DESIGN OF A HEALTH INFORMATION SYSTEM ENHANCING THE PERFORMANCE OF OBESITY EXPERT AND CHILDREN TEAMS

Complete Research

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Abstract

The globally increasing prevalence of childhood obesity is one of the most serious public health challenges of the twenty-first century. Due to the need for multi-professional therapies that require a high amount of personnel and financial resources, IT-supported interventions promise help. So far, meta-studies show their limited impact on health outcomes. This work presents therefore a design theory that helps constructing health information systems (HIS) that positively impact the performance of obesity expert and children teams. Team performance is measured through self-reports, patients' adherence to therapy and positive health outcomes. In order to assess the utility of the proposed design theory, its underlying design process was adopted by an interdisciplinary team of therapists, patients, their parents, IS researcher and computer scientists. This team developed and evaluated several HIS services collaboratively over the course of two years. Results of this design process show first evidence of the utility of the HIS design theory. However, challenges with regard to the design process still exist and are discussed.

Keywords: Health information system, design theory, design process, childhood obesity, therapy, prevention, evaluation.

1 Introduction

The prevalence of overweight and obesity in childhood has dramatically increased over the last decade (Aeple et al., 2013; Sassi, 2010). According to the 2013 fact sheet of the World Health Organization, more than 40 million children under the age of five were overweight in 2011. The prevalence of this disease pattern has tripled in Europe since the 1980s, whereas this effect can be primarily observed in childhood and adolescence (Branca et al., 2007, p. 9). In Switzerland and in most Central and Northern European countries, the overweight rates of children and adolescents have doubled between 1997 and 2007 (Aeberli et al., 2010; Knöpfli et al., 2007; Zimmermann et al., 2004). Although the prevalence of pediatric adiposity did level off until 2012 (Murer et al., 2013; Rokholm et al., 2013), it is expected that almost 20% of the Swiss children will suffer from overweight or obesity in 2022 (Schneider et al., 2009b). This epidemic dissemination has not only psychological and physiological drawbacks for those being affected, but it has also serious implications for the public and private healthcare sector: First, already during childhood severe cardiovascular and metabolic co-morbidities are present (L'Allemand-Jander, 2010). Second, pediatric obesity tracks into adulthood in more than 75% of 7–11 year old children (Andersen et al., 2010; Reilly and Kelly, 2011; Toschke et al., 2008). Third, public health costs are drastically increasing due to overweight- and obesity-related comorbidities (Hänggli et al., 2008; Wabitsch and Mooss, 2009; Wang et al., 2011). In Switzerland, for example, obesity-linked disease costs have more than doubled from 2.600 Mio USD in 2001 to 5.800 Mio USD in 2006 (Schneider et al., 2009a) which equals to almost 10% of all health expenses in Switzerland (Swiss Statistical Office).

In order to address these serious issues, multi-professional programs with physical activity, nutritional and behavioral components have been proposed (Sempach et al., 2007) and shown to have positive effects on therapy outcomes (Ho et al., 2012; Oude et al., 2009; USPSTF, 2010), for example, on body composition and metabolic parameters (Savoye et al., 2007). Similar beneficial effects could be demonstrated in low-threshold primary care interventions, if performed by specialized healthcare providers (Sargent et al., 2011). However, implementation of conventional family- and home-based childhood obesity interventions is challenging for parents, often requiring them to attend multiple educational sessions. Attrition rates for traditional interventions are frequently high, namely 30% to 50%, due to competing demands for parents' time (Knowlden and Sharma, 2012). For example, in Switzerland, less than one percent of overweight children can participate in those programs due to limited personal and financial resources (Hänggli et al., 2008). In addition, obesity interventions are also required in rural regions but they are not affordable today as well (ibid.). In summary, limited personnel resources and costs have a negative impact on health care supply while, at the same time, multi-professional programs are strongly recommended.

Health information systems (HIS) have not only the potential to improve outcomes of health interventions but also to reduce their costs significantly (Agarwal et al., 2010; Spring et al., 2013; Spring et al., 2012). However, up till now, effects on obesity-related health outcomes were rather small and un-sustained (e.g. Illner et al., 2012; Ngo et al., 2009; Reed et al., 2012). It is therefore still an open issue how to design evidence-based HIS tailored to overweight and obese children that significantly improve health outcomes in the long term.

In order to address these challenges, we propose a design theory that aims at building novel HIS that improve the performance of obesity expert and children teams. The applicability of the design theory is demonstrated by the design and evaluation of one HIS artifact, which is embedded into a health care concept with these overall goals: (1) to increase the data quality of patients' self-monitoring activities, e.g. measuring steps per day, (2) to intensify the feedback from patients to therapists, (3) to visualize the implementation of lifestyle modifications in the home environment, (4) to document therapy-relevant everyday situations by high-resolution data, e.g. measuring mood or diet-related situations, (5) to reduce the families' time demands and number of on-site consultations while allowing for

punctual interventions from distance, and (6) to appeal to the patient and to support her to reach therapeutic goals. Additionally, potential side effects of IT use have to be addressed in order to avoid excessive gaming or screen time. For that purpose, a HIS design theory for IT-supported childhood obesity programs is presented. In line with this theory, several HIS services are collaboratively developed and evaluated by obesity experts, overweight and obese children, their parents, IS researchers and computer scientists. These HIS services are then evaluated by longitudinal field studies with therapists, children and their parents as part of existing obesity therapy and prevention programs.

