IMPROVED MEDICATION COMPLIANCE THROUGH HEALTH IT: DESIGN AND MIXED METHODS EVALUATION OF THE APPLICATION ePILL

Research-in-Progress

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Abstract

Enhancing information provision in patient information leaflets for medication with health IT has the potential to improve lacking medication compliance. Following the design science research paradigm, a web application (ePill – electronic patient information leaflet) providing information on pharmaceuticals and supplementary services while avoiding drawbacks of patient information leaflets was created. Mixed methods are employed for artifact evaluation and refinement in subsequent design cycles. ePill can mend the prevalent problem of medication compliance by alleviating the process of gaining knowledge about medication one is taking. A special focus is on the tradeoff between offered functionality and information security and privacy concerns. Building on foundations of information systems research as well as medical sciences, this research is on the verge of both domains.

This paper examines the theoretical background, presents completed design cycles, including creation, design as well as results of qualitative evaluations, and discusses the planned quantitative ePill evaluation in progress.

Keywords: design science research, health information technology, medication compliance, mixed methods evaluation, patient information leaflet, web application, artifact
Introduction

Medication needs to be taken correctly. However, patients often do not comply with prescribed regimens. This worsens overall morbidity and mortality rates (Cramer 1995; DiMatteo et al. 2002). Besides a negative impact on patients’ state of health, bad medication compliance raises the overall cost of healthcare due to an increased need for medical treatments, e.g., hospitalizations (Breitscheidel et al. 2010). In the literature, diverse definitions of medication compliance are used (Cramer et al. 2008). In this paper, we adopt the definition proposed by the International Society for Pharmacoeconomics and Outcomes Research. Accordingly, medication compliance is “the extent to which a patient acts in accordance with the prescribed interval and dose of a regimen” (Cramer et al. 2008). Enhancing medication compliance is a multifaceted challenge: Various factors have been reported to influence medication compliance: level of education (Mahfouz and Awadalla 2011), level of knowledge on illness and drugs (Ibrahim et al. 2010; Lai et al. 2007; Wens et al. 2005), quality of physician-patient communication (Ibrahim et al. 2010; Lai et al. 2007; Wens et al. 2005), duration of illness (Mahfouz and Awadalla 2011), costs of medication (Ibrahim et al. 2010), necessary lifestyle changes, and the social environment of patients (Wens et al. 2005). The multitude of factors as well as contradicting results determined in different studies show that improving medication compliance is a complex problem that needs to be further addressed. We aim to contribute to the efforts focused at improving medication compliance by enhancing information provision in patient information leaflets (PIL) for medication with health IT. Continuing our previous work in health IT (e.g. Kaletsch and Sunyaev 2011; Sunyaev and Chornyi 2012), the goal of this research is to design and evaluate health IT facilitating the process of gaining knowledge about the pharmaceuticals one is taking.

We developed an artifact – a web application prototype (ePill – electronic Patient Information Leaflet). It provides patient-friendly aggregation and refinement of information in PIL. ePill was developed and refined through qualitative evaluations to tackle problems regarding readability, comprehensibility, and content of PIL (Dehling and Sunyaev 2012). Patients suffering from type-2 diabetes represent the domain for quantitative, large-scale evaluation. Diabetes is a global burden: A recent study estimates that the global percentage of adults suffering from diabetes will rise from 6.4% (285 million adults) in 2010 to 7.7% (439 million adults) in 2030 (Shaw 2012). Patients suffering from type-2 diabetes need to comply with regimens to keep their blood sugar on appropriate levels – achieve glycemic control – because their cells are resistant to insulin so that their bodies cannot maintain desirable blood sugar levels without medical assistance. Although non-compliance can lead to serious chronic complications, like cardiovascular disease, studies report poor medication compliance of patients suffering from type-2 diabetes (Mahfouz and Awadalla 2011; Wens et al. 2005). Type-2 diabetes is not only a prevalent burden, but diabetics, who need to take medication on a continuous basis and are often treated with multiple pharmaceuticals in combination (Miccoli et al. 2011), are also particularly suitable for evaluation of ePill.

