudes and opinions about the adoption of smart wear by caregivers.

LITERATURE REVIEW

Theoretical Framework: Diffusion Theory.

Smart wear technology, a relatively new development integrates 'smart' functionality into clothing and other textile products' is an innovation that consumers may adopt for a variety of reasons. In order to understand how an innovation such as smart wear may become accepted and thus adopted, Roger's (1962, 1983, 1995, 2003) Diffusion Theory offers a means by which the acceptance of this innovation may be understood. Diffusion has been defined as "the process by which an innovation is communicated through certain channels over time among members of a social system" (Rogers, 1983, p.5). Although Diffusion Theory consists of four main elements: innovation, communication, social system and time, this research focused on the 'time' element which affects the rate of diffusion related to the innovations' relative advantage, compatibility, complexity, trialability, and observability.

The element of time in the diffusion theory refers to the length of time taken by members of a social system to adopt an innovation. This element includes the decision-making process of awareness, interest, evaluation, trial and adoption. Within this element of time, Rogers (1962, 1983, 1995, 2003), identified five innovation attributes which he theorized affects the rate of diffusion: relative advantage, compatibility, complexity, trialability, and observability. Relative advantage refers to the extent to which an innovation is perceived to be advantageous over the product or idea that it supersedes. Generally, the more individuals perceive an innovation to be advantageous, the faster the rate of adoption. In addition, the more significant the perceived benefit, the more attention individuals give it through communication with others, the faster it may diffuse. Compatibility is the extent to which an innovation is perceived to fit into an individual's lifestyle and is consistent with their values, experiences and needs. The more familiar an individual is with an innovation that is perceived to be congruent with their experiences, values and lifestyle, the faster diffusion may occur. Complexity refers to the perceived difficulty of use or understanding of an innovation. The more complicated individual's perceive the innovation to be, the less likely they will be to adopt. Trialability is the opportunity to try before adopting. Therefore, the triability of an innovation may enable

individuals to become more comfortable with an innovation thereby reducing the degree of perceived risk of adopting. Likewise, observability refers to the degree of visibility of the innovation to individuals. If the benefits of adopting an innovation are observed by others, communication may be stimulated which may then lead to a greater rate of adoption.

Product Development: Smart Wear Clothing

Smart wear, recently regarded as a wearable computer has recently been spotlighted by multiple researchers (e.g. Mann, 1996; Baurley, 2004; Pandian, Mohanavely, Safeer, Kotresh, Shakunthala, Gopal & Padaki, 2008; Sardini & Serpelloni, 2010). According to Lim (2009), smart wear research was initiated by MIT (Massachusetts Institute of Technology) for military use in the early 1990s. Baurley (2004) argued that the integration of smart functionality into clothing/ other textile products will have an impact in the use of clothing. The potential applications cover wide range of areas, and the possibilities in monitoring of health care are huge. According to Lymberis (2005), it is anticipated that smart fabrics with embedded functions would improve quality of life support (e.g. tracking motions; monitoring of stress, body fat, and various biofeedback mechanisms) in the future.

Since sensing stimuli from the environment for reaction is the key concept of the smart wear, the appropriate sensing and signal system has been investigated by several researchers (e.g. Friedl, 2003; Jovanov *et al*., 2003). Friedl (2003) developed software that monitored body functions to identify threshold levels to trigger an automatic electronic emergency alert. The software was tested by monitoring patients using sensors to detect life threatening functions (e.g. dehydration) in an evacuation situation.

Sensing technology can be incorporated/ woven into textiles as smart textiles, or incorporated into the garment. For example, Lind *et al.* (1997) developed a T-shirt for soldiers in combat using plastic optical and other specialty fibers woven through the actual fabric of the shirt. This smart shirt prototype functioned like a motherboard showing the exact location of damage by a bullet. The soldier's vital signs included heart rate, temperature, and respiration rate monitored through sensors integrated into the T-shirt, so the information on the wound and the soldier's condition could be immediately transmitted electronically to a medical triage unit (http://www.smartshirt.gatech.edu/).

Another example of smart wear in textiles is a jacket developed by Phillips Research Laboratories'. This jacket included knitted stretch sensors that prevented the wearer from being distracted by detecting posture and movements of the user (Farringdon *et al*., 1999).

In many instances, smart wear technology has been incorporated into garments in which sensors have been embedded, attached, or contained in clothing such as pocket type components in clothing items depending on types of sensors, wearability and function of the clothing. Lim (2009) argued that the smart underwear for patients must be compatible with the function of the clothing: comfortable, durable, washable, and reliable. This study suggested the prototype with the built-in ability. Three pockets in underpants, and five pockets in tank top were attached to contain glucose sensor to capture glucose level and biosensors to measure biomedical parameters. The glucose sensor is placed in the pocket and sewed onto the front waistline of underpants which receives signals from the chip inserted under the skin that assesses blood glucose levels. Sensors can be detached from pockets before laundering. The data is transmitted to PC through a wireless communication technique. Wireless device such as a PDA or mobile system transmits blood glucose level information directly to a hospital, home, office, etc., when the glucose levels are elevated. Based on the findings of this research, the authors confirmed that comfortable and unobtrusive biomechanical measurement equipment plays a significant role in the function of smart wear (p.7).