The remainder of this paper is structured as follows. We next motivate the current work by outlining lack of evidence-based IT interventions for childhood obesity. Against this background, we then describe a very first version of a HIS design theory for IT-supported childhood obesity interventions followed by a detailed description of its underlying design process. An overview of the HIS services is presented afterwards before results from two particular evaluations are described. The results are then discussed with regard to the design theory and its design process. This paper concludes with a summary and outlook on future research.

2 Shortcomings of IT Interventions for Childhood Obesity

Today, it is state-of-the-art that obesity programs address three, i.e. physical, nutrition and behavioral components (Hauner et al., 2007; Sempach et al., 2007) as multi-component programs have been demonstrated to be more efficacious than mono-component interventions (USPSTF, 2010). Moreover, goals of obesity therapy in the growing child do not exclusively focus on weight loss, but on improvement of lifestyle and mental health, since these are preconditions for long-term beneficial outcomes (Epstein et al., 2010; Sempach et al., 2007).

The lack of patients' resources and health budgets (Hänggli et al., 2008) initiated several attempts to increase the efficiency and quality of obesity interventions by HIS, but current reviews indicate that effects of HIS on obesity-related health outcomes were rather small and un-sustained (e.g. Connelly et al., 2013; Illner et al., 2012; Lieffers and Hanning, 2012; Ngo et al., 2009; Reed et al., 2012; Wieland et al., 2012; Williamson et al., 2006). For example, effects of low-threshold internet based interventions on improvement of lifestyle or obesity were shown, but limited, i.e. not sustained after two years, due to reduced usage of the web application (Williamson et al., 2006). In addition, the high attrition rate from self-administered IT-based systems is related to self-motivation and literacy, characteristics known to be reduced in a large group of overweight children, e.g. those originating from migration families or with lower socioeconomic and / or educational background (l'Allemand et al 2012;Rokholm et al 2010). In line with these results, Table 1 shows a selection of IT-supported obesity interventions and commercial applications of which six shortcomings can be observed.

First, the majority of interventions do not consider a multi-professional approach as recommended, i.e. a concurrent focus on physical activity, nutrition intake and behavioral support is not present. Second, only a few IT-supported health interventions are tailored to children and adolescents with their individual needs and requirements. Third, evidence-based effects on therapy outcomes are rare if at all present. Fourth, none of these applications has been evaluated as part of an existing multi-professional obesity intervention for children and adolescents. Fifth, none of these interventions or applications was either adapted to or evaluated with multi-culture obesity programs, which is crucial in the sense that cultural differences must be taken into account during their development. Finally and to the best of our knowledge, none of these applications was co-designed by therapists, children, their parents, IS researcher and computer scientists according to an design process for constructing evidence-based HIS and only few have incorporated the target group as co-designers (indicated by an asterisk * in Table 1).

Due to these facts, we next describe a first version of a HIS design theory for childhood obesity interventions.

Name	Reference	Component of program			Tailored to		Evidence-based effects on health condition
		Physical activity	Nutrition intake	Behavioral support	Children (11 to 13 year-olds)	Adolescents (above 13 year-olds)	
IT-supported overweight programs							
n/a	(Spring et al., 2013)	X	X	X	-	-	X
EMPOWER	(Knowlden and Sharma, 2012)	X	X	X	-	-	-
Mobile POD	(Turner-McGrievy and Tate, 2011)	X	X	-	-	-	-
*n/a**	(Arteaga et al., 2010)	X	-	-	-	X	-
UbiFit Gardens*	(Consolvo et al., 2009)	X	-	-	-	-	-
BALANCE	(Denning et al., 2009)	X	X	-	-	-	-
Barcode Ed*	(Siek et al., 2009)	-	X	-	-	-	-
MOPET	(Buttussi and Chittaro, 2008)	X	-	-	-	-	-
HyperFit*	(Jarvinen et al., 2008)	X	X	-	-	-	-
Shakra	(Anderson et al., 2007)	X	-	-	-	-	-
Wellnavi	(Kikunaga et al., 2007)	-	X	-	-	-	-
DietSense	(Reddy et al., 2007)	-	X	-	-	-	-
PmEB	(Tsai et al., 2007)	X	X	-	-	-	-
Houston	(Consolvo et al., 2006)	X	-	-	-	-	-
Hip-Teens	(Williamson et al., 2006)	X	X	X	X (girls-only)	X (girls-only)	(X) no long-term effects
Fish N‘ Steps	(Lin et al., 2006)	X	-	-	-	-	-
Chic Clique*	(Toscos et al., 2006)	X	X	-	-	X	-
Commercial applications							
ActiSmile	actismile.ch	X	-	-	X	-	-
eBalance	e-balance.de	X	X	X	-	-	-
DietTV	diettv.com	-	X	-	-	-	-
DirectLife	directlife.philips.com	X	-	-	-	-	-
Fitbit	fitbit.com	X	X	-	-	X	-
Jawbone Up	jawbone.com/up	X	X	-	-	X	-
Mandometer	mandometer.com.au	-	X	X	X	X	-
Myca Nutrition	mycanutrition.com	-	X	X	-	-	-
Nike Fuelband	nike.com	X	-	-	-	X	-
Vitalcoach	meinvitalcoach.de.ubi.com	X	X	-	-	-	-
Weightdoc	weightdoc.me	X	X	X	X	X	-
WiiFit	wiifit.com	X	-	-	X	X	-
Zamzee	zamzee.com	X	-	-	X	X	-

