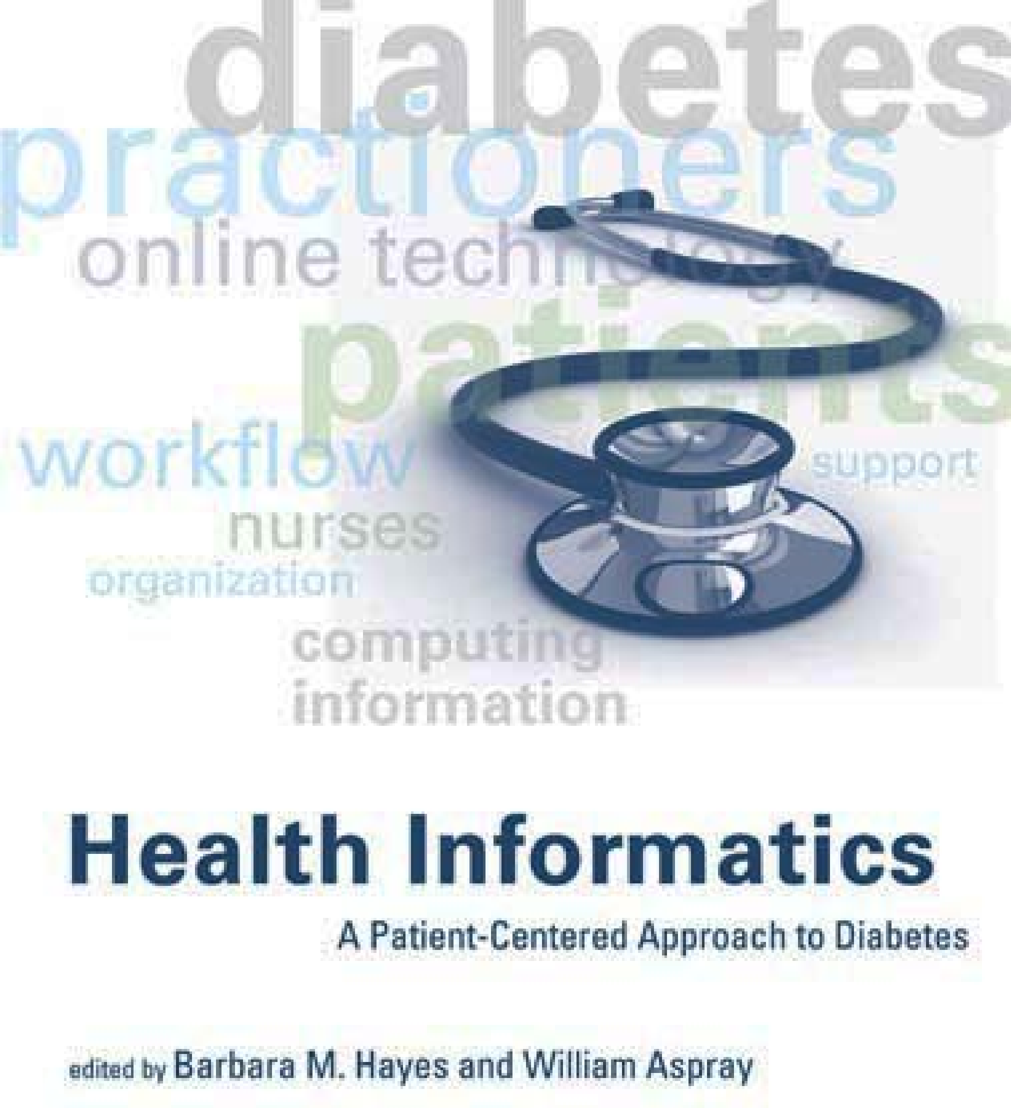

Faiola, A., & Kharrazi, H. (2010). Diabetes education and serious gaming: Teaching adolescents to cope with diabetes, in Health Informatics: A Patient-centered Approach to Diabetes, 151-177, MIT Press.

5 Diabetes Education and Serious Gaming: Teaching Adolescents to Cope with Diabetes

Anthony Faiola and Hadi Kharrazi

Computer gaming is a relatively new medium that has won wide acceptance among younger demographic groups. Health care providers know that their adolescent patients play videogames. Acknowledging this interest, researchers have begun to explore the potential of gaming to augment and reinforce disease management education. This chapter begins with a discussion of a number of behavior change and health belief models in the context of type 1 diabetes and hypoglycemia. It reviews factors affecting patient adherence and categories of intervention to improve adherence. The authors suggest that videogaming, an engaging medium with wide acceptance in the target adolescent population, may be used to increase adherence. They present a prototype of a game designed to educate adolescents of driving age about hypoglycemia, their susceptibility to it, and the necessity to take action to prevent it when driving. The chapter concludes with a review of the potential for serious games to educate and improve adherence in diabetes, as well as a number of existing serious games that are designed to assist with the management of diabetes.

Hypoglycemia (low blood glucose) can occur in diabetes patients and has the potential to be fatal and cause fatal accidents. Adherence to treatment is critical to prevent severe hypoglycemic states. Proper patient behavior is also crucial for long-term management of diabetes and prevention of complications. Behavioral models in health care, such as Theory of Planned Behavior or the Health Belief Model, are being used to improve the behavior of patients with chronic conditions. Traditional patient empowerment methods can be helpful in achieving higher compliance, but adolescents need a higher level of motivation. Serious games are shown to be effective in increasing compliance to treatment. Serious games can also be used to educate adolescents on how to minimize the effects of hypoglycemia while driving. Diabetes education, blood glucose awareness education, and interactive games are shown to be effective in preventing these consequences.

Type 1 Adolescent Diabetes Mellitus

Type 1 Diabetes Mellitus (T1DM) is a chronic, lifelong disease that is common among children and adolescents. It is estimated that 8.7% of individuals less than 20 years of age have diabetes (Center for Disease Control and Prevention, 2007). The majority of diabetic children and adolescents in the United States have type 1 diabetes, which is estimated to affect 1.7 per 1,000 children and adolescents (Amillategui, Calle, Alvarez, Cardiel, & Barrio, 2007; Lipman, 1993). Moreover, the aforementioned group's failure to maintain glycemic control and inability to adhere to treatment often leads to long-term complications. In many cases, what follows is a degradation of quality of life that impacts the child's personal and social existence (Hahl et al., 2002).

Diabetes is the sixth leading cause of death listed in U.S. death certificates, resulting in $132 billion in total direct and indirect costs in 2002 (Center for Disease Control, 2006). Chronic uncontrolled hyperglycemia can lead to microvascular (retinopathy, nephropathy, and neuropathy) and macrovascular (coronary artery disease and stroke) complications, resulting in significant morbidity and early mortality. Diabetes remains the largest identifiable cause of blindness and chronic renal failure in the United States. Intensive treatment of diabetes significantly reduces the risk of microvascular complications and, with intensive treatment of hypertension and elevated levels of lipids, may reduce the risk of cardiovascular complications.

T1DM is almost always initiated by an autoimmune process that results in failure of the pancreas to produce insulin. Multiple daily injections of insulin are required for survival. Although tight control of blood sugar levels is recommended to reduce the risk for long-term complications, tight control carries the risk of severe hypoglycemia (low levels of blood sugar), which may result in impaired judgment, loss of consciousness, and seizure. Frequent self-testing of blood sugar in combination with the use of a long-acting insulin and meal time injections of rapid-acting insulin or insulin pumps can decrease, but not eliminate, the risk of severe hypoglycemia. The mechanisms that regulate blood glucose are complex and involve the carefully orchestrated interaction of multiple hormones, intestinal peptides, autonomic nervous system, liver, skeletal muscles, exercise, diet, and insulin pharmacokinetics (Cryer, 2003).

Hypoglycemia

Etiology Individuals with T1DM are at risk because all three of the physiological defenses against the development of hypoglycemia (decrements in insulin and increments in glucagon and epinephrine) are compromised. Mild hypoglycemia, experienced as tremulousness, sweating, hunger, and anxiety, is common and, although annoying, is not dangerous if promptly treated with oral rapid-acting carbohydrates. Severe hypoglycemia, however, can be dangerous and may be life threatening if left untreated or if it occurs when driving. Severe hypoglycemia is increasingly common with new recommendations to achieve normoglycemia. Consequently, the rate of hypoglycemia and hypoglycemia unawareness has increased markedly, ranging from 1.15 events per patient per year in a Scottish survey to 16.1 and 17.9 events per 100 patients per year in Australia and Europe, respectively (Donnelly et al., 2005; Frier & Fisher, 1999; Gerich, Mokan, Veneman, Korytkowski, & Mitrakou, 1991; Johnson, Koepsell, Reiber, Sergachis, & Platt, 2002; Leese et al., 2003; Zammit & Frier, 2005).