Peksoz, Park, An and Cao (2009) established design criteria when they developed a smart firefighter coat and gloves that sensed the wearers' emergency situation, and transmitted alerts. It was determined the sensors should be on the coat, in close proximity to major organs to monitor body climatic fluctuations (e.g., temperature & humidity, heart rate, blood oxygen saturation). Results regarding design criteria included wearability, such

as dexterity, comfort, easy care and sensor reliability (e.g., non-interference of measurement and transmission of information.

Recently, there have been many attempts to combine personal mobile/computer devices and entertainment systems into clothing. Usually, the clothing is designed to hold the device, so that it is easy to remove for laundering. Outfits such as jeans, feature a special pocket that stores an iPod and has a joystick in the watch pocket which allows the jeans wearer to control the iPod without having to remove the garment. (Baker, 2006). Dunne, Ashdown, and Smyth (2005) identified body-centric wearability issues including weight distribution, movement and mobility, sizing and fit, thermal management, and moisture management are critical to the comfort and functionality of a wearable device.

Smart Wear and Diffusion Theory

Diffusion theory has been used to assess the adoption of smart wear with respect to time dimension and perceived preferences in product characteristics that influence the timing of adoption. Ko, Sung, and Yun (2009) analyzed attributes and influence on purchasing intentions of the use of commercial digital devices in clothing, such as iPods and wireless technology among a young population. This cross cultural study included a sample from Korea and America. Relative advantage/compatibility and complexity were found as attributes associated with smart wear. Relative advantage was the most important attribute and included social image, economic benefit, time benefit, and compatibility with lifestyles and existing wardrobe. In the U.S., complexity and cost were important attributes, suggesting the less complex and lower the cost of a garment the more likely users will adopt. Complexity to U.S. participants was related to awareness of smart wear clothing, psychological/social risks, performance risks, and time lost learning the technology. Awareness of smart wear decreased perceived complexity. The researchers also concluded that reducing psychological risk can be done by enhancing usability and profitability of smart clothing. These factors will increase relative advantage, stimulating adoption.

Ariyatum, Holland, Harrison, and Kazi (2010) noted that applications of smart clothing have not been successful in entering the mass market because consumers' needs have been unrecognized. Results from a focus group with product designers demonstrated that current designs of embedding smart technology in personal sport wear and healthcare clothing should aim to match user needs, purchasing criteria (i.e., aesthetics and function) and lifestyle (i.e., compatibility).

Research Questions

While there has been research related to design development of smart wear, which has demonstrated ample capabilities, very limited research has assessed consumers' adoption of the technology. Research about the diffusion of smart wear has primarily focused on wearers' and designers' perceptions of product characteristics that influence timing of adoption. These studies have focused mainly on smart wear in general, consumer markets rather than health care (e.g., Ariyatum, *et al.*, 2010; Ko, Sung, & Yoo, 2009). The main research question for this study was to investigate care providers' attitudes and opinions related to the use of, and adoptability of, smart wear, emphasizing key components from Rogers' (1995) theory (relative advantage, complexity, compatibility). Thus, specific research questions included: what are care providers' attitudes and opinions of the:

1. advantages and/or disadvantages of the use of smart wear?
2. ease and/or difficulty of use of smart wear?
3. compatibility of smart wear with their lifestyle?

METHODOLOGY

Participants

After approval of the research by the University's Institutional Review Board, Involving Human Subjects, a mass email was sent to all faculty, staff, and students of a large, Midwestern University (United States) to recruit potential focus group participants. The email message briefly introduced smart wear technology and invited adults who were, or had been, caring for a dependent child or adult to

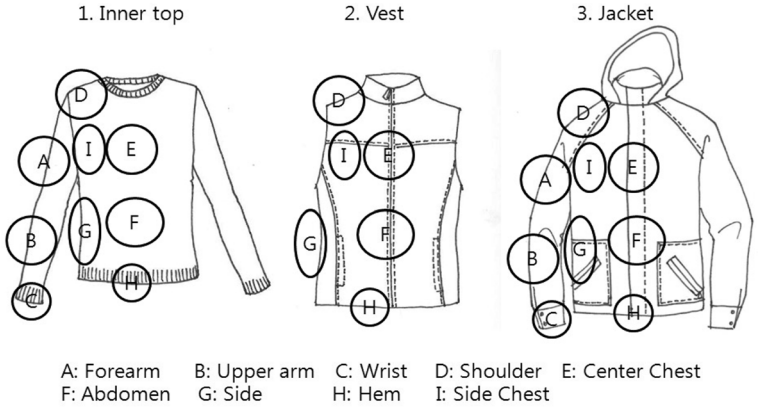

Figure 1. *Illustration of Upper Clothing*

learn more about the technology and to share their impressions in a focus group. Fliers were also distributed in the local community to recruit potential participants. Interested participants were given two weeks to respond to the advertisement. Prior to the start of the study, a demographic survey, a semi-structured interview question list for the focus group, and a brief PowerPoint presentation were developed. Validity of the demographic survey and focus group questions was assessed by six professionals (e.g, four in fashion, one in family studies, and one in dietetics).