*Table 1. Examples of IT-supported obesity interventions and commercial applications. Remark: * target-group was used as co-designer of the program / application*

3 HIS Design Theory Enhancing Childhood Obesity Programs

The proposed design theory has the overall objective to help constructing HIS that enhance multi-professional childhood obesity programs. In particular, this theory should guide the design process for HIS that improve the health condition of overweight and obese children by applying evidence-based knowledge from both perspectives, i.e. obesity and IS research. Walls et al. (1992, p. 41) state in reference to Simon (1981) that a design theory prescribes „the properties an artifact should have if it is to achieve certain goals and the method(s) of artifact construction.“ Consistently, the design theory proposed in this work (cf. Figure 1) describes not only relevant concepts such as justificatory knowledge, design principles or relevant classes of artifacts, but it also outlines the procedural aspects such as principles of implementation and evaluation. A detailed description of the rationale of these components and relationships is provided in the following paragraphs.

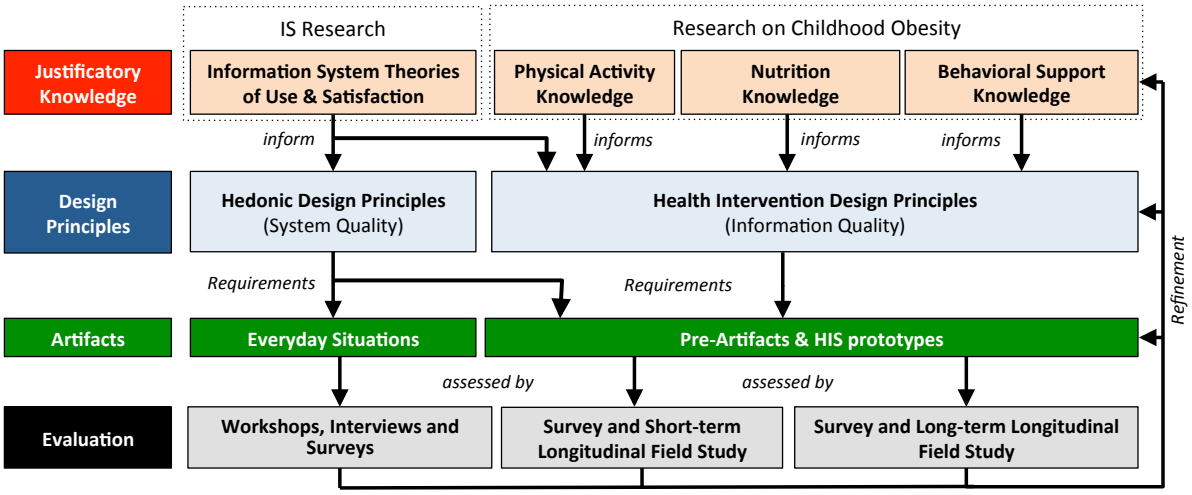

Figure 1. Outline of a design theory for HIS-supported childhood obesity interventions.

First, justificatory knowledge is required from obesity research in general (e.g. Epstein et al., 2010; Kumaharaa et al., 2010; Suter and Schutz, 2008) and research on childhood obesity in particular (e.g. Durrer and Schutz, 2008; Epstein et al., 2007; l'Allemand et al., 2008; l'Allemand et al., 2006; l'Allemand et al., 2012; Lu et al., 2012) as it explains why particular health-related conditions exist (e.g. obesity due to genetic endowments or psychosocial problems) and how health promoting behavior can be enhanced by various sources of information and motivation strategies (DiMatteo et al., 2012; l'Allemand and Laimbacher, 2013). This health-related knowledge is complemented by IS research which must be taken into account as it guides the design process towards useful HIS. In particular, IS theories that predict usage and user satisfaction with a particular system such as the IS success model (DeLone and McLean, 1992; DeLone and McLean, 2003), the IS continuance model (Bhattacherjee, 2001) or research on positive design theory (Zhang, 2007) explain why HIS are used, a precondition for any investigation into the effects of HIS such as an increase in performance measures of obesity expert and children teams (e.g. health outcomes).

Second, justificatory knowledge informs particular design principles for HIS. Design principles are technological rules which can take the form of “If you want to achieve Y in situation Z, then something like action X will help.” (Van Aken, 2004, p. 227) According to this logic, Y is a health-related goal (e.g. 10.000 steps per day), Z are everyday situations relevant to multi-professional obesity programs (e.g. decision in the morning on whether to take a bus or a walk to school) and X are

particular health promoting actions that are supported by HIS (e.g. to actually walk to school while being motivated by getting feedback of the number of steps by a pedometer). In line with prior work on hedonic IS (Lowry et al., 2013; van der Heijden, 2004) and positive design theory (Zhang, 2007), we assume that design principles for HIS must address not only utilitarian aspects, for example the ability to activate health promoting behavior of overweight and obese children, but also hedonic aspects (e.g. patient enjoyment during HIS usage) due to the fact that it was shown that hedonic characteristics significantly influence utilitarian characteristics and actual system use (Gerow et al., 2013; Kamis et al., 2008; van der Heijden, 2004). We hereby refer to the integrated model of user satisfaction and technology acceptance (Wixom and Todd, 2005) and argue that system quality of HIS is defined by hedonic design principles from IS theories of use and satisfaction, whereas information quality is defined by utilitarian design principles from IS research and research on childhood obesity, e.g. IS use theories and health promotion models that address nutritional, activity and behavioral components (Pender et al., 2010; Sempach et al., 2007). Because of their goal-oriented health promotion focus, the latter design principles are also summarized as health intervention design principles.