Prevention and Preventive Outcomes The risk of severe hypoglycemia is increased by strenuous exercise, with sleep, among individuals with longer duration diabetes (hypoglycemic unawareness), and following an episode of hypoglycemia. Severe hypoglycemia is also greater among those attempting to achieve normal blood glucose levels (normal levels of Hemoglobin A1c), as well as those in poor control who fail to assume responsibility for managing their diabetes (Cryer, 2004). Increasing duration of diabetes increases the likelihood for hypoglycemia for at least two reasons: (a) Patients are less able to respond to low blood sugar levels (defective glucose counter-regulation) because of absent glucagon and decreased epinephrine responses, and (b) they are also more likely to develop hypoglycemia unawareness because of the loss of the neurogenic (autonomic) warning symptoms (e.g., palpitations, tremor, anxiety, diaphoresis, and hunger) that previously allowed the patient to recognize and correct developing hypoglycemia. Both syndromes are associated with a substantially increased risk of severe iatrogenic hypoglycemia.

Compared with younger individuals, adolescents are at increased risk for severe hypoglycemia because many have had diabetes for 10 or more years, exercise is often vigorous and unplanned, sleeping in on weekends is common, and the frequency of self-testing blood glucose and attention to dietary recommendations decreases as adolescents assume greater responsibility for diabetes management. Moreover, the common use of alcohol ushers in additional complications. Ingestion of alcohol increases the risk for severe hypoglycemia hours later because it interferes with the ability of the liver to produce blood glucose when the individual is not eating. This interference and potential impairment of judgment make excessive alcohol use particularly dangerous.

Behavioral Models

Behavioral Change Models

Disease management programs were developed under the assumption that health services utilization and morbidity could be reduced for those with chronic illness by augmenting the traditional episodic medical care system with services and support between doctors' visits (Linden & Roberts, 2004). For many chronic diseases, much opportunity exists to improve the quality and consistency of care, such as regular tests of glucose control (HbA1c). Behavioral models attempt to achieve disease management goals by:

1. Accurately identifying those in the population with the disease or at significant risk of developing the disease,

2. Convincing those with the greatest risk of morbidity and health services utilization to participate in the program, and

3. Intervening with physicians and patients to effect some change in health behavior.

Behavioral models are categorized according to targeted intervention levels: individual, interpersonal, and community. Some of the behavioral models target all of the levels that are categorized under comprehensive models (Linden & Roberts, 2004). Figure 5.1 depicts the behavioral models used in different levels.

In the next sections, the Planned Behavioral Model and the Health Belief Model are described in more detail as they are used by two studies discussed later in this chapter.

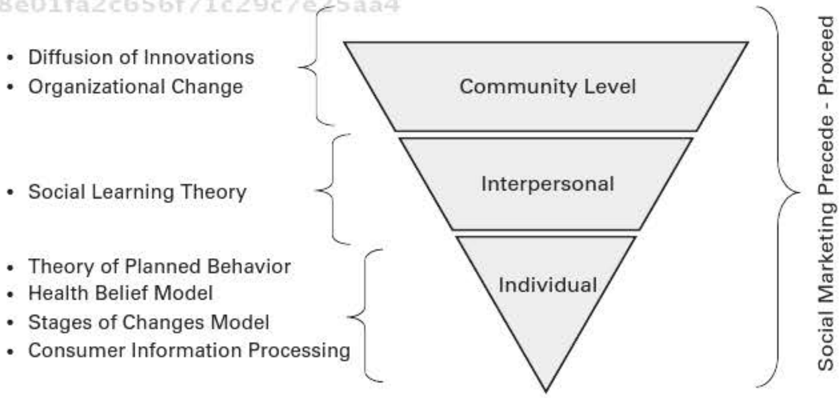

Figure 5.1
The behavior modification inverse pyramid (Linden & Roberts, 2004).

Theory of Planned Behavior

According to the theory of planned behavior (TPB), human action is guided by three components that include beliefs about the: (a) "likely outcomes of the behavior and the evaluations of these outcomes (behavioral beliefs)," (b) "normative expectations of others and motivation to comply with these expectations (normative beliefs)," and (c) "presence of factors that may facilitate or impede performance of the behavior and the perceived power of these factors (control beliefs)" (Ajzen, 1991). Thus, behavioral beliefs make a behavior favorable or unfavorable (attitude), normative beliefs produce a social pressure (subjective norm), and control beliefs show the intensity of control factors (perceived behavioral control). In combination, behavioral beliefs, subjective norms, and perceptions of behavioral control lead to the formation of a behavioral intention. As a general rule, the more favorable the attitude and subjective norm and the greater the perceived control, the stronger should be the person's intention to perform the behavior in question.

Finally, given a sufficient degree of actual control over the behavior, people are expected to carry out their intentions when the opportunity arises. Intention is thus assumed to be the immediate antecedent of behavior (Ajzen, 1985). Behavioral changes can be achieved by targeting any of the factors: attitudes, subjective norms, or perceptions of behavioral control. The result of such an intervention should produce changes in behavioral intentions, and, given adequate control over the behavior, the new intentions will be carried out under appropriate circumstances (Ajzen, 1985). Figure 5.2 is a schematic representation of the theory.

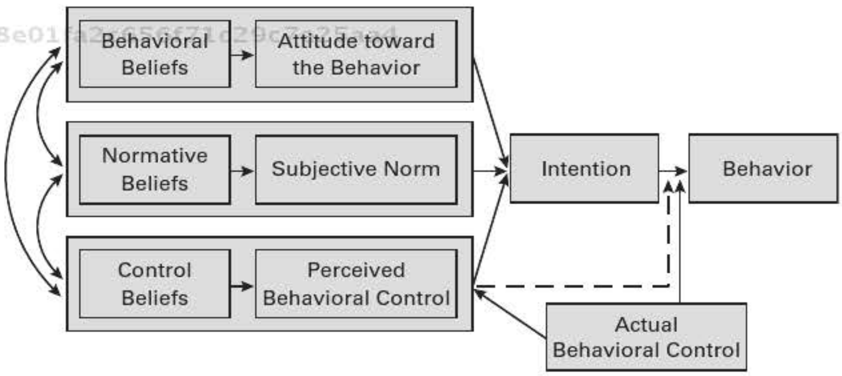

Figure 5.2
The Planned Behavioral Model (Ajzen, 1991).

Health Belief Model

The Health Belief Model (HBM) is a theoretical framework designed to explain and predict preventive health behaviors. Originally developed by Hochbaum and later modified by Rosenstock, it is based on Bantura's Social Learning Theory (Becker, 2002). HBM outlines that an individual's intention to engage in a health behavior is determined by general health values, specific health beliefs about vulnerability to a particular health threat, and beliefs about the consequences of the health problem. HBM can be used to evaluate or influence an individual's behavioral changes with regard to a particular health condition. The model suggests that, following a *clue to action*, the likelihood that an individual will take action concerning a health condition is determined by the person's desire to take action and by the perceived benefits of the action weighed against the perceived costs of barriers. The model also evaluates how an individual estimates his or her susceptibility to a condition and the benefits of detection and treatment for that particular illness (figure 5.3).