Procedures

Upon recruitment, each focus group, comprising of eight people, gathered in either a local community center or a conference room at the university. After the study protocol was explained by a trained facilitator, participants completed a brief (5-10 minutes) demographic survey. A five to ten minute presentation (including video clips) was given and shown to participants to introduce smart wear technology and some of the ways it has been used-typically in recreational contexts. However, it was explained that the objective of the current project was to investigate attitudes and opinions regarding the application of smart wear technology in the caregiving context.

A focus group methodology was selected because of the exploratory nature of the study. Such a procedure allows participants to express their perceptions openly and to clarify their responses to the facilitator as opposed to responding to forced-choice survey questions. This type of method has demonstrated that group dynamics can contribute to a sense of synergy that can result in responses that no single individual might come up with; and listening to other respondents can stir thoughts that might not otherwise be expressed by participants (Stewart & Shamdasani, 1990). Having multiple focus groups helps account for the diverse atmosphere that can be constructed by the personalities and moods of any given group of individuals.

For the sake of consistency, the same facilitator led all of the focus group discussions. The facilitator was a graduate student and was trained by one of the investigators with previous focus group facilitation experience. A semi-structured interview schedule was used for all groups, which included a variety of questions to facilitate discussion about perceived advantages, disadvantages, concerns, questions, suggestions, etc. regarding smart wear technology in general and in a caregiving context. Focus group discussions were audio and video recorded, and were transcribed for analysis. Additionally, an illustration (Figure 1) was created by a member of the research team that represents potential garment locations for smart wear technology. The illustration was shown to each participant who was asked to do the following: "Based on the sketches, choose the most preferable type of smart wear for your dependent. Where would you like the smart wear sensor to be embedded in their dependents' clothing? Why?"

Analysis

A qualitative theme analysis (e.g., content analysis) was used to evaluate the focus group data. Four investigators separately reviewed the focus group transcripts to look for themes as they applied to the research questions. Once each investigator coded all the data, the investigators met to compare their coding schemes. Through discussion a consensus was reached regarding the overall themes as they pertained to the research questions. Given that some participants differed as to the type of care they had experienced (or interest) in providing (child care versus elder care), the investigators looked for and noted differences in responses that may be influenced by caregiver type.

RESULTS AND DISCUSSION

Sample

A total of 32 participants (eight people in each of four focus groups) were included in the study. The sample was predominantly Caucasian (78.13%), ranged in age from 19 to 75 years (M=43.27, SD=20.87), and mostly middle class. Participants were from diverse professions: instructor and university professors (n=6), university students (n=6), housewife (n=4), retired (n=3), project manager and administrator (n=2), pastor (n=1), engineer (n=1), architect (n=1), substitute teacher (n=1), finance and student loan business servicer (n=1), child care provider (n=1), custodial group leader (n=1) and clinical person (n=1). Most had no prior knowledge of smart wear (66%), while a few had some knowledge and experience with GPS technology integrated into athletic apparel. Twenty five (78%) were currently caring for another individual in their home (14 of which included an adult receiving care, typically an aging parent or grandparent, seven of which also cared for a child at the same time).

Analysis of Responses

Advantages of smart wear Rogers (1962, 1983, 1995, 2003) Diffusion Theory suggests that one of the elements for the rate of diffusion or adoption of a innovation is related to the relative advantage of the idea/ product. Generally adoption of an idea or product will be quicker if it is perceived to be more beneficial that the idea or product it supersedes. Focus group participants expressed several concepts/ ideas where they felt smart wear garments would be advantageous. These included concepts such as 1) geographical location, 2) economical, and 3) maintain independence.

Geographical location As care providers, keeping track of the location of children or elderly adults who are at risk for getting lost, smart wear that would allow location detection such as GPS tracking would provide the ability to locate individuals who 'wandered off'. For example, participates commented: "it would help with the safety, being like a monitor for a small child or older person who wandered off – it would be a huge benefit. That is an adult child's worst fear of an Alzheimer's patient to wander off", and "my husband's defensive with [his] memory loss, [he] has a hard time getting lost in a town he grew up in". Both caregivers of children and frail adults voiced interest in location functions of this technology.

Economical The advantage of smart wear being economical was addressed in terms of financial and time-consuming issues. One participant discussed a situation where smart wear may have provided a financial benefit: "For my mother who lived at home, I was spending maybe $150 a week on gas which was 70 mile round trip helping take care of her. As soon as she went into assisted living that is about $4,000 a month. I would have paid a lot more for smart wear at that point if it would have kept her in her home. She would have been happier, I would have been happier, and the expense of the nursing home would not have occurred as soon either." Other focus group members concurred: "I would say eventually it [smart wear would] cut down cost for medical procedures that would be something that could be done at home to monitor instead of an overnight stay at the hospital.", and "With my grandpa, there were many times we had to take him to the hospital due to his falling and passed out. It

was numerous expenses having to deal with that...if we could get to him quicker and just know that something is wrong, would save tons of stress on his part." Caregivers of frail adults more frequently vocalized issues related to economic factors.

Maintain independence Reinforcement of independence of elderly dependents was considered a major advantage. "I have an elderly aunt who lived by herself and her biggest fear was that she would fall or die and no one would know. After she told me that, I paid for a life-line service and she was so relieved and thrilled that she could keep her independence because she knew if she couldn't stay by herself; the next step was a nursing home. And they still had to come to the home a couple of times [to] care for her, but there is a lot to be said for this … I can see where the smart wear could be valuable if something was wrong and she couldn't have activated the necklace." Independence was a key concern among caregivers of frail adults.