Third, the design principles must then be selected and (probably) revised according to the individual needs of a particular obesity intervention, be it a group program with obese children, an individual obesity program with overweight teenagers or an obesity prevention program. The selected and revised design principles represent then the requirements for informal pre-artifacts (e.g. narratives and situational descriptions) (Janzen et al., 2010), semiformal pre-artifacts (e.g. conceptual models like entity relationship diagrams) (Maass and Janzen, 2011) or technical implementations in form of HIS prototypes.

And finally, the artifacts designed in the preceding step must be evaluated by workshops, interviews, surveys and various longitudinal field studies. Key constructs to be evaluated must then fit to the hedonic and utilitarian characteristics of the envisioned HIS such that the design principles of the proposed design theory can be tested and such that both components of HIS are addressed, i.e. system quality and information quality. Results of the evaluations are then fed back to revise the justificatory knowledge, its underlying design principles and the resulting artifacts, respectively.

In line with this approach, we next present details of the first design process adopted in the current investigation.

4 Design Process

A structured design-science method for IS development was adopted (Hevner et al., 2004; Janzen et al., 2010). Together with IS researcher and computer scientists, experts covering all relevant dimensions of childhood obesity from one children's hospital (three senior physicians, one nutrition expert and a certified sports scientist), medical practice (one physician) and a university's department of physiology, denoted as therapists thereafter, participated in several build-and-evaluate loops during HIS development as shown in Figure 2. The foci of HIS development were an obesity therapy program (targeting parents and their obese children aged between 11 and 13) and an obesity prevention program (targeting adolescents aged between 14 and 18). One must note that Figure 2 does end with the first longitudinal field study as it is the current state of progress regarding the obesity therapy program.

In a first step, current problems of childhood obesity programs were identified by therapists and patients in discussions with IS researcher and computer scientists. A relevant body of domain knowledge as outlined in Section 3, i.e. predictors of health promotion models, evidence-based guidelines of multi-professional programs for childhood obesity, practical experience with current overweight and obesity programs (incl. the six overall goals of the obesity care concept outlined in the

introduction) and special characteristics of the patients and their families were discussed. As a result of this step, an initial set of design principles for the envisioned HIS was identified.

In a second step, therapy-relevant situations (e.g. binge eating at home) were identified by workshops and everyday activities with patients. To increase a common understanding of the identified problems, therapists, IS researcher and computer scientists replicated those situations particularly harmful to therapy outcomes. The resulting situations were then written down in the form of brief narratives, revised with regard to redundancies and validated against the list of problems from the first step. Subsequently, the situations were rewritten with the help of the design principles such that a HIS addressed these problems, the so-called HIS-supported therapy and prevention situations.

In the third step, therapists, patients, their parents, IS researcher and computer scientists evaluated the HIS-supported situations with regard to the behavior-service fit (BSF) construct from situation-service fit theory (Maass et al., 2012). BSF represents "the match between a service with individual or group behavior." (ibid.) The resulting list of HIS-supported situations was ranked and it was collaboratively decided among therapists, IS researcher and computer scientists which of them would have the highest potential to improve the performance of obesity expert and teenager teams. The identification and refinement of HIS-supported therapy and prevention situations was done in several iterations in which more and more details regarding potential HIS prototypes were discussed.

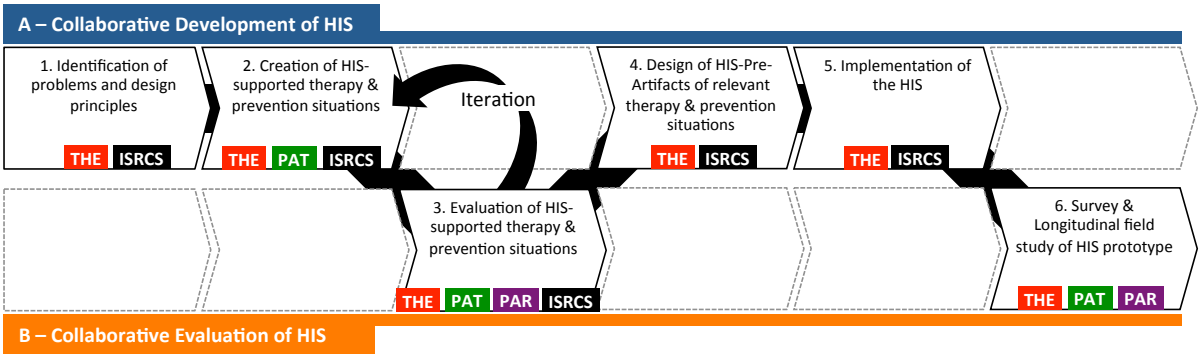

Figure 2. Design process. Note: HIS: Health Information System; THE: therapist; PAT: patient; PAR; parent of patient (if applicable); ISRCS: IS Researcher and computer scientists

Fourth, semiformal diagrammatic representations, denoted as pre-artifacts (Janzen et al., 2010; Maass and Janzen, 2011; Maass and Varshney, 2012), were then created for the three HIS-supported situations by therapists, IS researcher and computer scientists. In this task, situations from the third step guided the design of the pre-artifacts. Due to a concise separation into information sphere (e.g. nutritional tips), social system (e.g. interaction between therapist and patient), service system (e.g. photo service) and physical object system (e.g. a tablet PC), the use of pre-artifacts allowed us to bridge the gap between the informal notion of narratives and the technical program code as an intermediate conceptual model.