This model is important because the key factors that are thought to influence behavior are modifiable through intervention. It includes knowledge about the condition but maintains that knowledge alone is insufficient to change behaviors. This is

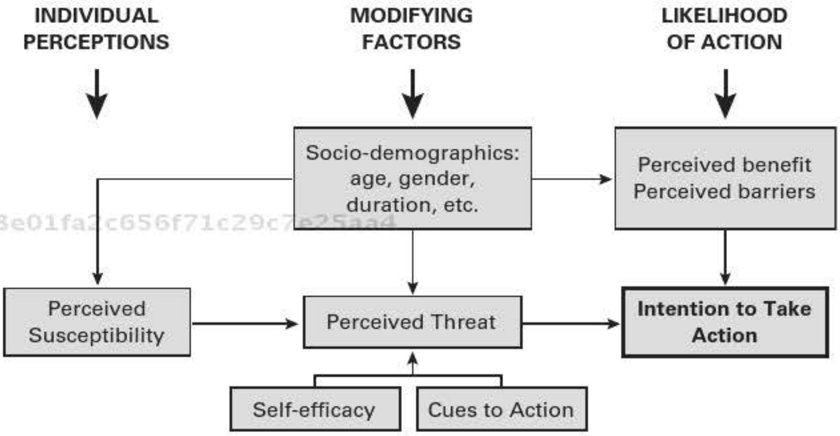

Figure 5.3
Perceived susceptibility is the perception of the likelihood of experiencing a condition that would adversely affect one's health. *Perceived threat or seriousness* refers to the beliefs a person holds concerning the effects a given condition would have on his or her life. *Perceived benefits of taking action* are the positive aspects of the behavior. *Barriers to taking action* refer to the characteristics of a treatment or preventive measure that may be inconvenient, expensive, unpleasant, painful, or upsetting. *Cues to action* provide the impetus to act. The net of benefits minus barriers provides the path of action. These cues may be internal or external.

in contrast to other theories that explain behaviors solely by means of nonmodifiable factors such as age, race/ethnicity, socioeconomic status, or factors that are difficult to change such as psychopathology. Knowledge and perceptions about a condition may be modified through interventions. HBM and its modifications (such as the Theories of Reasoned Action and Planned Behavior) have been shown to explain a wide array of health behaviors from dental hygiene to nutrition. Interventions based on the HMB and its variations have been shown to be effective in changing health behaviors ranging from condom use to nutrition and exercise (Champion et al., 2002; Chew, Palmer, & Kim, 1998; Mirotznik, Feldman, & Stein, 1995; Orr, Langefeld, Katz, & Caine, 1996).

Preventing Adolescent Hypoglycemia

Adherence to Treatment

Rates of adherence[1] for individual patients are usually reported as the percentage of the prescribed doses of the medication actually taken by the patient over a specified period. Some investigators have further refined the definition of adherence to include data on dose taking (taking the prescribed number of pills each day) and the timing of doses (taking pills within a prescribed period). Adherence rates are typically higher among patients with acute conditions, compared with those with chronic conditions; persistence among patients with chronic conditions is disappointingly low, dropping most dramatically after the first 6 months of therapy (Haynes, McDonald, & Garg, 2002; Jackevicius, Mamdani, & Tu, 2002).

Factors Affecting Adherence Winnick, Lucas, Hartman, and Toll (2005) describes the key factors affecting adherence as social and economic circumstances, particularly health literacy, patient belief systems, patient education, acceptability and palatability of the medication, and adverse effects of the medication. Figure 5.4 depicts the factors affecting adherence.

Several studies have shown that age is significantly correlated with compliance (Johnson, Silverstein, Rosenbloom, Carter, & Cunningham, 1986). In studies of diabetic patients, adolescents exhibited poorer compliance than younger children to injections, exercise, dietary, and glucose test prescriptions (Bond, Aitken, & Somerville, 1992).

Adherence Interventions Osterberg and Blaschke (2005) categorize the adherence interventions into four general categories:

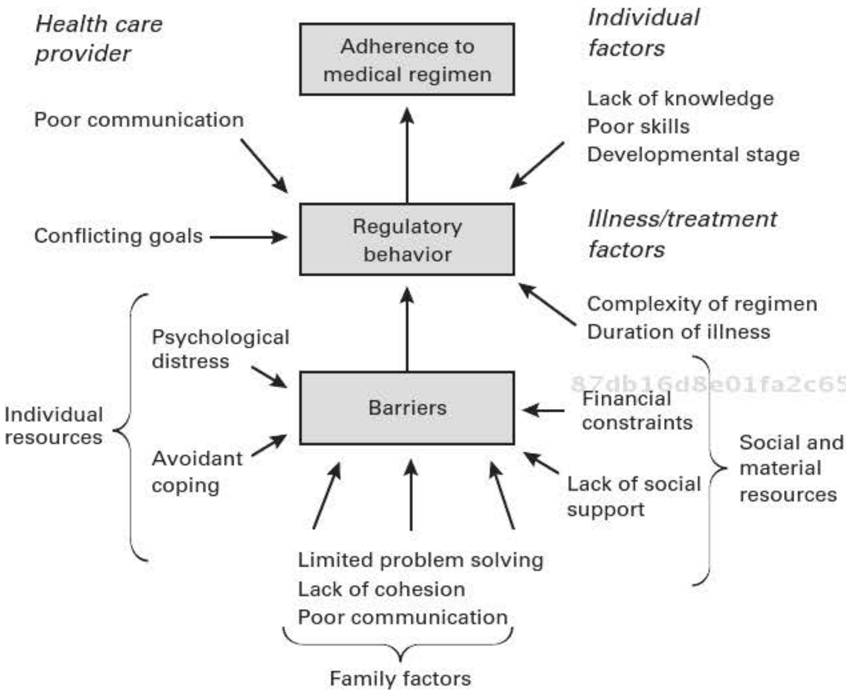

Figure 5.4
Factors affecting treatment adherence (Fielding & Duff, 1999).

1. Patient education should involve patients, their family members, or both.

2. Dosing schedules should be improved, including the use of pillboxes to organize daily doses, simplify the regimen to daily dosing, and remind patients to take medications.

3. Clinics should increase their hours and therefore shorten wait times. Patients who miss appointments are often those who need the most help to improve their ability to adhere to a medication; making follow-up visits convenient and efficient for the patient is important.

4. Improve communication between physicians and patients with interventions that enlist ancillary health care providers, such as pharmacists, behavioral specialists, and nursing staff.

Patient Empowerment

Definition Diabetic educators have defined *patient empowerment* as “the discovery and development of one’s inherent capacity to be responsible for one’s one life. [And the necessity to] influence their own behavior and that of others to improve the quality of their lives" (Funnell & Anderson, 2003). The major hurdle in traditional methods of patient empowerment is motivating patients to change their behavior and maintain that change. This problem becomes even more pronounced in adolescents.

Patient Empowerment and Serious Gaming One of the most significant factors in better health outcomes for children with long-term or chronic disorders is empowering the patients to consistently comply with the treatment regimen even when they are not experiencing direct effects. Ubiquitous digital games, now considered a mass medium (Wolf, 2001), can be exploited to achieve these health objectives. The factors that make digital games so engaging can be applied successfully in health contexts where motivation and engagement are necessary for the management of chronic conditions.

Today, the world of computer gaming has expanded rapidly to include applications other than entertainment, such as education. This new genre of games is named *Serious Games* (Blackman, 2005; Ye, 2004). As such, games differ in their use of visual, textual, and auditory channels for feedback, scaffolding challenges, visible goal indicators, overviews and schematics, and ease of learning (Dyck, Pinelle, Brown, & Gutwin, 2003). This is in stark contrast to most of the applications we use. The process of learning how to play, how to improve skills, and how to succeed is much more natural in most games than in other software applications.

Enhancing Compliance in Type 1 Diabetics with Serious Games

Serious games have been used in behavioral change studies. In a study with type 1 diabetic patients, a game framework based on the Theory of Planned Behavior was used to increase the compliance/adherence rate to treatment. Parents reported the compliance rates of their children, and the children (patients) were awarded in the game based on their compliance to treatment. Health points collected by compliance can be used in the game to buy new items or play additional minigames. The study showed a significant increase in compliance rates (Kharrazi, Watters, & Oore, 2008). Figure 5.5 includes screenshots of the game plus the parents' entry form.

In an ideal framework for chronic diseases such as type 1 diabetes, both patients' medical records and personal profiles can be used to determine the behavioral stage of the patient. Then the proposed behavioral model can be interpreted and analyzed by an adaptive system to create new adapted strategies for the patient to be challenged. The tailored strategy in the game will cause positive reinforcement to improve behavioral changes in the patients. This framework is depicted in figure 5.6.

