Parkview Health

Parkview Health Research Repository

Health Services and Informatics Research

Mirro Center for Research and Innovation

1-2006

Mobile applications that empower people to monitor their personal health

Kay Connelly

A M. Faber

Y Rogers

Katie Siek

Tammy Toscos PhD

Follow this and additional works at: https://researchrepository.parkviewhealth.org/informatics

Part of the Health Information Technology Commons

Mobile applications that empower people to monitor their personal health

K. H. Connelly, A. M. Faber, Y. Rogers, K. A. Siek, T. Toscos

Researchers have an opportunity to develop assistive applications that empower people to change unhealthy habits through monitoring their behavior. Mobile applications can enhance self-monitoring by providing real-time feedback and employing persuasive technology. The projects presented demonstrate the potential of persuasive, assistive applications for both chronically ill and healthy individuals.

Keywords: health informatics; patient-centered; assistive applications; preventative applications; mobile computing

Mobile Computertechnologie zur Überwachung gesundheitsspezifischer Daten für Normalverbraucher.

Mobile Geräte durchdringen zunehmend alle Lebensbereiche. Daher haben Forscher die Möglichkeit, assistierende Anwendungen zu entwickeln, die Normalverbrauchern erlauben, ihre gesundheitsspezifischen Daten im Alltag zu verfolgen. Traditionelle handschriftliche Methoden mit Zettel und Stift können durch mobile Geräte ersetzt werden. In diesem Artikel beschreiben die Autoren zwei Anwendungen, die sowohl Gesunde als auch Kranke unterstützen.

Schlüsselwörter: medizinische informatik; patientenorientiert; assistierende anwendungen; vorbeugende anwendungen; mobile computing

1. Introduction

People can schedule appointments, call around the world, and pay their taxes all from devices that fit in the palm of their hand. However, many are still using traditional pen and paper methods when they monitor their personal health. The pervasiveness of mobile computing gives researchers the opportunity to revolutionize the way people monitor their personal health, changing the paradigm from calculating one's own progress for personal monitoring to having automatic computation enriched with timely feedback. Researchers in the Security for Ubiquitous Resources Group (SURG) at Indiana University focus on creating mobile applications that empower people to take charge of their health.

In this paper, we present two applications we are developing that enable people to monitor and possibly improve their health. We begin with the Dietary Intake Monitoring Application (DIMA) that empowers the chronically ill to closely monitor their nutritional intake, thereby assisting them in adhering to their prescribed diets. We then present Chick Clique, an application that encourages healthy teenagers to increase their physical activity. We chose these two applications to highlight the shift to mobile computing applications for managing chronic disease and health maintenance. Finally, we discuss five factors to consider when developing these types of applications and the implications of our work.

2. Empowering the Ill

Our research efforts delve into the design, development, and deployment of assistive technology applications to aid the chronically ill. Here we discuss the development of the Dietary Intake Monitoring Application (DIMA) for dialysis patients.

2.1 Motivation for DIMA

Dialysis patients can only consume one liter of fluid and two grams of sodium each day. Traditional food diary methods for monitoring intake fail in 80% of patients. Further, only 11% of patients who successfully use food diaries record information in it daily. Patients who do not comply with their dietary restrictions run the risk of serious health complications and death (*Welch, 2003*). Fortunately, studies have shown that compliance rates of electronic diaries are as high as 94% (*Stone, 2003*).

Computerizing fluid and sodium intake for dialysis patients has many benefits. First, individuals can enter data in a variety of ways, such as by using voice recordings, touch screens, bar-code scanning, and a stylus. Second, mobile technology is lightweight, portable, easily accessible, and easy to carry in a pocket or purse, but sufficiently obtrusive to trigger clients to remember to record their data. Third, there is no sick-role stigma associated with mobile technologies; indeed, these technologies are associated with affluence and success, which could encourage patients to use them. Fourth, automatic time stamping allows an assessment of time intervals between recordings. Fifth, data from a mobile device can be transferred to a personal computer, saving time and reducing errors that might occur with manual entry. Finally, the age of individuals does not affect their ability or willingness to use the technology.

These findings motivated us to create a personal digital assistant (PDA) application for dialysis patients to monitor their nutritional intake with real-time feedback. Our target patient population comes from an inner-city dialysis ward and has varying literacy, math, and computer skills. Thus, our project focuses on simplifying the interaction between the device and patient in order to ensure that most, if not all, patients will be able to self-monitor.