Disadvantages of Smart Wear

Although the participants expressed several areas where smart wear was seen as advantageous, there were also several ideas expressed were smart wear was seen as having potential disadvantages. Disadvantages or concerns of smart wear included 1) privacy or security issues, and 2) accuracy of data.

Privacy/security issues Focus group members expressed concerns about privacy/security related to unexpected information leak: "I don't want somebody to be able to hack into this data and corrupt it. Let's say someone could change the data while I am wearing the smart wear clothing…", "Is it that much more beneficial that I know where they (the dependent) are compared to somebody else being able to access that information and know where that person is?", "I can see it being an ethical issue as who has a right to track … who is wearing the clothing and to what degree should they have access to that information?" Additionally, "…the big Brother thing as far as someone monitoring your blood pressure … How would that affect the ability to get life/health insurance, [change the] cost of premiums ...". Both caregivers of children and frail adults voiced interest in location functions of this technology.

Accuracy of data Although monitoring of vital signs was seen as an advantage, accuracy issues were expressed. Concern was expressed about the reliability of information provided by smart wear: "Would there be a possibility of interference electronically in the community that would intercept the effectiveness of the particular [smart wear] device...", "For me, I think one of the cautions I would want to know about is the learning curve. What all do I need to do [to use smart wear] and how dependable is it. How much can I rely on it being accurate?", "I am concerned about false alarms … something is triggering wrong or interpreted wrong and someone has made an [unnecessary] trip." Caregivers of frail adults more frequently vocalized issues related to accuracy of collected data.

Considerations about price

Potential price of smart wear was expressed both as an advantage and a disadvantage depending on the situation being considered. Some participants suggested that dependents without specific needs for monitoring would not be willing to pay for smart wear: "I couldn't personally at this point picture a need for it. Thankfully our little girl is healthy ... In my situation with an 8 and 6 year old… No, I wouldn't clearly have a desire for this. Now if I were taking care of elderly parents with health element takes it up a notch, or a small child that couldn't communicate, then that puts it in a whole other game for me, but at this point, it would be just a game for me and I say no". On the other hand, other respondents stated: "I would definitely consider it [paying for smart wear], we had 5 kids in 7 years, so our kids are young and close together and I don't feel comfortable taking them out to the museum, vacation, etc., because if I had all 5 kids with me by myself I wouldn't feel safe, I would use it for that reason alone."

Participants also wondered if insurance would cover all or part of a fee for smart wear, especially for medical functions. It was also suggested that usage of

smart wear could be cost saving ultimately: "if it was available for my grandmother, and you had that cost of someone coming in and taking the vitals or sit with them all the time, and to do all of those things it would be interesting to see [cost comparisons]. Because over a course of ten years … if it would last the ten years … it would be cheaper to buy it once than to pay someone for ten years." Thoughts on reasonable costs included: "I would imagine that a shirt for somebody that exercises … giving you back blood pressure and stuff like that … you could probably sell that for $100 and probably couldn't keep them on the shelves.", "I am very blessed to have a very healthy child, but if we did have a child that was challenged in some way that needed to be monitored I would hope that insurance would help cover some of it, but I think under $100 or even a little more would still be very valuable investment.". Generally, caregivers of elderly dependents expressed adoption intention and willingness to pay for smart wear technology, if reasonable and affordable, than those expressed by caregivers of children. Thus participants were split as to the overall relative advantage of smart wear. Expressions revolved around what the actual need was, how great the need was perceived, did the benefit outweigh the potential disadvantages and did the potential cost outweigh the potential benefits. Caregivers of children and frail adults alike voiced concerns about the cost of smart wear technology.

Ease and/or Difficulty of Smart Wear Use

Roger's (1962, 1983, 1995, 2003) Diffusion Theory, in addition to an innovation's relative advantage, identified complexity as an element that influences the rate of adoption. Complexity refers to the perceived difficulty of the use or understanding of an innovation. The more complex or complicated an individual perceives the innovation to be; the less likely they will be willing to adopt it. The caregivers in the focus groups hypothesized about the potential for ease or difficulty of use since none had the opportunity to have firsthand experience with smart wear. Their thoughts were expressed in relation to the initial presentation completed at the start of each focus group to introduce them to smart wear technology. One participant stated: "I think I would want to know more about it, how it works and what happens if it runs out of batteries. I would trust my child to go hiking and then it stops working, like how long does it last? ", "for me, I think one of the cautions I would want to know about is the learning curve. What all do I need to do and how dependable is it. How much can I rely on it being accurate?" Other concerns included: "I think it might be important to have an alert type of thing, if there is danger. If you're a caregiver … are you going to be able to sit and watch that monitor constantly?", "as far as safety, what comes to my mind is like garage door openers can trigger sometimes unexpected down the street. Would there be a possibility of interference electronically in the community that would intercept the effectiveness of the particular device."

Caregivers expressed concerns regarding the complexity of the data that might be gathered from smart wear and how that data might be interpreted: "I am not trained to interpret a lot of the data that I have access to. It can make me an alarmist … sometimes … information give us … we feel like we have an allowance to kind of step into situations that were best left out of and we don't understand the whole picture.", "another thing is storage of this data ... Where are the storage facilities going to be for this amount of data? … Who is going to be the person/ group of people looking at the data? Is it just the average person or is it going to be the medical professional sitting there analyzing every little piece?" Caregivers of frail adults were particularly concerned about the complexity of the data.