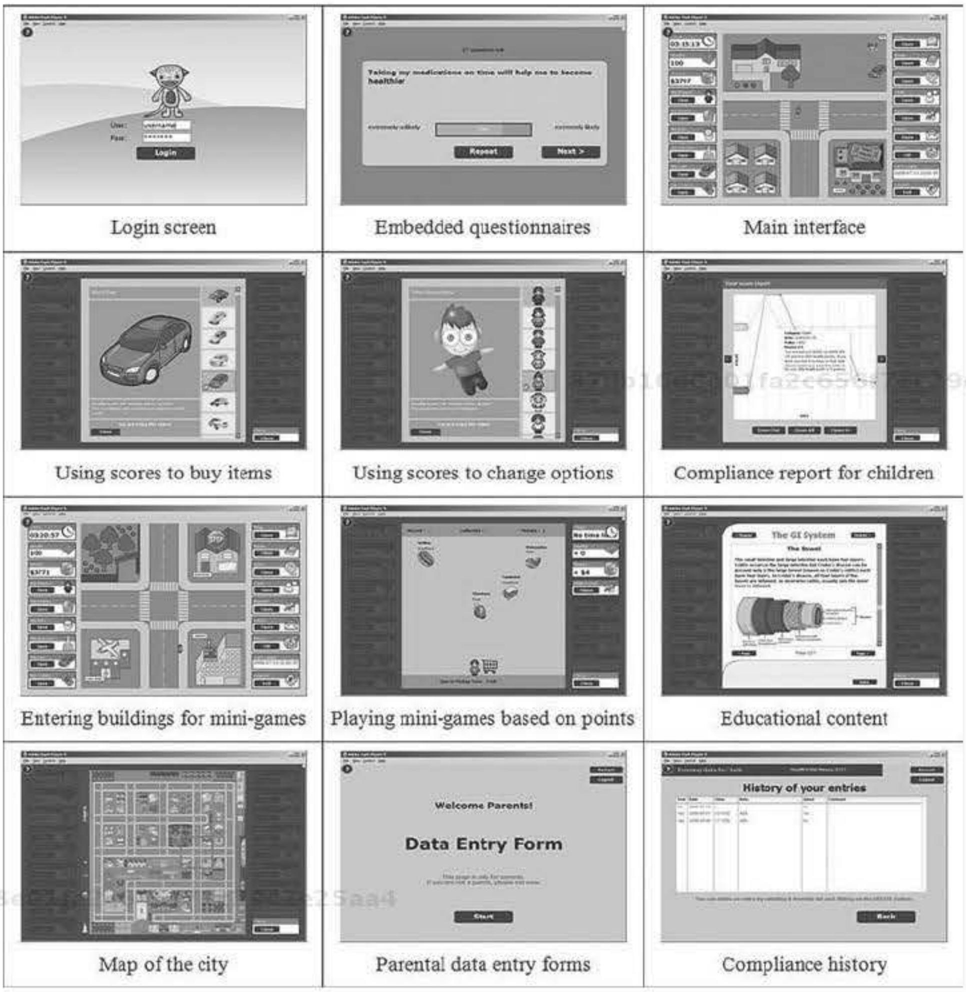

Figure 5.5
Screenshots of a serious game designed for diabetic patients (Kharrazi, Watters, & Oore, 2008).

Preventing Consequences of Adolescent Hypoglycemia

Hypoglycemia and Driving

Hypoglycemia affects mood and impairs cognitive function, causing problems with attention, memory, and judgment. Although data are conflicting, motor vehicle accidents (MVAs) appear to be more common among adults with diabetes compared with those without diabetes (Stork, van Haeften, & Veneman, 2006). A U.S. survey of adults

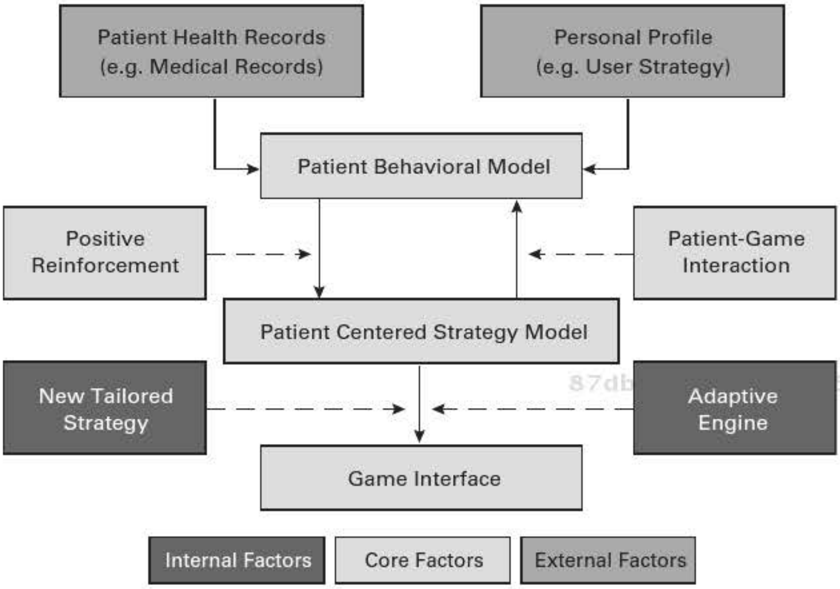

Figure 5.6
Schematic view of a serious game framework to track/improve compliance in chronic health conditions such as diabetes based on behavioral change models.

with T1DM revealed that 31% admitted to having driven in a hypoglycemic stupor during the past 2 years, and 28% experienced hypoglycemia while driving in the past 6 months. Laboratory studies in adults using driving simulators demonstrate that at a blood glucose level of 47 mg/dl, performance was reduced with increased swerving, spinning, time spent outside the appropriate lane, and compensatory slow driving (Cox, Penberthy, Zrebiec, Weinger et al., 2003).

Only 50% of those demonstrating reduced driving ability would not drive under similar conditions. Although 79% of the adults detected hypoglycemia at a blood glucose level of 50 mg/dl, only 32% took corrective action (Cox, Gonder-Frederick, & Clake, 1993; Cox, Gonder-Frederick, Kovatchev, Julian, & Clarke, 2000). Adults with recurrent hypoglycemia-related accidents have been found to be more sensitive to insulin and experience greater impairment in neurological function and judgment than others at the same glycemic level (Stork, van Haeften, & Veneman, 2006).

Adolescents as a Vulnerable Group Despite the lack of data, the authors believe that adolescents with diabetes may be at greater risk for automobile accidents. Automobile accidents are the leading cause of death among adolescent women and white adolescent males and often involve the use of alcohol (Bingham, Shope, & Raghunathan, 2006; Williams, 2006). Accidents are most common during the first 6 to 12 months of driving (controlled for adolescent's age). Increasing evidence shows that the adolescent brain is quantitatively different from that of adults (i.e., not yet mature with respect to attention, information processing, and judgment), which, combined with lack of driving experience, probably accounts for some of the increased accident rates among this age group (Casey, Tottenham, Liston, & Durston, 2005; Johnson & Munakata, 2005; Paus, 2005).

Alcohol and substance abuse are common among adolescents ages 15 to 21. Research indicates that alcohol impairs cognitive function, and adolescents are more vulnerable to the effects of alcohol (Cheyne et al., 2004). Although alcohol-related automobile deaths have decreased among adolescents, they are among the leading causes of death in this age group (Williams, Ferguson, & Wells, 2005; Keall, Frith, & Patterson, 2005). In addition, inexperienced drinkers become intoxicated at lower levels of alcohol with greater impairment of judgment, and those with diabetes are more likely to become hypoglycemic when consuming alcohol. Concomitant use of marijuana further impairs judgment and increases the risk for accidents (Asbridge, Poulin, & Donato, 2005).

Several other factors may place adolescents at increased risk, including those with diabetes. Cell phone use while driving is widespread. A recent study of college students in Bloomington found that 21% of MVAs involved the use of a cell phone by one of the drivers (Seo & Torabi, 2004). Adolescents generally do better when presented with clear guidelines and expectations for behavior. Some evidence indicates that when parents explicitly outline their expectations for driving, teens have fewer accidents (Hartos, Shattuck, Simons-Morton, & Beck, 2004). However, many parents do not present guidelines or rules for driving to their adolescent children (Sherman, Lapidus, Gelven, & Banco, 2004; Votta & MacKay, 2005).

The authors could find no data on the degree to which parents of adolescents with diabetes provide explicit guidelines or rules about driving and the prevention of hypoglycemia. We suspect that only a small minority of parents are sufficiently knowledgeable about hypoglycemia and driving to allow them to help their adolescent.

Diabetes Education for Improving Lifestyle

Diabetes Education Education is fundamental to improving the lifestyle of diabetic patients. Many children with diabetes, however, are not receiving education that can prevent ill health, with ramifications as severe as early death. Knight, Dornan, and Bundy (2006) suggest that there is a "widespread assumption that transferring knowledge will improve health outcomes but there is little empirical support for this assertion" (p. 485). Although there are reasons to anticipate that online medical education has the "potential to improve clinical performance and patient outcomes, there is little data to support that positive assertion" (Casebeer et al., 2003). For example, systematic reviews have demonstrated that educational and psychosocial interventions have issued in limited benefits on glycemic and behavioral outcomes (Murphy, Rayman, & Skinner, 2006).