In a fifth step, computer scientists implemented the HIS application according to the pre-artifacts. In addition, computer scientists gathered further details for the technical implementation from therapists whereas the IS researcher took the role of an intermediate actor that assured consistency and requirements coverage of the resulting HIS prototype with the pre-artifacts.

In the final step, the first HIS prototype was evaluated by a first short-term longitudinal field study, which was approved by the local ethical committee, and a survey. For that purpose, perceived characteristics of the prototype were evaluated to ensure utility, ease of use and enjoyment with it

(Davis, 1989; van der Heijden, 2004). Due to the fact that (1) obese children and teenager deserve special consideration and protection in such a field study, and (2) the study was part of an ongoing multi-professional obesity program with defined time slots available to patients and therapists, not only a limited amount of patients was sampled but also single-item instruments were used, an approach which has been shown to be as valid as multi-item instruments (Bergkvist and Rossiter, 2007). Furthermore, only those patients were included in the study who passed a physical and psychological examination and who had a body mass index around the 97th percentile representing mid- to light-level obese children (l'Allemand et al., 2006). Each patient or rather parent got also a monetary compensation for her participation.

5 Results

In the following subsections, the results of the design process are presented.

5.1 Problem definition and design principles

According to the first step of the design process, nine problems of obesity therapy and prevention programs were identified: (1) misfit of patients' perceptions of therapy-relevant behavior and actual behavior (e.g. unrealistic estimates of quantity of nutrition-intake), (2) insufficient achievement of patients' therapy-related objectives, (3) lack of recognition of obstacles harmful to therapy-relevant behavior, (4) lack of a structured day-to-day routine, (5) insufficient incorporation of family and friends in the therapy, (6) reduced self-perception and self-esteem of patients, (7) lack of on-demand support in everyday situations, (8) conflicting roles of patients (e.g. towards family, friends, teacher and therapists) and finally, (9) insufficient understanding on how to efficiently establish a therapy contract between therapist and patient. Against this background, justificatory knowledge from IS research and obesity research was applied and mapped to the objectives of multi-disciplinary obesity therapy and prevention programs as outlined in the introduction of the paper. As a result, the following design principles for HIS were identified by therapists, IS researcher and computer scientists:

DP1. The HIS should address nutrition, physical activity and behavioral components.

DP2. The HIS should enhance the communication of obesity expert and patient teams.

DP3. Parents of children aged between 11 and 13 must take an active user role in the HIS.

DP4. Individual intervention goals should be made explicit and communicated by the HIS.

DP5. The HIS should provide information about the progress of the intervention.

DP6. The HIS should provide reminders in everyday situations to increase adherence.

DP7. Long-term incentives should be communicated in a motivating way via the HIS.

DP8. The HIS should be appealing but not motivating w.r.t. excessive gaming or screen time.

5.2 HIS-supported therapy and prevention situations

Being aware of the problems of obesity programs and design principles for HIS, therapists and IS researcher have written down a preliminary set of 26 everyday situations harmful to a healthy lifestyle. Then, in a workshop with eight patients, an additional list of 26 everyday situations was added. Afterwards, the resulting 52 situations were mapped to each other and checked for redundancies and consistency. Overall, 19 situations resulted from this step which were then transformed to HIS-supported situations, i.e. HIS services were introduced that addressed the problems described in the situations. Then, five therapists and eight patients evaluated these 19 situations with the following behavior-service fit item (Kowatsch and Maass, 2013; Maass et al., 2012) on a six-point Likert scale ranging from strongly disagree (1) to strongly agree (6): *'[I/My patients] would behave like Peter to improve my/their health behavior.'* The 13 top-ranked situations were then selected and the parents of

the patients as well as 21 independent IS researcher not involved in the design process were asked to evaluate the situations from their perspective, too. This additional step was chosen to incorporate not only the social environment of the patients but also evaluations from technically savvy persons with regard to the HIS. The evaluations from each of the participating stakeholders were aggregated and standardized. The results are shown in Figure 3.

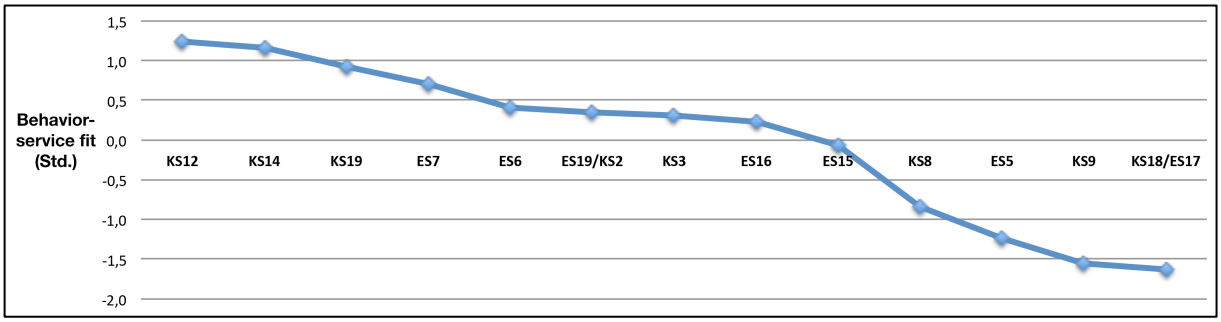

Figure 3. Ranked list of 13 HIS situations by patients (KS) and therapists (ES) and evaluated by therapists (N=5), patients and parents (N=8 each) and IS researcher (N=21)