Connelly, Kay H., B.S., M.S., Ph.D., Assistant Professor, Associate Director of the Center for Applied Cybersecurity Research, Department of Computer Science, **Faber, Anne M., B.S., M.S.**, Department of Computer Science, **Rogers, Yvonne, B.A., M.Sc., Ph.D.**, Professor of Informatics, School of Informatics, **Siek, Katie A., B.S., M.S.**, Department of Computer Science, **Toscos, Tammy, B.S., M.S.**, School of Informatics, all: Indiana University, Computer Science Department, Lindley Hall 215, 150 S. Woodlawn Ave., Bloomington, IN 47405-7104, USA (E-Mail: connelly@cs.indiana.edu)

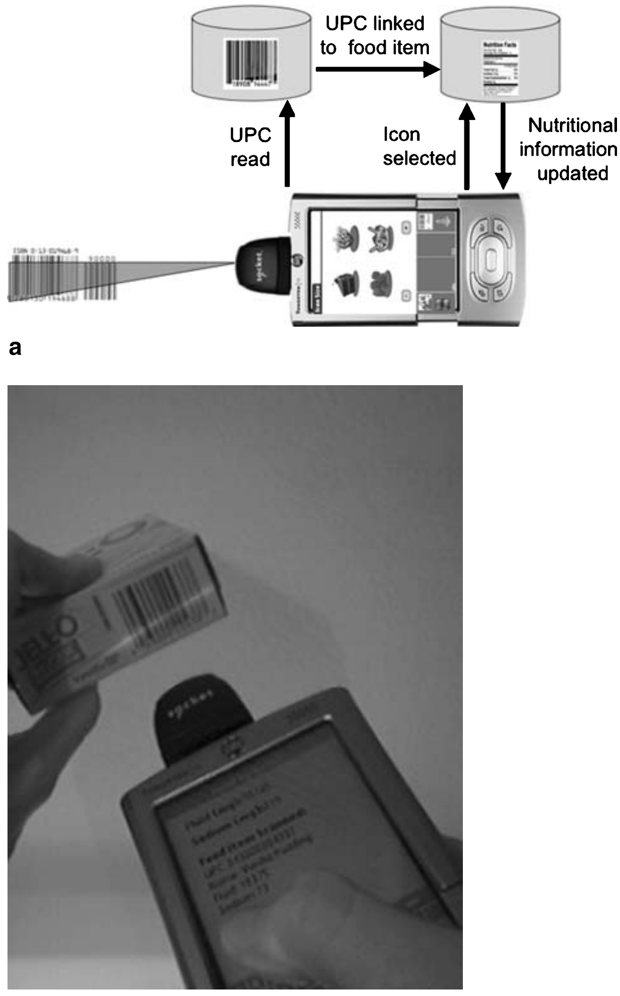


Fig. 1. (a) DIMA architecture and (b) DIMA prototype scanning a food item

2.2 Overview of DIMA

Researchers in hemodialysis adherence, computer science and informatics, nutrition, biostatistics, and nephrology are collaboratively developing DIMA. Patients can input food items by scanning a barcode or selecting the appropriate icons as shown in Fig. 1. DIMA gives real-time feedback on a user's intake in reference to prescribed fluid and sodium levels. The assistive application stores the patient's consumption information and updates fluid and sodium levels. Clinicians review a patient's intake history when the data is downloaded during dialysis treatments. From a technologist's point of view, we are interested in studying how patients use DIMA and adopt it into their everyday lives. Overall, the success of DIMA will be measured by patients' ability to control their dietary intake (*Connelly, 2005*).

2.3 Developing DIMA

We are developing DIMA with an iterative, user-centered approach by conducting three formative studies to inform our design. Our first study explored if dialysis patients could physically interact with PDAs. Participants completed three conventional PDA tasks (e.g., pushing buttons, viewing icons, and recording voice messages) and two additional tasks (e.g., scanning bar codes with two kinds of scanners). All of the tasks were measured quantitatively, such as by the number of incorrect button presses, preferred icon size, or number of incorrect recordings or scans.

We found patients could physically interact with the PDA, suggesting that use of technology to self-monitor dietary and fluid intake would be feasible in this patient population. However, they preferred icons that are larger than standard PDA icons (*Moor, 2004*). Patients thought all of the PDA tasks were easy to complete and were less intimidated if we called PDAs tools instead of computers.