Murphy, Rayman, and Skinner (2006) argue that the goal of education is to increase knowledge by developing attitudes that lead to "improvements in quality of life, reduction in or prevention of complications, and facilitation of the responsibility, decision making and self-care of people with diabetes" (p. 485). Sumner, Baber, and Williams (2000) also note that, although there is some merit to health education, people with diabetes are not getting much benefit. The authors believe that the lack of impact of diabetes education results from such education's inability to call patients to action. Successful diabetes education must do more than disseminate knowledge; diabetics must be empowered to use their newly obtained knowledge in problem solving and self-management.

Innovations in technology are emerging with pedagogical strategies that can alter the way health and medical education is delivered (Rossett & McDonald, 2006). For example, between 2001 and 2006, physicians using the Internet for medical/health education rose from 2.7% to 31% (Brown, Proctor, Sinkowitz-Cochran, Smith, & Jarvis, 2001). Also, as Murphy, Wadham, Rayman, and Skinner (2007) point out, improving diabetes care for children and young people requires "behavioral and educational programs to provide the support and motivation necessary to integrate the complex demands of diabetes self management into daily life" (p. 1261).

In the early 1990s, the concept of empowerment for diabetic patients brought in a renewed way of addressing health education (Funnell et al., 1991). Funnell et al. continue to support their claims that diabetics are empowered when they have sufficient knowledge, with a twofold result: (a) rational decisions and sufficient control and resources to implement their decisions, as well as (b) sufficient experience to evaluate the effectiveness of those choices.

There is a critical need to take innovative approaches to effectively delivering diabetes education that can address the complexity of developmental issues that face children and adolescents specifically. The aim of educational interventions is to teach diabetic patients the skills and knowledge related to everything from glucose level testing and injection techniques to carbohydrate counting (Murphy, Rayman, & Skinner, 2006). Although psychosocial interventions are more focused on providing support to problem solving, coping skills, and behavioral therapy, Murphy and colleagues argue that combining these with psychotherapeutic interventions can help to improve "knowledge, skills and self-efficacy across various aspects of diabetes self-management" (p. 936).

Research on adults with diabetes indicates that hypoglycemia awareness education is effective at reducing the risks of severe hypoglycemia while driving (Asbridge, Poulin, & Donato, 2005; Cheyne et al., 2004; Seo & Torabi, 2004; Sherman, Lapidus, Gelven, & Banco, 2004). We could find no research specifically addressing adolescents.

Blood Glucose Awareness Education Blood glucose awareness education (BGAE) is designed to teach individuals to more accurately estimate when blood glucose levels are low (68–70 mg/dl). Although the programs and study designs vary, the data indicate that the interventions have a long-term impact. One study demonstrated a significantly reduced accident rate 4 years after the intervention (Cox et al., 2001). However, it had no impact on adult subjects' decision to avoid driving when hypoglycemic.

At the same time, a Dutch study on adults with BGAE found that the decision not to drive during hypoglycemia improved significantly, and patients were involved in traffic accidents less often (i.e., 0.6 vs. 0.2 accidents per patient per year) (Broers et al., 2002). These and other findings suggest that BGAE may well be a relatively simple and effective method to reduce traffic violations and accidents in adult patients with diabetes. To date, however, no research has been conducted with young adults (Cox, 2006).

The existing programs for BGAE and driving are intensive group interventions requiring multiple sessions over a 3-month period (Cox, 2006; Cox et al., 2001). We believe that such an intervention can be successfully adapted for use with adolescents to take advantage of newer interactive media technologies. Computer-based education using new media technologies has been used successfully with adolescents in research settings. For example, computer-assisted interviews with audio have been found to be better than paper-and-pencil questionnaires or one-on-one interviews to collect *sensitive* personal information with adolescents. The effectiveness of computer- and Web-based interventions varies depending on the outcome and the intensity of the intervention (Chen & Yeh, 2006; Griffiths, Lindenmeyer, Powell, Lowe, & Thorogood, 2006; Suminski & Petosa 2006; Sundberg et al., 2005).

Moreover, brief (single-session) interventions can increase knowledge. Behavioral change requires greater intensity and refresher updates. Computer technology offers advantages over traditional formats: cost, fidelity, replicability, ease of use, engaging interactivity, data storage, and dissemination capacity. Computer technology allows for more private disclosure than interventions in live group settings. Furthermore, variation in administration, which is always possible when interventions are delivered in person, is eliminated in computer-based approaches; all respondents receive the same information, rendering this method of delivery highly consistent over repeated administrations.

Using Serious Games to Educate As suggested earlier, patient empowerment is considered to be one of the key factors for improving and maintaining the health status of the population, particularly within the context of chronic diseases such as diabetes. Early education after initial diagnosis of a chronic disease has not been shown to be effective in causing patients to change their behavior toward managing their chronic disease. For example, providing medical information to young diabetics has not been shown to be associated with improved injection behaviors (Keers et al., 2004). Consequently, interventions that can change patients' long-term behavior, rather than simply transfer abstract knowledge about their disease, need to be designed. To address this problem, health educators are turning to serious gaming technologies that are designed and usability tested to provide unique solutions (Faiola, 2006; Faiola & MacDorman, 2008; Kharrazi, Watters, & Oore, 2008).

A study conducted by Schinke and Schwinn (2005) developed and tested a gender-specific intervention (GSI) for preventing substance abuse among adolescent girls. Analyses of pretest to posttest gain scores showed that, compared with girls receiving conventional intervention, GSI girls possess a larger repertoire of stress-reduction methods; report lower approval of cigarettes, alcohol, and drugs; identify more unhealthy ways to deal with stress; report lower likelihood of cigarette use or alcohol consumption if asked to do so by best friends; and hold stronger plans to avoid cigarettes, alcohol, and drugs in the next year. Although computer-mediated prevention approaches show promise with youths (ages 18–21), no controlled studies to date have tested these approaches in the delivery of gender-specific intervention for girls and substance abuse.

Youths who receive prevention programs via computer can navigate through topic modules at their own pace; receive stimulating and varied content through interactive games, skill demonstrations, and guided rehearsals; and, in the process, enjoy high-quality graphics, judiciously placed text, and developmentally and culturally tailored audio tracks and computer animations. Computers are ideal for intervening with youth on such sensitive topics as drug and alcohol use because they allow for more private disclosure than interventions in live group settings.

As the entertainment sector of gaming continues to grow, serious game design and development is now serious business. Interactive single- and multiplayer games are increasingly being used to train individuals in a broad array of industries, in both the private sector and the military. Serious games are being used to train, educate, and change human behavior. As Breslin, McGowan, Pecheux, and Sudol (2007) outline, Stanford University's Medical Media and Instructional Technology group is using game technology to create a three-dimensional virtual emergency room (ER) department, where residents and medical students control the actions of their onscreen avatars in a virtual ER environment. Through these simulated ER spaces, they learn the best ways to respond to different trauma scenarios. Schott and Hodgetts (2006) add that some of the positive health benefits associated with the use of game technologies are in relation to surgical training and therapeutic interventions, physical exercise, health education, and community participation. Also, the U.S. Army has recently created six new Medical Simulation Training Centers to provide training for combat medics and create a standardized program of instruction. "Eventually this training will be extended to teach combat-lifesaving techniques to all soldiers" (p. 17).

The Serious Games Initiative, a group founded at the Woodrow Wilson Center for International Scholars, is another place in health care where interactive game development is advancing. The purpose of the group is to support community, knowledge, and business development using gaming technologies to advance health and the overall health care industry. In the 2008 Games for Health national conference, many emerging applications of game technology for health care were showcased. For example, in a game using PDWii technology, patients with Parkinson's disease receive help in balance and mobility. This new application of the PDwii technology is currently being developed by Red Hill Studios and the University of California–San Francisco School of Nursing. The findings of this research will be used to track patient progress while being integrated into the patients' daily regime. Kid's Interactive Creation Kiosk (K.I.C.K.) is another game that uses a new touch screen system and software technology developed for young children by a team of graduate students at Carnegie Mellon's Entertainment Technology Center. The game design focuses on hospital waiting rooms and other similar health care settings (Sawyer, 2002).