Participants expressed a lack of information as to how smart wear technology, especially related to the data and how it would be used, interpreted, and stored. They did not express any concerns in relation to difficulty in using smart wear garments. There were, however, thoughts related to how the garments might be worn, the care or maintenance of the garment and the appearance of the garment. These thoughts are related to the compatibility element in Roger's (1962, 1983, 1995, 2003) Diffusion Theory.

Compatibility of Smart Wear with Lifestyle

Compatibility in Roger's (1962, 1983, 1995, 2003)

Diffusion Theory is defined as the extent to which an innovation is perceived to fit into an individual's lifestyle. Participants discussed compatibility components in relation to 1) customization, 2) comfort/safety, 3) reliability, 4) manageability, 5) maintenance, and 6) appearance. In general, both caregivers of children and of frail adults voiced concerns about compatibility. However, neither type of caregiver expressed more concerns than the other.

Customization Caregivers discussed how each of their dependents had specific needs that would require flexibility in the smart wear. If it could be customized to the specific needs, smart wear could fit into their lifestyle easily. "As the caregiver for my husband, we would want it customized to his needs, he gets lost easy, so the GPS [is important] … he doesn't have a heart problem, but I would want to know his heart is beating!", "part of the adoption process as far as integrating this into whatever target market you are looking as far as that goes. It would be need to be so specific. It would need to be developed for a child or it would need to be developed for sports, or medical and especially for medical it would have to be packaged well as far as someone in later stages of life will not want to look like a moon man or Tron."

Comfort/safety The wearing of smart wear was discussed. If it is like wearing 'regular' clothing, it would be compatible with the lifestyle. "I want a shirt that keeps me warm in the winter and cool in the summer, not to substitute for what my body can do, for instance I don't like feeling chilled.", "So it should be very light weight especially for children.", "With older people too, Alzheimer's patients or something, it might have to get really comfortable to them, or they be trying to take it off all the time, so it should be so comfortable that they wouldn't be aware of it.", "…if you're wearing it and you do something like cut something or get it wet will it shock you? I had a bad cell phone once and it would shock you. So if it goes bad will it harm the person who is wearing it?"

Reliability Caregivers expressed the fundamental issue that in order for smart wear to function, it must be worn. Concerns were expressed related to the ease of which the smart wear garment may be removed inappropriately. "I have concerns, but is this idea of the tee shirts really easy for somebody to take off the child.", "if we are aware of the technology then strange people can be too, and they could recognize it and say "oh-oh" and take that one off!", "…maybe it needs to be something that couldn't be removed…in public!". On the other hand, "I wished zipped jackets had locks on them so once he [the dependent] got it on he could not take it off.", "Autistic children tend not want to wear certain types of textured clothing or younger children will take their clothing off."

Manageability Caregivers questioned how smart wear would function in laundering, refurbishing, and reusing. "I would need to be able to launder it, those types of things", "Is it reusable, do you take the stuff off of it and wash the tee shirt, I am wondering about the re-usability of it.", "I mean from a cleanliness point of view you got to launder this stuff.", "Or the washing process if they didn't take the right precautions of looking at the tag for the care of the garment they could damage the data or the chip.", "…Manageability of the battery during laundry."

Maintenance Participants wondered about the maintenance of the smart wear over time. What technology updates might be needed? They suggested that there needs to be "…the ability to adapt it after you have already purchased it, or be able to upgrade for a lower cost.", "…the technology piece offers upgrades, like your cell phone. if you are investing into it then you could adapt with it, if you put the original investment in it and the GPS gets better or whatever, you're gonna want the updates not buy new", "if it is for children, they are going to outgrow those garments real quick. So is it something you can buy separately and connect so as they grow up they actual garment is cheaper and the actual piece with all the information does all the connections is that a separate piece or be sold separately that can be moved through different garments or sizes?", "Let's say I spend $300 and get

the technology could I afford $10 to get different shirts to put the thing in? I think I would be more interested in seeing if you could change out the clothing, I'd be more will to look at the technology if I could change out what it came in."

Appearance One of the important areas of discussion by the focus group members related to the compatibility of smart wear was the appearance of the smart wear. Would it be fashionable? Would it look like a 'regular' garment? In addition, there was concern about making sure the sensors in the smart wear would not easily be removed, or would monitor who and what it was intended to monitor? Participants stated: "Whereas if we are wanting people to wear these types of things day in and day out they have got to look a lot better than something that looks robotic, I want something that moves and functions like clothes and I don't feel like strange fibers. There are different aspects for different populations. That would need to be addressed.", "I'd think the size of it [the sensors] if you were using it on small children as far as security concerns. It would need to be very inconspicuous."