Out of this list, the following HIS-supported situation addressing nutrition-behavior was chosen by therapists and IS researcher to be considered first for technical implementation: *'Peter goes shopping with his family on Saturday morning. On their way, recipe recommendations are provided to him that perfectly fit to his nutrition plan. He chooses three recipes that he likes and, as a result, ingredients of these recipes were directly transferred to the shopping list of the parents.'* (cf. KS14 in Figure 3)

In a second iteration, therapists and IS researcher separated KS14 into a shopping preparation situation (the esodic situation), the actual shopping task in the retail store (the core situation) and the shopping documentation after shopping (the closing situation). Participating patients with their parents were then asked to evaluate these situations, again, with the behavior-service fit item and to provide additional feedback with regard to the implementation. Overall, feedback from six patients, six mothers and five fathers was returned. Results indicate that that the three sub-situations were rated positive and that the families would also participate in a pilot test carried out later.

5.3 Pre-artifacts and HIS services

Consistent with prior research (Janzen et al., 2010; Maass and Janzen, 2011) and in addition to the design principles, the selected HIS-supported situations were used by IS researchers to create a set of pre-artifacts that were used to build a shared understanding among therapists, IS researcher and computer scientists and thus, as a blueprint for the technical implementation of the HIS services. An overview of all HIS services is shown in Table 2. That is, a brief description with relevant data sources is provided for each service together with a mapping of the design principles. An example of a pre-artifact of the recipe recommendation service is shown in Figure 4. The prototype excluding the recipe recommendation service is described in more detail by Pletikosa Cvijikj et al. (2014).

#	HIS Service	Description	Data Source	Design Principles
1	Recipe recommendation	It recommends recipes based on available and desired ingredients.	Lists of available and desired ingredients, Swiss recipe database 'TipTopf'	1 (nutrition & behavioral), 2,3,8
2	Photo	It captures everyday situations of patients objectively (e.g. plate of dinner).	Photo camera	1 (nutrition, physical activity & Behavioral), 2

#	HIS Service	Description	Data Source	Design Principles
3	Physical activity	It captures steps per day of a patient with the help of an external device.	FitBit flex pedometer	1 (physical activity), 2, 4, 5, 7, 8
4	Mood monitoring	It captures the mood state and the feeling of satiety of a patient.	Self-Assessment Manikin (Bradley and Lang, 1994), self-reports	1 (nutrition & behavioral), 2, 8
5	Relaxation exercise	It captures the mood state of patients before and after a pre-defined relaxation stimulus (either a movie, song or image).	Self-report on mood and feeling of satiety, time to relax, attention, degree of movement via accelerometer	1 (nutrition, physical activity & behavior), 2
6	Speed of eating	It captures time, feeling of satiety and images before, at 50%, 75% and 100% of completing a meal.	Photo camera, time to complete a meal and self-report on feeling of satiety	1 (nutrition & behavior), 2, 4
7	Food diary	It allows teenagers to track their food intake, i.e. particular ingredients (quantity, calories and photo).	Photo camera, SGE nutrition database (with 7000+ entries)	1 (nutrition & behavior), 2
8	Goal setting	It allows therapists to set up individual goals together with patients and parents.	Practical experience of therapists, capabilities of patients and their parents	1 (nutrition, physical activity & behavior), 2, 4, 5, 6, 7, 8
9	Notification	It notifies therapists and patients in case the prototype is not used for a pre-defined time.	Last time of service usage, triggered by goal-setting service	2, 3, 4, 6

Table 2. Overview of HIS services supporting obesity therapy and prevention programs