The popularity of digital games across a broad demographic has led researchers to speculate that game interaction can be useful in health contexts. Games can engage users in a way that educational material does not. Although the main focus of the games is entertainment, this entertainment is based on "serious" challenges, which make it suitable for any context where factors such as effective learning, self-motivation, and skill practice are required (Kharrazi, Watters, & Oore, 2008). There are similarities in the goals of digital games and treatment objectives. These can include motivation to deal with the treatment, engagement, persistent compliance with the treatment, skill improvement, and strategies to cope with difficulties (Watters et al., 2006).

Studies have shown that children who know more about their disorder have better health outcomes. The use of games to encourage the learning of health content has become popular over the last 5 years. The idea is that game scenarios and interactions will increase the motivation of children to engage in the educational content (Kharrazi, Watters, & Oore, 2008). Long-term application of games for the treatment phase of chronic disorders has not been studied to the same degree as short-term application of games for the initial learning phase. Palermo, Valenzuela, and Stork (2004) used Personal Digital Assistants (PDAs) for children with headaches or juvenile arthritis to keep their daily journals. In a study with 60 children (ages 8–16), they found that the children with the PDA electronic diary completed the diary on more days than the children using the paper journal. Furthermore, the children using the PDA made fewer errors.

Educational Gaming for Adolescent Drivers

A recent pilot study of an educational game was aimed at adolescent diabetic drivers with T1MD. This study was a required first step (phase 1) in developing a larger (phase 2) and more intensive intervention within the context of a computer-assisted BGAE program. As such, the resources required to develop and implement a large-scale intervention to change behaviors is beyond the scope of what is outlined here. The purpose of the pilot study is to change adolescents' and parents' attitudes about hypoglycemia and driving, as well as to change their knowledge of perceived susceptibility, perceived seriousness/threat, perceived benefits to taking action, and barriers to taking action. Finally, the ultimate intent is to decrease the risk of hypoglycemia while driving among adolescents with diabetes. Changing these factors is the cornerstone for ultimately changing adolescent driver behaviors.

In phase 1, the authors adapted the Cox intervention from one that requires 3 months of group meetings to a brief educational intervention to be used on a lap top computer (Cox, Gonder-Frederick, Kovatchev, Julian, & Clarke, 2000; Cox et al., 2001). In this phase, four gaming modules or scenarios were developed, along with the HBM attitudinal and behavioral measures. Next, adolescent participants were recruited, and the education game modules were tested for content clarity and usability through a usability and user experience evaluation of the product. After the usability findings were collected and analyzed, the appropriate changes were made.

Each game module/scenario began with a driving scene in which the adolescent was the driver. The car was controlled by the up, down, left, and right arrow keys and the space bar. The participants were presented with scenarios one at a time. The text of the scenario dropped down, and the participants were asked to follow along as a voice read each of the four scenarios. At the conclusion, the participants were compelled to choose one of three answers (figure 5.7). As the participants went through the scenarios, the context of the scenario with the questions increased in difficulty. The answers given by the participants are automatically collected during the session and sent to a database.

In phase 2, researchers will administer the gaming modules to 150 adolescents ages 14 to 18 and one of their parents. Information on behavior, attitude, and knowledge acquisition will be collected and analyzed to better predict the likelihood that adolescents and their parents will take action concerning the existing health condition. Guided by the literature on the HBM, we created Likert scales for five factors:

Figure 5.7
Phase I of educational gaming for adolescent drivers with diabetes.

(a) perceived susceptibility to hypoglycemia while driving, (b) perceived seriousness/threat, (c) perceived benefits of and barriers to taking action to prevent hypoglycemia, (d) intention to take action, and (e) self-efficacy of preventing hypoglycemia.

The Children and Adolescent (Young Adult) Diabetes Program at Riley Hospital for Children currently provides diabetes-related care to more than 1,500 children and adolescents: 430, ages 14 to 18, have type 1, 50% of whom are less than 16 years old, and 51% are males. Based on anecdotal evidence gathered from conversations with the adolescents and their parents and previous research experience with this population, we anticipate at least 75% participation in the final full study. This ensures that we will be successful in enrolling 150 adolescent/parent pairs for phase 2. This chapter only outlines the initial pilot study using the gaming modules with approximately 20 adolescents with diabetes and their parents.

Measures of knowledge of hypoglycemia and satisfaction with the education gaming module will be adapted from the intervention developed by Daniel Cox, PhD. We anticipate that all measures will contain three to five items. Using information from the pilot phase, we examine the psychometric properties of the HBM items with inspection of the correlation matrices of the items in each of the scales, followed by the calculation of internal reliability.

Using these findings from phase 2, we prepare an application for extramural support to adapt and expand the education project to a Web-based format and conduct a large multicenter intervention to test the efficacy in reducing hypoglycemia while driving and hypoglycemia-related MVAs.

Other Serious Games in Type 1 Diabetes

"Packy & Marlon" (Packy & Marlon, 2008) is a side-scrolling adventure game that helps children and teens with diabetes to improve their diabetes self-management. Players must keep their character's diabetes under control by measuring and monitoring blood glucose, taking insulin, selecting a balanced diet in three meals and three snacks a day, and handling diabetes emergencies (figure 5.8).

"Glucoboy" (Glucoboy, 2003) is a device that is plugged into Gameboys to help children with diabetes monitor their blood glucose levels. The product operates independently of the videogame system but downloads videogame programs that are contained within its circuitry into the Gameboy as a reward for maintaining good blood sugar control. By causing the patient to assume so much responsibility for proper diabetes management, the Glucoboy plays an essential dual role. First, it provides accurate medical diagnosis for the disease. Second, it becomes an incentive

Figure 5.8
Packy and Marlon.

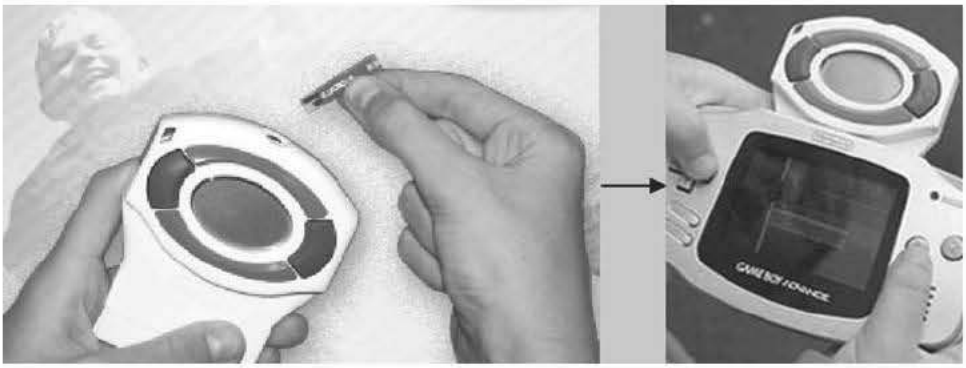

Figure 5.9
Glucoboy.

delivery platform that serves as a portal for obtaining medical data, the foundation for a fully automated, individualized, disease management program (figure 5.9).

There are also multiple serious games for type 2 diabetes that are not included in this chapter. These games are mainly aimed at preventing the general population from becoming obese and/or consuming unhealthy food.

Conclusion

Hypoglycemia in type 1 diabetes can result in severe consequences, such as driving accidents caused by unconsciousness. Managing hypoglycemia in adolescents is critical due to their lack of insight into their disease and the lower compliance rate to treatment. Behavioral models have been used to change the behavior of the patients toward their disease and to improve their adherence to treatment. In this chapter, the

Planned Behavioral Model and the Health Belief Model were the underlying behavioral models used in the interventions. However, multiple models, including hybrid models, can be tested in future studies.

Interactive media, including serious games, are becoming an inescapable part of our everyday life. With the emerging digital gaming culture, serious gaming will become an increasingly vital part of health care education for upcoming generations. Advanced interactive user interfaces now provide new opportunities for serious games that can be used not only to educate younger patients about their disease but also to empower them for a positive change in their behavior both now and into full adulthood.

Chronic care constitutes a large slice of national health care expenses. Serious gaming can be an economical solution to educating, motivating, tracking, and empowering chronic patients for long-term management of diabetes and prevention of complications. Serious games can lower not only the cost of chronic diseases but also the additional costs associated with side effects. Moreover, serious games aimed at health education do not involve large expenses because minimum health care staff are required to interact with the patient.