The placement of sensors in smart wear was discussed and participants were asked to indicate on illustrations provided, where they would prefer sensors be located and in what type of garment (see figure 1). Eighty one percent of the respondents chose inner top as the most preferred type of garment for smart wear sensors to be included. They indicated that the inner top was suitable for most situations. From the focus group discussion of not wanting sensors to be removed easily, caregivers tended to prefer undershirt type of garments to outer garments: "if it had an undershirt type that could be worn. I like the idea of the jacket, but my kids take their jackets off and throw them on the ground." Even though smart wear for leisure such as ski or climbing would be a jacket which could provide thermal comfort in a cold environment, caregivers were more concerned about the ease of taking off and thus the smart wear monitoring would be eliminated.

Related to the body surface where a sensor could be place that would be compatible to the garment and ease of utilizing. The shoulder part was the most preferred position of sensor (25.6%), which was followed by side chest (20.5%), side (17.9%), center chest (15.4%), forearm (10.3%), upper arm (7.7%), and abdomen (2.6%). No participant selected the wrist or the hem area of the garment as the preferable position to have sensors. The reasons provided for the selection of the shoulder part were that it seems to be the least annoying place for the wearer, the best location for accessibility (easy to turn on/off) for the caregiver, and the best location for avoiding damage to the sensor.

CONCLUSIONS

This research was designed to investigate the attitudes and opinions for the use of smart wear from the viewpoint of caregivers. Faculty, staff, university students of a large, Midwestern University (United States) and adult community volunteers who were, or had been, caring for a dependent child or adult were recruited for participation in focus groups to learn about the smart wear technology and to share their opinions. A qualitative theme analysis (e.g., content analysis) was used to analyze the focus group data. Thirty two caregivers of children, parents, grandparents, elderly relatives, and/or spouses with health problems participated in the focus groups. The majority of the participants' (65%) reported not having previous knowledge about smart wear but was generally positive and interested about the technology. Though care providers differed on the nature of the care they provided (i.e. care of a child versus care of a frail adult), their attitudes and concerns were very similar.

Care providers' attitudes and opinions of the advantages and disadvantages of the use of smart wear was influenced by dependents specific needs (compatibility), comfort and/or safety, appropriateness of the clothing related to removability of the smart wear, financial constraints, laundering and care, and the technological up-keep. Disadvantages or concerns of smart wear included privacy or security issues (e.g. unexpected informational leak), accuracy of data (e.g. reliability of information provided by

smart wear). Depending on the circumstance, potential price of smart wear was expressed both as advantage and a disadvantage.

Regarding ease and/or difficulty of smart wear, since none of the focus group members had actually used smart wear, their thoughts were expressed in relation to the initial functionality and operational use of smart wear under various situations. Participants expressed concerns regarding the complexity of the data (i.e. how the data was gathered and who collected this information), storage capabilities (i.e. where the information was stored), and interpretation (i.e. who, how, and were) of smart wear data. Difficulty in using smart wear was not expressed as a concern, although thoughts about maintenance, appearance and how the garment could be worn were expressed. There were concerns about the ease of use of the product, but most of the concerns seemed based on unknowns about the product. If they knew more about it (e.g., how challenging the equipment and software would be to use), the concerns could have been minimized.

There was consensus among focus group members regarding compatibility of smart wear with their lifestyle. Discussions focused around customizations, comfort/safety, reliability, manageability, and appearance. In reference to the placement of the smart wear sensors on clothing, 81% of the participants chose the inner top of the garment and preferred undershirt type of garments to outer garments. A majority of the respondents preferred the sensor placement to be laid on the shoulder as this would be comfortable to the wearer. There appeared to be a great desire to increase flexibility of the product and customizable to fit into their lifestyles. Much of the concern was driven by financial cost (e.g., transferrable to other garments, withstand or avoid rigors of washing garments). If cost effective, much of this concern may have been minimized.

In terms of adoptability, unlike participants taking care of dependents without specific diseases, care givers of elderly dependents seems to have more of a positive intention to adopt smart wear and reported a general willingness to pay for the technology as long as it was reasonable and affordable. In addition, participants saw clear potential advantages, some of which might have been offset by concerns or perceived disadvantages. However, the disadvantages appear to have the potential to be addressed and thus diminished, depending on the final functioning of the product-such as ensuring privacy and accuracy and being cost effective.

Finally, Rogers (2003) theory of the diffusion of innovation provided a useful framework to examine the variables related to the diffusion of smart wear. These findings supported previous research about commercial smart wear and innovation characteristics that influence exposure and time toward adoptability (Ariyatum, *et al*., 2010; Ko, Sung, & Yin, 2009). Specifically, perceived relative advantage, compatibility, and complexity influenced adoption considerations. Participants indicated they were not familiar with the technology, so observability was a factor in non-adoption. Greater visibility could be enhanced through a healthcare insurance system. Triability was not described by participants as important for adoption. The impact of triability related to smart wear may not be understood due to the novelty of this technology for consumer use. The results of this research are congruent with previous findings about smart wear for commercial use. Some of the similarities included economics, time, compatibility with lifestyles, usability, performance risks, and time lost learning the technology that may influence adoption (Ko, Sung, & Yin). Additional considerations in smart wear related to care were geographical location and enabling independence.

Unlike smart wear for commercial use, two perspectives were found in considering smart wear for caretaking within the social system. For example, from the perspective of the care provider the relative advantage of a GPS feature was important in maintaining and providing independence to those in need of care. Also, various features in the design of the product were found, including the environmental impacts (e.g. changes in lifestyle, relational impacts), the capabilities of the smart wear technology (e.g. ease of use), and the design of the clothing (e.g. bulkiness). Therefore, several factors may need to be taken into consideration, prior to the final adoption of the smart wear by care providers.