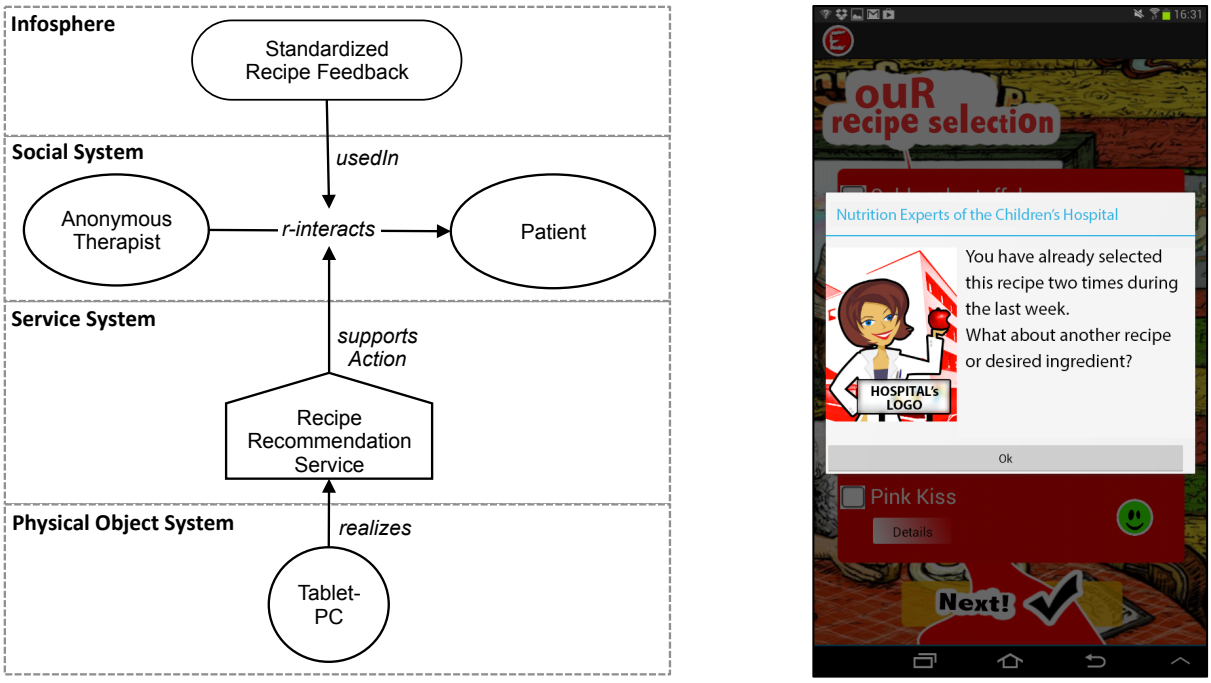

Figure 4. Example of a pre-artifact (left) and its implementation (right).

5.4 Field study and survey-based evaluation

In the following two subsections, results of a first longitudinal field study and a survey with therapists (not involved in the field study) are presented. The study was part of an individual obesity therapy program of a children's hospital. It was tailored to 11 to 13 year-old children and their parents. The focus of the evaluations was (1) to assess the predictors of HIS use and (2) to test selected performance measures of obesity expert and teenager teams because actual effects of HIS use on health-related outcomes will be assessed by two longitudinal field studies in 2014.

5.4.1 Field study

The field study was collaboratively supervised by one therapist and one IS researcher. It was carried out in four steps: (1) acquisition of patients, (2) explaining and handing out the HIS prototype for a test during the first consultation, (3) usage of the prototype by patient and parent at home and (4) final evaluation of the HIS prototype during a second consultation. First, the therapist selected several patients who already participated in an individual obesity therapy. Then, patients and their parents were orally informed about the objectives of the HIS prototype and signed an informed consent. Second, the IS researcher explained to the patient and parent how the recipe recommendation and photo services were used on a seven-inch tablet PC (Samsung Galaxy Tab 2). They were trained to get used to the prototype on site, any technical questions were clarified and, playing through a real-life situation with the prototype, the therapist commented on the recipe selections as part of the obesity therapy. Afterwards, direct feedback regarding the prototype was gathered and a questionnaire was handed out to patient, parent and therapist to evaluate both the prototype and the consultation. Third, patient and parent were given the task to use the recipe recommendation and photo services at least once at home to allow for discussion of the results during the second consultation. They also had to test the prototype at home for meal planning and preparation. To enable the family to buy the ingredients of the selected recipes, a monetary compensation was provided. This step took three weeks. Finally, in the second consultation, patient, parent and physician discussed the results of prototype usage, namely the interaction log, i.e. data about the frequency of use of the recipe recommendation and photo services, and completed a second questionnaire.

The questionnaires included only the 'overall' items of the perceived usefulness, ease of use and enjoyment constructs (adapted from Kamis et al., 2008; van der Heijden, 2004) due to the restrictions described in Section 4. Furthermore, team performance was preliminary measured by one self-report item (cf. Sambamurthy and Chin, 1994; Venkatesh et al., 2012) and objectively by the frequency of HIS service usage at home. Both hedonic and utilitarian characteristics of the HIS were therefore considered in reference to the proposed HIS design theory.

Overall, six male patients each with one parent participated in the first consultation and four patients with one parent in the second consultation between April and June 2013. The attrition was attributed to the low motivation of two families. The consultations took between 30 to 60 minutes. The average age of the patients was 12.8 years. The descriptive statistics of the first field study are provided in Table 3. With regard to objective team performance measures, four usage sessions were recorded at home on average from the system protocol. Furthermore, each session lasted approximately eleven minutes and patients took 12.3 photos on average between the first and second consultation as shown in Figure 5. The descriptive statistics show that all means lie over the neutral Likert-scale value of 3.5 at both the first and second consultation. Thus, it can be stated that the HIS-supported consultation and the two services of the prototype were perceived useful in the context of the obesity therapy program. Furthermore, team performance resulted in over average ratings. Results on perceived enjoyment and perceived ease of the HIS prototype were rated positive, too. According to the objective group performance construct, it can be concluded that those patients who participated in the field study, were highly motivated and did use the prototype several times.

Construct	Item (taken from the therapist's questionnaire for ease of presentation)	Patient		Parent		Therapist	
		T1	T2	T1	T2	T1	T2
Team performance (HIS-supported consultation)	I think that this consultation has helped to improve the teamwork with my patient.	5.33 (.82)	4.75 (.50)	5.00 (.63)	5.13 (.85)	5.17 (.75)	5.00 (.00)
Perceived usefulness (HIS-supported consultation)	I think that this consultation has helped my patient in the context of obesity therapy.	5.00 (.89)	4.75 (.96)	5.00 (.52)	5.13 (.85)	5.17 (.75)	4.75 (.50)
Perceived enjoyment (HIS prototype)	I think that my patient has enjoyed the use of the app during the consultation.	4.50 (.84)	4.40 (.89)	5.67 (.52)	4.00 (.00)	5.17 (.75)	4.75 (.50)
Perceived ease of use (HIS prototype)	I think that the app is easy to use.	–	3.75 (1.26)	–	5.25 (.96)	–	–