Designing a food input interface for patients with varying literacy skills is challenging because icons must be used to express everything. Our second qualitative study used low fidelity, paper prototypes that showed individual food items, top-level interface designs, consumption-level icons, and intake warnings, examples of which are shown in Fig. 2. We interviewed patients, renal dietitians, nurses, and nephrologists in the development of the icons and interfaces. Paper prototypes have been successfully used to create and validate PDA interfaces for various medical applications (*Grisedale, 1997; Holzinger, 2004*). The aim of our second study was to learn how patients organized food and interpreted consumption-level icons.

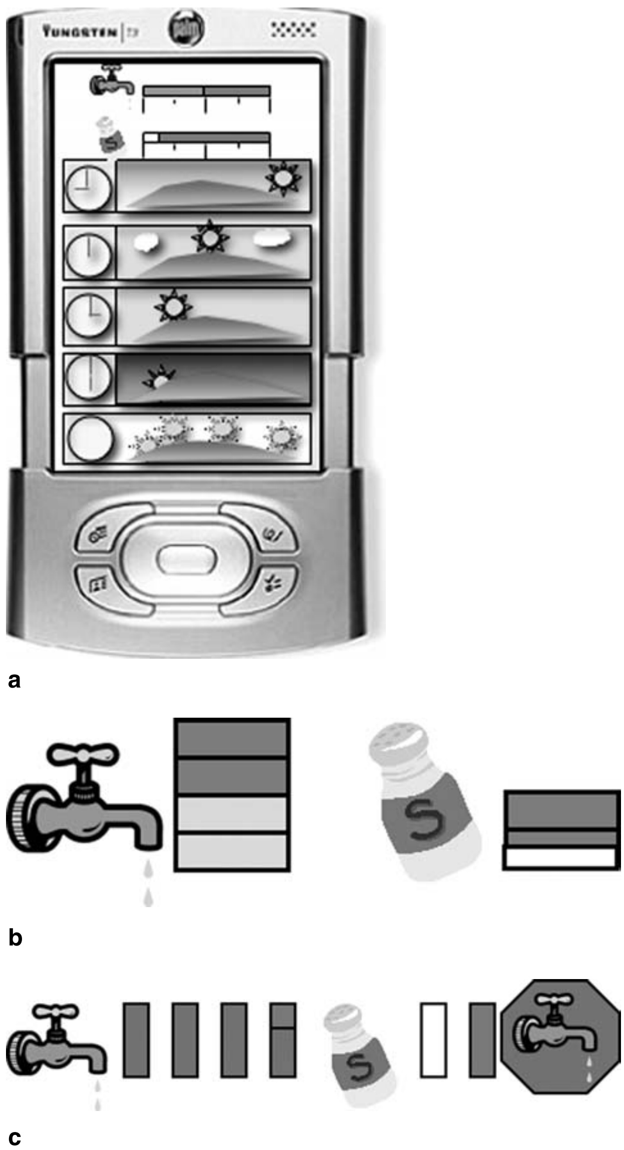


Fig. 2. (a) Example of a top-level interface design categorized by time of day; (b) a consumption-level icon; and (c) a consumption-level icon intake warning

Our results indicated that patients organized foods similarly – a combination of food groups and what they can and cannot eat. Although patients could not correctly interpret their preferred consumption-level icon, they knew to alter their behavior when they saw warning screens. In addition, we found participants were eager to show us how much they knew and sometimes prejudice of peers who did not have the same knowledge base, leading us to suggest that designers could capitalize on participants' desires to be elite when integrating technology into their lives (*Siek, 2006*).

We are in the process of conducting the last formative study, which has two goals: (1) to determine how much training will be needed to use DIMA and (2) to determine when patients input the food data. During initial interviews with dialysis patients, they told us they did not eat any foods with barcodes. However, after further discussion, we found that they typically ate canned and frozen foods that do have barcodes. Thus, we have to find out the best way to teach patients about identifying and scanning barcodes.

In addition, we are interested in when people scan the food items they eat (e.g. during meals, before bed, etc.). One of the biggest problems with traditional food diaries is that patients wait until the end of the day to record their consumption. We hope by introducing an easy method of inputting food items, like scanning, patients will input what they consume throughout the day as they eat enabling real-time feedback and proactive decision support.