IMPLICATIONS

Although research related to smart wear has generally focused on the design and technology for specific performance issues, and potential acceptance/ purchase intention of wearers, to date, no studies have attempted to understand the needs for smart wear from the view point of care providers. Thirty two caregivers of children, parents, grandparents, elderly relatives, and/or spouses with health problems participated in the focus groups. As the perceived advantages of smart wear, caregivers enumerated geographical location, effectiveness, peace of mind, and independence. Caregivers felt that smart wear could offer some real advantages for monitoring their dependents, but felt that flexibility of being able to customize to their situation, utilizing only the components they needed. Lastly, participants were accepting of the possibility of adopting smart wear as long as it looked and behaved like "regular" clothing and the sensors for the smart wear technology were located in an area that did not hinder comfort, was not bulky to draw attention to it, and was not in danger of damage through normal wear.

The findings identify features to focus upon for assessing smart wear prototypes for care taking. For example, a group of care takers could use a prototype of smart wear and complete a Likert-type survey about wearability, comfort, safety, and appearance, etc. These surveys could be framed using Rogers (2003) theory of diffusion, incorporating questions focused on the broader environment, the design of the apparel, and the smart wear technology. This study also provides tangible guidance for the development of the smart wear. For example, the preferred placement of the technology in this group was on the shoulder and as part of an undergarment. Clothing preferences were identified, such as garments that were not easily removed and were washable. This study also provides guidance in developing the smart wear technology, such as assuring privacy of the data, and making the data easy to understand, upgradeable, and customizable. In addition, the features of smart wear that were found to be advantages can be highlighted in promotions and advertising smart wear, such as the cost saving benefits of smart wear and increased independence of the elderly or other dependent when wearing smart wear.

Research related to smart wear has generally focused on the design development with the majority in the health care area (e.g., Ariyatum, *et al.*, 2010; Ko, Sung, & Yoo, 2009). Very limited research has considered the adoption of the technology by consumers, specifically caregivers. Therefore, this study provided an exploratory investigation that utilized focus groups who were care providers. Three research questions related to care providers' attitudes and opinions about smart wear addressed: what are care providers' attitudes and opinions of the: 1). advantages and/or disadvantages of the use of smart wear? 2). ease and/or difficulty of use of smart wear?, and 3). Compatibility of smart wear with their lifestyle? Although participants were diverse professionals, they had little knowledge about smart wear technology. The caregivers were introduced and educated about smart wear technology through PowerPoint presentations and video clips. In order for participants to express their perceptions openly and to clarify their responses, a focus group methodology was selected. The results of the focus groups were examined through utilizing an in-depth qualitative analysis which was performed by four investigators who separately reviewed the focus group transcripts to themes related to the research questions. Although this innovative research has several benefits with practical and fundamental information, the data from in this study was limited as data was collected from volunteers abiding in a specific geographical location via focus groups.

Future Recommendations

Focus groups, while ideal for exploratory research, are not generalizable to the broader population. Future research on a larger scale with diverse groups of care providers, including heterogeneous ethnic groups, is needed to determine if the attitudes and opinions expressed in the focus groups are common in the population. In addition, research with a larger specific group of care providers (e.g. Alzheimer's care providers, or geriatric) would provide valuable information as to how smart wear could meet the

needs of a particular group with health concerns. Further, research conducted with children or a specific population in a confined facility (e.g., group homes, retirement/nursing homes) would provide insight into the use of smart wear for those populations. This research investigated caregivers' views of smart wear. An additional direction for further research would be to examine how, by using smart wear, the caregiving relationship might change.

Beyond considering attitudes and opinions related to the possibility of using smart wear, future research is needed in the development of a prototype consumers could test to gain users' feedback in the use of an actual product. This study discovered that the majority of the participants were not aware of smart wear and what functions it could perform. With a prototype, consumers would learn firsthand what it looked like and how it worked (i.e., how challenging the equipment and software would be to use). Would consumers view smart wear as more advantageous if they had more knowledge of the product? This would provide valuable information to developers and designers of smart ware which could lead to additional research in the evaluation of the marketability of smart wear product with family and consumer science professionals.

REFERENCES

Ariyatum, B., & Hollands, R. (2003). A Strategic Approach to New Product Development in Smart Clothing. White paper. Retrieved from http://www.idemployee.id.tue.nl/g.w.m.rauterberg/conferences/CD_doNptOpen/ADC/final_paper/135pdf

Ariyatum, B., Holland, R., Harrison, D., & Kazi, T. (2005). The future design direction of Smart Clothing development. *Journal of Textile Institute*, *96*(4), 199-210.

Baker, L. (2006). Levis redWire DLX Jeans iPod ready, Retrieved from http://www.searchenginejournal.com/levis-redwire-dlx-jeans-ipod-ready/2743/

Baurley, S. (2004). Interactive and experiential design in smart textile products and applications. *Personal and Ubiquitous Computing, 8*(3-4), 274-281.

Dunne, L. E., Ashdown, S. P., & Smyth, B. (2005). Expanding garment functionality through embedded electronic technology. *Journal of Textile and Apparel Technology and Management*, *4*(3).