In an ideal game, the game's behavioral model can be integrated into both the patient's personal health record and the hospital/doctor's health record system. The health record integration can help the system to reward the patient in the game based on actual improved health results, and it can also help the physician/health care staff to track the patient's compliance to treatment, including other age groups such as adults and elderly patients. Artificial intelligence agents can be used to alert both the patient and the physician if the health status deteriorates. Moreover, different behavioral change models should be experimented with to find the most suitable model for an interactive patient empowerment approach.

In summary, advancements in gaming technology, social and health informatics, and interaction design principles and practices have all provided new knowledge and approaches to facilitating patient education and patient empowerment to achieve higher compliance (Faiola, 2006; Kharrazi, Watters, & Oore, 2008). Although serious gaming development, with an emphasis on health education, is only in its infancy, the hope is that it could provide increased motivation resulting in higher levels of compliance for treatment of both diabetes and a broad range of other diseases and health conditions, such as asthma, cystic fibrosis, and dental hygiene.

Acknowledgment

Portions of this chapter are used with permission from Dr. Donald Orr, Adolescent Medicine, Indiana University, School of Medicine, Indianapolis, Indiana.

References

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In J. Kuhl & J. Beckmann (Eds.), *Springer series in social psychology* (pp. 11–39). Berlin: Springer.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179–211.

Amillategui, B., Calle, J. R., Alvarez, M. A., Cardiel, M. A., & Barrio, R. (2007). Identifying the special needs of children with type 1 diabetes in the school setting. An overview of parents' perceptions. *Diabetic Medicine*, *24*(10), 1073–1079.

Asbridge, M., Poulin, C., & Donato, A. (2005). Motor vehicle collision risk and driving under the influence of cannabis: Evidence from adolescents in Atlantic Canada. *Accident; Analysis and Prevention*, *37*(6), 1025–1034.

Becker, M. H. (2002). The health belief model and personal health behavior. In K. Glanz, B. K. Rimmer, & F. M. Lewis (Eds.), *Health education monographs*: vol. 2, no. 4. *Health behavior and health education: Theory, research and practice*. San Francisco: Wiley & Sons.

Bingham, C. R., Shope, J. T. & Raghunathan, T. (2006). Patterns of traffic offenses from adolescent licensure into early young adulthood. *Journal of Adolescent Health*, *39*(1), 35–42.

Blackman, S. (2005). Serious games ... and less! *ACM SIGGRAPH Computer Graphics*, *39*(1), 12–16.

Bond, G.G., Aitken, L.S., & Somerville, S.C. (1992). The health belief model and adolescents with insulin dependent diabetes mellitus. *Health Psychology*, *11*, 190–198.

Breslin, P., McGowan, C., Pecheux, B., & Sudol, R. (2007). Serious gaming: Advanced computer simulation games help to transform healthcare and disaster preparedness. *Health Management Technology*, *10*(14), 16–17.

Broers, S., le Cessie, S., van Vliet, K. P., Spinhoven, P., van der Ven, N. C., & Radder, J. K. (2002). Blood glucose awareness training in Dutch type 1 diabetes patients: Short-term evaluation of individual and group training. *Diabetic Medicine*, *19*, 157–161.

Brown, T. T., Proctor, S. E., Sinkowitz-Cochran, R. L., Smith, T. L., & Jarvis, W. R. (2001). Physician preferences for continuing medical education with a focus on the topic of antimicrobial resistance. *Society for Healthcare Epidemiology of America. Infection Control and Hospital Epidemiology*, *22*, 656–660.

Casebeer, L. L., Strasser, S. M., Spettell, C. M., Wall, T. C., Weissman, N., Ray, M. N., et al. (2003). Designing tailored web-based instruction to improve practicing physicians' preventive practices. *Journal of Medical Internet Research*, *5*(3), e20.

Casey, B. J., Tottenham, N., Liston, C., & Durston, S. (2005). Imaging the developing brain: What have we learned about cognitive development? *Trends in Cognitive Sciences*, *9*(3), 104–110.

Center for Disease Control and Prevention. (2007). *National diabetes fact sheet*. Retrieved September 24, 2009, from http://www.cdc.gov/diabetes/pubs/factsheet.htm

Champion, V. L., Skinner, C. S., Menon, U., Seshadri, R., Anzalone, D. C., & Rawl, S. M. (2002). Comparisons of tailored mammography interventions at two months postintervention. *Annals of Behavioral Medicine*, *24*(3), 211–218.

Chen, H. H., & Yeh, M. L. (2006). Developing and evaluating a smoking cessation program combined with an Internet-assisted instruction program for adolescents with smoking. *Patient Education and Counseling*, *61*, 411–418.

Chew, F., Palmer, S., & Kim, S. (1998). Testing the influence of the health belief model and a television program on nutrition behavior. *Health Communication*, *10*, 227–245.

Cheyne, E. H., Shefwin, R. S., Lunt, M. J., Cavan, D. A., Thomast, P. W., & Kerr, D. (2004). Influence of alcohol on cognitive performance during mild hypoglycaemia: Implications for type 1 diabetes. *Diabetic Medicine*, *21*(3), 230–237.

Cox, D. J. (2006, August 24). Personal correspondence with Daniel J. Cox, Ph.D., Professor of Psychiatric Medicine, University of Virginia Health System, Department of Psychiatric Medicine. Available at http://www.healthsystem.virginia.edu/internet/psychiatric/staffandfaculty/facultybios/cox.cfm.

Cox, D. J., Gonder-Frederick, L. A., & Clake, W. L. (1993). Driving decrements in type 1 diabetes during moderate hypoglycemia. *Diabetes*, *42*, 239–243.

Cox, D. J., Gonder-Frederick, L. A., Kovatchev, B. P., Julian, D. M., & Clarke, W. L. (2000). Progressive hypoglycemia's impact on driving simulation performance. *Diabetes Care*, *23*, 163–170.

Cox, D. J., Penberthy, J. K., Zrebiec, J., Weinger, K., Aikens, J. E., Frier, B., et al. (2003). Diabetes and driving mishaps: Frequency and correlations from a multinational survey. *Diabetes Care*, *26*, 2329–2334.

Cox, D. J., Schlundt, D., Gonder-Frederick, L., Kovatchev, B., Polonsky, W., & Clarke, W. (2001). Blood glucose awareness training (BGAT-2): Long-term benefits. *Diabetes Care*, *24*, 637–642.

Cryer, P. E. (2003). Glucose homeostatis and hypoglycemia. In P. R. Larsen, H. M. Kronenberg, S. Melmed, & K. S. Pollonsky (Eds.), *Williams textbook of endocrinology* (10th ed., pp. 1558–1618). Philadelphia: Saunders.

Cryer, P. E. (2004). Diverse causes of hypoglycemia-associated autonomic failure in diabetes. *New England Journal of Medicine*, *350*, 2272–2279.

Donnelly, L. A., Morris, A. D., Frier, B. M., Ellis, J. D., Donnan, P. T., Durrant, R., et al. (2005). Frequency and predictors of hypoglycaemia in type 1 and insulin-treated type 2 diabetes: A population-based study. *Diabetic Medicine*, *22*, 749–755.

Dyck, J., Pinelle, D., Brown, B., & Gutwin, C. (2003). Learning from games: HCI design innovations in entertainment software. *Proceedings of the 2003 Conference on Graphic Interface* (pp.159–169). Halifax: Graphic Interface.

Faiola, A. (2006). Designing humane technologies: A potential framework for human-computer interaction design. *International Journal of the Humanities*, *2*(3), 1877–1886.

Faiola, A., & MacDorman, K. (2008). Exploring the influence of web designer cognitive style on information design: A cross-cultural comparison of a holistic and analytical perspective. *Information Communication and Society*, *11*(3), 348–374.

Fielding, D., & Duff, A. (1999). Compliance with treatment protocols: Interventions for children with chronic illness. *Archives of Disease in Childhood*, *80*, 196–200.

Frier, B. M., & Fisher, B. M. (1999). Impaired hypoglycaemia awareness. In B. M. Frier & B. M. Fisher (Eds.), *Hypoglycaemia in clinical diabetes* (pp. 111–146). New York: Wiley.

Funnell, M. M., & Anderson, R. (2003). Patient empowerment: A look back, a look ahead. *Diabetes Educator*, *29*, 454–458.

Funnell, M. M., Anderson, R. M., Arnold, M. S., Barr, P. A., Donnelly, M., Johnson, P. D., et al. (1991). Empowerment: An idea whose time has come in diabetes education. *Diabetes Educator*, *17*, 37–41.