For this study, we have developed an application where patients scan food item barcodes or voice record what foods they consume. We will meet with the patients every other day to go over the voice recordings and give hints about where barcodes can be found on the food items they did not scan. Our future work includes deploying a full implementation of DIMA, studying patients' acceptance of the application in their lives, and testing DIMA in other chronically ill populations.

3. Empowering the healthy

Recently, we have broadened our research agenda to include applications that empower the healthy. Empowering healthy people and teaching them about how their actions affect their health is an important step to improve quality of life and decrease future illness. In this section, we describe an application for teens called Chick Clique.

3.1 Motivation for Chick Clique

The prevalence of overweight adolescents in the United States has tripled in the past 20 years (*National health report, 2002*) due to poor dietary habits and a lack of physical activity (*The surgeon general's call, 2005*). The trends for adolescents are of notable concern because overweight adolescents are at an increased risk of becoming overweight or obese adults (*National health report, 2002*). Some researchers believe that the current generation of children may not outlive their parents, naming the killer ''Sedentary Death Syndrome'' (*Booth, Chakravarthy, 2002*). In this project, we target girls because they are more likely to become less active throughout adolescence (*The surgeon general's call, 2005*) and are twice as likely to use dangerous techniques for losing weight (*National health report, 2002*).

The goal is to determine how technology can be used to encourage changes in behavior and thinking. Technology is frequently designed to draw people's attention to specific information in an attempt to change what they do or think. For example, advertisers use pop-up ads on web sites in an attempt to lure people into purchasing items. B. J. Fogg has labeled this phenomenon ''persuasive technology.'' Persuasive technology can be used to change people's behaviors in non-commercial domains such as preventative healthcare and fitness (*Fogg, 2003*). Chick Clique focuses on changing people's habits by doing something that will improve an individual's well being through monitoring their behavior.

Chick Clique is a persuasive cell phone application that motivates teenage girls to exercise through the self-monitoring of steps taken, feedback on achieving a predefined step goal, and exploitation of peer pressure. We utilize peer pressure because competition influences teenagers' desire to exercise (*Booth, Chakravarthy, 2002*). Indeed, the teenagers we interviewed during our ethnographic study confirmed this finding. In addition, almost half of the teenagers in the United States own cell phones and teenage girls in particular enjoy text messaging to stay in continuous contact with their friends (44% of Teens and Tweens own Cell Phones; *http://www.ahorre.com (2005)*).

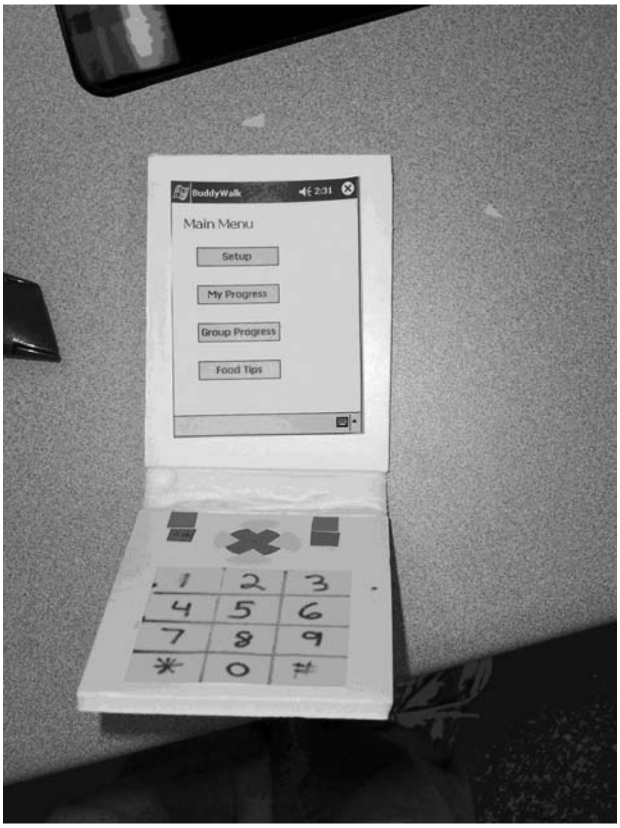
3.2 Overview of Chick Clique

Chick Clique is designed for a group of up to four friends to engage in a friendly competition where the group's walking statistics are tracked. Each girl carries a cell phone and pedometer. Initial set-up is

a

b

Fig. 3. (a) Chick Clique group progress; (b) Chick Clique individual progress; and (c) Chick Clique physical prototype



c

Fig. 3 (*continued*)

easy – the teenager enters her ''clique'' of three friends, similar to a chat interface buddy list. During the course of a day, she reads her pedometer and manually enters the number of steps she has taken into her cell phone. We specifically chose manual entry of the step count because automating the process runs the risk of the participants never looking at their personal step counts during the day. Text messages are sent to everyone at specific times during the day indicating the clique's performance and where they are in terms of achieving their individual daily stepping goal as shown in Fig. 3. The girls will also receive positive feedback from the system when they reach their individual step goal.