Farringdon, J., Moore, A. J., Tilbury, N., Church, J., & Biemond, P. D. (1999). Wearable sensor badge and sensor jacket for context awareness. Proceedings of the 3rd International Symposium on Wearable Computers. (ISWC). 107-113.

Friedl, K. E. (2003). Signs of illness: When will technology provide greater advantage than the practiced eye of the clinician (or the military commander)? *Diabetes Technology and Therapeutics. 5*(5), 857-859.

Jovanov, E., O'Donnel Lords, A., Raskovic, D., Cox, P. G., Adhami, R., & Andrasik, F. (2003). Stress monitoring using a distributed wireless intelligent sensor system. *IEEE Engineering in Medicine and Biology Magazine. 8*(3). 49-55.

Kang, K., & Jin, H. (2007). A study on consumers' clothing buying intention adopted by the Technology Acceptance Model. *Journal of Korean Society of Clothing and Textiles, 31*(8), 1211-1221.

Kim, H., Park, S., Kim, T., & Suh, C. (2011, November). *Survey on the perception and preference on the smart wear to prevent child missing*, Poster Session presented at 2011 Fall Conferece of the Society of Fashion and Textile Industry, 265-267.

Ko, E., Sung, H., & Yun, H. (2009). Comparative analysis of purchase intensions toward smart clothing between Korean and U.S. consumers. *Clothing and Textiles Research Journal, 27*(4), 1-16.

Langenhove, L. V., & Hertleer, C. (2004). Smart clothing: A new life. *International Journal of Clothing Science and Technology, 16*(1/2), 63-72.

Lee, J. (2011). Suggestion of functional smart jacket based on wearable technology, *Journal of Korean Society of Clothing and Textiles, 35*(3), 292-303.

Lind, E. J., Jayaraman, S., Park, S., Rajamanickam, R., Eisler, R., Burghart, G., & McKee, T. (2007). A sensate liner for personal monitoring applications, In Digest of Papers of the 1st International Symposium on Wearable Computers, 98-105. Los Alam-

oitos, CA:IEEE Computer Society.

Lim, H. (2009). Smart underwear for diabetic patients. *Journal of Textile and Apparel, Technology and Management, 6*(1), 1-11.

Lymberis, A. (2005). Progress in R & D on wearable and implantable biomedical sensors for better healthcare and medicine. *Conference on Microtechnologies in Medicine and Biology.* N/A 296-298.

Mann, S. (1996). Smart clothing: The shift to wearable computing, *Communications of the ACM, 39*(8), 23-24.

Noh, M., & Park, H. (2011). Acceptance of the smart clothing according to trend and information innovation. *Journal of the Korea Contents Association, 11*(11), 350-363.

Noury, N., Dittmar, A., Corry, C., Baghai, R., Weber, J.L., Blanc, D., Klefstat, F., Blinovska, A., Vaysse., S., & Comet, B. (2004). VTAMN-A Smart clothe for ambulatory remote monitoring of physiological parameters and activity, *Proceedings of the IEEE EMBS Conference*, 3266-3269.

Paradiso, R., Loriga, G., & Taccini, N. (2005, Sep.). A wearable health care system based on knitted integrated sensors. IEEE Transactions on Information Technology in Biomedicine, *9*(3), 337-344.

Paek, K., & Ashdown, S. (2009). Development and analysis of smart jacket for the elderly. *Journal of Korean Society for Clothing Industry, 11*(2), 315-325.

Pandian, P. S., Mohanavelu, K., Safeer, K. P., Kotresh, T. M, Shakunthala, D. T., Gopal, P., & Padaki, V.C. (2008). Smart vest: Wearable multi-parameter remote physiological monitoring system. *Medical Engineering and Physics, 30*, 466-477.

Park, H., & Noh, M. (2011). The influence of product attribute of smart clothing on initial trust and purchase intention: Focused on sensor-based smart clothing. *Journal of the Korean Home Economics Association, 49*(6), 13-22.

Peksoz, S., Park, H., An, S, K., & Cao, H. (2009). Smart clothing for firefighter protection, Proceedings of the *Intelligent Textiles and Mass Customisation International Conference,* Casablanca, Morocco. (ISBN: 978-9954-8878-1-4).

Rogers, E. M. (1962). Diffusion of innovations. New York, NY: The Free Press.

Rogers, E. M. (1983). Diffusion of innovations (3rd Ed). New York, NY: The Free Press.

Rogers, E. M. (1995). Diffusion of innovations (4th Ed). New York, NY: The Free Press.

Rogers, E. M. (2003). Diffusion of innovation (5th Ed). New York, NY: The Free Press.

Sardini, E., & Serpelloni. (2010, September). Instrumented wearable belt for wireless health monitoring. Proceedings of Eurosensoors. Linz, Austria.

Stewart, D. W., & Shamdasani, P. N. (1990). Focus groups: Theory and practice. *Applied Social Research Methods Series*, *20*, Newbury Park, CA: Sage Publications.

Suh, M., Carroll, K., & Cassill, N. (2010). Critical review on smart clothing product development. Journal of Textile and Apparel Technology and Management, *6*(4)

Tao, X. (2001). Smart Fibres, Fabrics and Clothing. Cambridge: CRC Woodhead Publishing Ltd.

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