Table 3. Mean values and standard deviations (in brackets) based on 6-point Likert scales ranging from strongly disagree (1) to strongly agree (6). Note: T1/2 = first/second consultation; $N(T_1) = 6$ and $N(T_2) = 4$ children with parents, one therapist

Figure 5. Images taken by patients with the photo service of the application

5.4.2 Cross-evaluation of the HIS Services by therapists

The two services of the HIS prototype were further cross-tested by therapists that were not involved in the field study. The survey consisted of three parts. First, a brief description of the HIS prototype was provided in which the two services of the prototype were explained in a standardized way. Second, results from the field study, i.e. selected recipes and photos as depicted in Figure 5, were shown to the therapists in order to assess the utility regarding obesity consultations in general. Finally, a slightly adapted version of the field study's questionnaire was handed out. Consistently, six-point Likert scales ranging from strongly disagree (1) to strongly agree (6) were employed.

Overall, seven therapists participated in this cross-evaluation. They found that team performance can be enhanced by the HIS prototype (Mean = 4.86, Std. Dev. = .69) and that it is perceived useful in particular for nutrition-related components of obesity therapy programs (Mean = 4.71, Std. Dev. = 1.38). In line with the results of the field study, perceived enjoyment (Mean = 4.43, Std. Dev. = 1.13) and ease of use (Mean = 4.14, Std. Dev. = 1.21) of the HIS prototype were rated positive. Thus, the preliminary results of the first longitudinal field study can be seen as cross-validated.

6 Discussion

The overall result of the design process shows first support of the utility of the proposed HIS design theory that aims to enhance current childhood obesity and prevention programs. In particular, justificatory knowledge from both childhood obesity and IS research informed the development of HIS design principles. With the help of these principles, several HIS-supported therapy and prevention situations, pre-artifacts and HIS services have been designed, technically implemented and evaluated step-by-step by an interdisciplinary team of children, parents, therapists, IS researcher and computer scientists. Finally, results of one field study and one cross-evaluation by external therapists resulted in positive assessments regarding the first HIS prototype. Although no health-related outcome parameters

(e.g. binge-eating behavior) have been evaluated so far, it can be assumed that the design process and its underlying theory have the potential to pave the ground towards evidence-based HIS designs for complex healthcare situations with several stakeholders.

However, the design process as it was carried out in practice revealed several challenges. First, it took almost one year before the first HIS prototype was ready to be evaluated (incl. the recipe recommendation and photo services). This was due to strict time constraints and major effort required to synchronize all relevant stakeholders during the daily activities in a children's hospital. Second, designing a novel HIS for obese and overweight children and their families had to tackle major problems in the field of obesity therapy in general, i.e. attrition from therapy and difficulties to achieve sustained lifestyle changes. Third, from the view of obesity experts, the main challenge while building a HIS was to create a shared understanding with IS researcher and computer scientists. Thus, several workshops had to be conducted first to develop this understanding between different professions. Fourth, therapists, IS researcher and computer scientists had to address the reduced literacy and decision-making ability of the patients. That is, the HIS-supported situations proposed by patients and their evaluations were far from realistic to have a significant effect on the effective use of the HIS services or finally, an actual change in health-promoting behavior. Fifth, it was a major challenge of both therapists and patients to focus on a limited number of HIS services. Finally, it was important for clinical use that potential side effects, namely excessive use, can be monitored by the prototype.

As a result, the following two major changes have been implemented with regard to the design process and applied to the second and third iteration of HIS service development of which the services no. 3 to no. 9 as listed in Table 2 were affected. First, only therapists, IS researcher and computer scientists developed relevant HIS-supported therapy and prevention situations, pre-artifacts and prototypes against justificatory knowledge from their fields, their practical experience and instruments that were already in use for obesity and prevention programs such as a paper-based list of goals, time tables or food diaries. And second, patients were only recruited for short and selective evaluations of the HIS-supported situations and HIS services during the design process. These changes resulted in a much more dynamic design and evaluation process which was accepted by all relevant stakeholders. As a result, five HIS services could be implemented within three months (no. 3 to no. 7 in Table 2) and two more services within two months. However, these HIS services need to be still evaluated by longitudinal field studies before their hedonic and utilitarian values can be assessed. And only with positive results, the changes mentioned above can be tested empirically.

7 Summary and Outlook on Future Work

In this paper, we justified the need for high-quality and efficient therapy and prevention programs that tackle childhood obesity, one of today's major disease patterns. HIS have the potential to increase the performance between obesity expert and children teams but various studies show that there is little knowledge about evidence-based effects on health outcomes. We therefore proposed a HIS design theory and exemplified its underlying design process by results from an interdisciplinary healthcare project. The resulting HIS services combine all components known to be crucial for beneficial outcomes (Epstein et al., 2007; l'Allemand and Laimbacher, 2013): a multi-professional intervention including nutrition, activity and behavior modification, a support to improve self-perception and self-esteem, an assistance in structuring the day-to day life and the backing by parents and therapists. Most importantly, HIS services resulting from this design approach are expected to remain appealing in the long-term. In our future work, we will therefore conduct several field studies in which also health-related outcome parameters are evaluated in order to further validate, revise and improve the HIS design theory and its underlying design process as proposed in the current work.

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