3.3 Development of Chick Clique

A paper prototype was developed to partially test the usability of the interface, examining two essential characteristics: (1) learnability and (2) satisfaction (*Holzinger, 2005*). We used the think aloud method during our user studies to gain more insight into usability problems. The teenagers we interviewed found the interface intuitive and easy to use and did not hesitate to tell us that Chick Clique was an effective and fun way to inspire teenage girls to exercise.

The teenagers wanted the updates and step count input automated to ''improve the impact of the mobile phone application''. The level of automation was a design decision we made because we wanted the teenagers to internalize their activity level, thus manually entering their step count would require them to look at their individual activity a few times a day. We need to further study this delicate balance between ease-of-use and health outcomes.

As an initial inquiry, we conducted a user study with two groups of four teenagers using a prototype developed for a PDA. The study evaluated the learnability and satisfaction more rigorously as well as gave some initial insights into the impact of social support via text messaging and peer pressure on the level of activity (i.e. persuasive efficacy). The initial study was of short duration, so we cannot make any conclusions as to the ability of Chick Clique to increase physical activity in the long term.

The participants manually enter their step counts into the PDA. To simulate the design concept of automatic text messaging, they established two regular times each day when they would communicate their step counts. When they received this information they entered it into the PDA application and viewed statistics as desired.

Chick Clique was persuasive because it raised the fitness awareness of the study participants. One participant stated that ''[Chick Clique] makes me think more about what I eat and how much exercise I get. It helps you feel on top of your fitness and health goals.'' This participant's step levels were higher when she used Chick Clique.

Overall, participants found viewing group performance to have the greatest impact on their activity level. However, the increased awareness of health issues went beyond the original Chick Clique design goals of monitoring step count. Many of the participants stated that they messaged one another discussing other health related issues and topics, something they wouldn't ordinarily do. One participant said that using Chick Clique ''brought us all together more. We could talk about being healthy and our issues with being healthy, because no one [normally] want to talk about that and [we were] more comfortable''.

All of the participants agreed Chick Clique would be more effective on a cell phone. This would allow for immediate viewing of the group statistics since cell phones are more likely to always be carried. Also, the timing of contact between participants was complicated. One participant stated, ''It was frustrating because I didn't get the feedback [when I wanted it] because the others weren't staying on top of it.'' Thus, our next step is to port Chick Clique to a cell phone and perform a longer user study to examine changes in behavior.

4. All things considered

While developing these two systems, five factors emerged that should be taken into account when creating assistive, mobile health applications.

4.1 How much automation is too much?

One thing to consider when developing applications that are intended to persuade, inform and change behavior is the question of how much data entry should be automated via technology. The user may be robbed of the benefits afforded by internalizing the impact of behavior upon certain outcomes such as the feelings of physical well-being when achieving a stepping goal. The teenage girls that used Chick Clique wanted step entry and group progress updating to be automated. The concern here would be that automating step entry would remove the heightened awareness of daily physical activity levels and that the opportunity to make important connections between health and exercise would be missed.

4.2 User acceptance and adoption

Before labeling a health application as a success or failure, it is imperative to study user acceptance and adoption issues within the target population. A better understanding of these two issues can help researchers recognize why participants are (or are not) using the application and increase the chance of success. As we discussed earlier, dialysis patients were hesitant to use the PDA when we described it as a personal digital assistant or small computer. However, simply changing the terminology from *digital computer* to *tool* made participants less intimidated and more likely to use DIMA. Studying user adoption helps researchers understand how to motivate diverse populations to incorporate the application into their lives.

4.3 Decreasing stigma of disease

Despite the advantages of mobile devices, researchers should be mindful of people's fears of using technology. A person who cannot physically or cognitively interact with a mobile device in a conventional way (e.g. unable to read the icons, small text, complex navigation structures), may draw attention to themselves, thus nullifying the decrease in stigma of disease. Researchers must be mindful of potential limitations and design applications with the user groups' abilities in mind.