Gerich, J. E., Mokan, M., Veneman, T., Korytkowski, M., & Mitrakou, A. (1991). Hypoglycemia unawareness. *Endocrine Reviews*, *12*, 356–371.

Glucoboy. (2003). Retrieved November 2, 2006, from http://www.diabetesincontrol.com/issue173/np.shtml

Griffiths, F., Lindenmeyer, A., Powell, J., Lowe, P., & Thorogood, M. (2006). Why are health care interventions delivered over the Internet? A systematic review of the published literature. *Journal of Medical Internet Research*, *8*(2), e10.

Hahl, J., Hamalainen, H., Sintonen, H., Simell, T., Arinen, S., & Simell, O. (2002). Health-related quality of life in type 1 diabetes without or with symptoms of long-term complications. *Quality of Life Research*, *11*, 427–436.

Hartos, J. L., Shattuck, T., Simons-Morton, B. G., & Beck, K. H. (2004). An in-depth look at parent-imposed driving rules: Their strengths and weaknesses. *Journal of Safety Research*, *35*(5), 547–555.

Haynes, R. B., McDonald, H., & Garg, A. (2002). Helping patients follow prescribed treatment: Clinical applications. *Journal of the American Medical Association*, *288*, 2880–2883.

Jackevicius, C. A., Mamdani, M., & Tu, J. V. (2002). Adherence with statin therapy in elderly patients with and without acute coronary syndromes. *Journal of the American Medical Association*, *288*, 462–467.

Johnson, E. S., Koepsell, T. D., Reiber, G., Sergachis, A., & Platt, R. (2002). Increasing incidence of serious hypoglycemia in insulin users. *Journal of Clinical Epidemiology*, *55*, 253–259.

Johnson, M. H., & Munakata, Y. (2005). Processes of change in brain and cognitive development. *Trends in Cognitive Sciences*, *9*(3), 152–158.

Johnson, S. B., Silverstein, J., Rosenbloom, A., Carter, R., & Cunningham, W. (1986). Assessing daily management in childhood diabetes. *Health Psychology*, *5*, 545–564.

Keall, M. D., Frith, W. J., & Patterson, T. L. (2005). The contribution of alcohol to night time crash risk and other risks of night driving. *Accident; Analysis and Prevention*, *37*(5), 816–824.

Keers, J. C., Links, T. P., Bouma, J., Scholten-Jaegers, S. M. H. J., Gans, R. O. B., & Sanderman, R. (2004). Diabetes rehabilitation: Development and first results of a multidisciplinary intensive education program for patients with prolonged self-management difficulties. *Patient Education and Counseling*, *52*, 151–157.

Kharrazi, H., Watters, C., & Oore, S. (2008). Improving behavioral stages in children by adaptive applications. *Journal on Information Technology in Healthcare*, *6*(1), 83–95.

Knight, K. M., Dornan, T., & Bundy, C. (2006). The diabetes educator: Trying hard, but must concentrate more on behaviour. *Diabetic Medicine*, *23*(5), 485–501.

Leese, G. P., Wang, J., Broomhall, J., Kelly P., Marsden, A., Morrison, W., Frier, B. M., Morris, A. D., & the DARTS/MEMO Collaboration. (2003). Frequency of severe hypoglycemia requiring emergency treatment in type 1 and type 2 diabetes: A population-based study of health service resource use. *Diabetes Care*, *26*, 1176–1180.

Linden, A., & Roberts, N. (2004). Disease management interventions: What's in the black box? *Disease Management*, *7*(4), 275–291.

Lipman, T. H. (1993). The epidemiology of type 1 diabetes in children 0–14 years of age in Philadelphia. *Diabetes Care*, *16*, 922–925.

Mirotznik, J., Feldman, L., & Stein, R. (1995). The health belief model and adherence with a community center-based, supervised coronary heart disease exercise program. *Journal of Community Health*, *20*(3), 233–247.

Murphy, H. R., Rayman, G., & Skinner, T. C. (2006). Psycho-educational interventions for children and young people with type 1 diabetes. *Diabetic Medicine*, *23*, 935–943.

Murphy, H. R., Wadham, C., Rayman, G., & Skinner, T. C. (2007). Approaches to integrating paediatric diabetes care and structured education: Experiences from the Families, Adolescents, and Children's Teamwork Study (FACTS). *Diabetic Medicine*, *24*(11), 1261–1268.

Orr, D. P., Langefeld, C., Katz, B., & Caine, V. (1996). Intervention increases condom use among adolescent females. *Journal of Pediatrics*, *128*, 288–295.

Osterberg, L., & Blaschke, T. (2005). Adherence to medication. *New England Journal of Medicine*, *353*, 487–497.

Packy & Marlon. (2008). Retrieved September 1, 2008, from http://www.consoleclassix.com/snes/packy_marlon.html

Palermo, T. M., Valenzuela, M., & Stork, P. (2004). A randomized trial of electronic versus paper pain diaries in children: Impact on compliance, accuracy, and acceptability. *Pain, 107*, 213–219.

Paus, T. (2005). Mapping brain maturation and cognitive development during adolescence. *Trends in Cognitive Sciences, 9*(2), 60–68.

Rossett, A., & McDonald, J. (2006). Evaluating technology enhanced continuing medical education. *Medical Education Online, 11*, 4. http://www.med-ed-online.org/pdf/t0000074.pdf

Sawyer, B. (2002). *Games for health*. Available at http://www.gamesforhealth.org/archives/000213.html#more

Schinke, S., & Schwinn, T. (2005). Gender-specific computer-based intervention for preventing drug abuse among girls. *American Journal of Drug and Alcohol Abuse, 31*, 609–616.

Schott, G., & Hodgetts, D. (2006). Health and digital gaming: The benefits of a community of practice. *Journal of Health Psychology, 11*, 309–316.

Seo, D. C., & Torabi, M. R. (2004). The impact of in-vehicle cell-phone use on accidents or near-accidents among college students. *Journal of American College Health, 53*(3), 101–107.

Sherman, K., Lapidus, G., Gelven, E., & Banco, L. (2004). New teen drivers and their parents: What they know and what they expect. *American Journal of Health Behavior, 28*(5), 387–396.

Stork, A. D. M., van Haeften, T. W., & Veneman, T. F. (2006). Diabetes and driving: Desired data, research methods and their pitfalls, current knowledge, and future research. *Diabetes Care, 29*, 1942–1949.

Suminski, R. R., & Petosa, R. (2006). Web-assisted instruction for changing social cognitive variables related to physical activity. *Journal of American College Health, 54*, 219–225.

Sumner, J., Baber, C., & Williams, V. (2000). What do patients with type 1 diabetes know about hypoglycaemia? *Practical Diabetes International, 17*, 187–190.

Sundberg, R., Tunsätera, A., Palmqvista, M., Ellbjär, S., Löwhagen, O., & Torén, K. (2005). A randomized controlled study of a computerized limited education program among young adults with asthma. *Respiratory Medicine, 99*, 321–338.

Votta, E., & MacKay, M. (2005). Evaluating the acceptability and feasibility of the I Promise Program: A driving program for families with young new drivers. *Injury Prevention, 11*(6), 369–372.

Watters, C., Oore, S., Shepherd, M., Abouzied, A., Cox, A., Kellar, M., et al. (2006). *Extending the use of games in health care*. Paper presented at the 39th annual Hawaii International Conference on System Sciences, IEEE Computer Society.

Williams, A. F. (2006). Alcohol-impaired driving and its consequences in the United States: The past 25 years. *Journal of Safety Research, 37*(2), 123–138.

Williams, A. F., Ferguson, S. A., & Wells, J. K. (2005). Sixteen-year-old drivers in fatal crashes, United States, 2003. *Traffic Injury Prevention, 6*(3), 202–206.

Winnick, S., Lucas, D. O., Hartman, A. L., & Toll, D. (2005). How do you improve compliance? *Journal of the American Academy of Pediatrics, 115*, 718–724.

Wolf, M. J. (2001). *The medium of the video game*. Austin, TX: University of Austin Press.

Ye, Z. (2004). *Genres as a tool for understanding and analyzing user experience in games. CHI '04 extended abstracts on Human factors in computing systems* (pp. 773–774). Vienna, Austria: ACM Press.

Zammitt, N. N., & Frier, B. M. (2005). Hypoglycemia in type 2 diabetes: Pathophysiology, frequency, and effects of different treatment modalities. *Diabetes Care, 28*, 2948–2961.