4.4 To share or not to share . . . that is the question

Privacy is a key issue in the medical care of patients. DIMA and other health monitoring applications stand to push the envelope of what personal information individuals are willing to share. Researchers developing these technologies must carefully examine ways to ensure privacy needs are met and that access to the information is properly restricted. For example, an insurance company may cut benefits if dietary intake reports reflect non-compliance. Safeguards against breeches of confidentiality must be built into the technology, or we run the risk of patients not using the technology, thereby not gaining the benefits.

4.5 Searching for the silver bullet

Many grandiose claims have been made about the impact of assistive, mobile health applications that give the impression that they are the proverbial silver bullet. However, the reality is that even the best applications may fail to help some people. Success depends on the compliance and acceptance of the individual using the technology.

Our community must find the ideal balance between automation and internalization. We have to understand what causes participants to accept and adopt mobile solutions into their everyday lives. In addition, we must build in mechanisms to protect participants' data. All of these factors may vary depending on application, user group, and tasks. We may not create a silver bullet application, but with continued research we can create empowering assistive applications to help healthy and ill populations.

5. Conclusion

This paper described two applications that empower people to monitor their personal health and highlights factors to consider when developing such applications. DIMA can improve patients' quality of life and self-efficacy by allowing patients to make connections with the amount of fluid and sodium they consume and how they feel. Clinicians will also benefit from reviewing accurate data about patients' nutritional intake for diagnosis and personalized patient education. Chick Clique can motivate teenagers to increase their physical activity with the support of their friends. Information comes at opportune times to help user's link physical activity with feelings of well-being.

These applications are changing the paradigm of self-monitoring. Instead of paper-based food or exercise diaries, people can more accurately monitor themselves with mobile technology. The paradigm also changes the isolated process of self-monitoring into a communal, supportive process where multiple people who care about the health of the user can check the user's progress and give encouraging feedback. Developing applications to empower the ill and healthy allow us to not only help those who are ill now, but also research new ways to decrease illness in the future with preventative applications.

Acknowledgement

Katie Siek is supported by a NPSC fellowship and Sandia National Laboratories/CA. DIMA is supported by NSF grant EIA-0202048, the Lilly Endowment, and the Pervasive Technology Lab. Chick Clique is supported by an equipment donation from Microsoft. The authors thank Shunying An, Mona Prahful Gandhi, and Peter Gottschling for their help.

References

Booth, F. W., Chakravarthy, M. V. (2002): Cost and consequences of sedentary living: new battleground for an old enemy. President's Council on Physical Fitness and Sports Research Digest Series 3 (16).

Connelly, K. H., et al. (2005): Designing a PDA interface for dialysis patients to monitor diet in their everyday life. Proc. of HCI-International.

Ferraro, K. F., et al. (2003): The life course of sever obesity: Does childhood overweight matter? J. Gerontology, 58B (2): S110–S119.

Fogg, B. J. (2003): Persuasive Technology: Using computers to change what we think and do. Morgan Kaufmann Publishers.

Grisedale, S., et al. (1997): Designing a graphical user interface for healthcare workers in rural india. Proc. of CHI 1997. New York: ACM Press.

Hedley, A. A., et al. (2004): Prevalence of overweight and obesity among U.S. children, adolescents, and adults, 1999–2002. JAMA 291 (23): 2847–2850.

Holzinger, A. (2004): Application of rapid prototyping to the user interface development for a virtual medical campus. IEEE Software 21 (1): 92–99.

Holzinger, A. (2005): Usability engineering for software developers. Communications of the ACM 48 (1): 71–74.

Moor, K. A., et al. (2004): A comparative study of elderly, younger, and chronically ill novice PDA users. Bloomington: Indiana University.

National health report: Prevalence of overweight among children and adolescents (2002).

Siek, K. A., et al. (2006): Pride and prejudice: How chronically ill people think about food. Proc. of CHI 2006. New York: ACM Press.

Stone, A. A., et al. (2003): Patient compliance with paper and electronic diaries. Controlled Clinical Trials, 24 (2): 182–199.

The surgeon general's call to action to prevent & decrease overweight and obesity (2005).

Welch, J. L. (2003): Differences in perceptions by stage of fluid adherence. J. Renal Nutrition, 13 (4): 275–281.

View publication stats