Improved presentation of information in PIL could enhance medication compliance in various ways: Patients could more easily inform themselves on prescribed pharmaceuticals, enabling them to understand why and how they have to take pharmaceuticals, in spite of a potentially lacking quality of physician-patient communication. Additionally, access to a web application is not subject to time constraints and does not require an appointment. A dynamic web application is well suited to aggregate information on multiple pharmaceuticals so that patients can, for example, check whether a common medicine, like a cough syrup, is compatible to other pharmaceuticals they are taking. This way, side effects or adverse drug reactions, which might lead a patient to stop taking a prescribed pharmaceutical (Miccoli et al. 2011), can be avoided without reading a lot of leaflets or consulting a physician. To verify such causal relationships and the utility, quality, and efficacy of ePill, the artifact needs to be further evaluated.

Related Research

Written information on pharmaceuticals is often in need of improvement: The font size is too small (Chubaty et al. 2009; Luk et al. 2010; Winterstein et al. 2010). Formatting aspects like line spacing or margins are not appropriate (Chubaty et al. 2009; Winterstein et al. 2010). Readability is impaired by printing on unsuitable paper with text showing through or other distractions (Chubaty et al. 2009). The required reading level is too high (Wallace et al. 2006; Winterstein et al. 2010). Many difficult/technical
terms are used (Rajasundaram et al. 2006). More effective use of headings and bullet points could improve text structuring (Luk et al. 2010) and an excessive amount of information as well as irrelevant information is provided (Rajasundaram et al. 2006; Wallace et al. 2006; Winterstein et al. 2010).

Medication compliance can be measured with several methods. Common measures include self-reporting, interviews, pill counts, and outcome measurement; more extensive and invasive direct measures, like measuring blood drug concentration can also be employed (Chatterjee 2006). Self-reporting and interviews can be biased by dishonesty of patients. When using self-reporting, patients might forget to report/log their drug intake as well as taking their medication; on the other hand, patients might feel compelled to take their pharmaceuticals since they have to report on it. Pill counts can be distorted if patients discard their medication instead of taking it. Assessing medication compliance based on the outcome of the therapy can be unreliable because treatment is not the sole factor influencing outcome and patients treated with an unsuitable regimen might, for example, be wrongfully determined to be non-compliant. With respect to the ePill evaluation, direct measures are far too invasive and extensive. Since patients might have varying levels of drug concentration by default, direct measures are not flawless either. Moreover, such measures represent only a single point in time and patients might take their medication right before the measurement and be non-compliant otherwise. To evaluate ePill's positive effect on medication compliance, it is not necessary to definitely determine whether a patient is compliant. It suffices to show that ePill can reduce non-compliance. The medication possession ratio (MPR) (Steiner et al. 1988) facilitates such assessments. MPR represents the number of dispensed daily pharmaceutical supplies divided by the length of the refill interval. Patients might still discard medication which could lead to false positives; however, patients that obtained not enough medication cannot be compliant as long as all refills are recorded. MPR is a good indicator for the capability of ePill to improve medication compliance because it can demonstrate that access to ePill can significantly reduce time spans in which medication is not available. Studies report that MPR correlates with other medication compliance measures and can be used to assess medication compliance (Breitscheidel et al. 2010; Steiner and Prochazka 1997). Feasibility issues regarding the actual application of MPR are revisited in the description of the evaluation process.

Actual practice of intervention research (Greenwald and Cullen 1985) has been criticized (Glasgow et al. 2003; Tunis et al. 2003). Successful results of efficacy trials are often not validated in effectiveness trials since it is often assumed that interventions proven successful in efficacy trials would be reconfirmed in effectiveness trials. Since efficacy trials might employ very specific study populations, it should not be generally assumed that efficacy trial results can be generalized to the general population (Glasgow et al. 2003). Yet, due to a specific focus, efficacy trials are more likely to produce significant results. It would be a waste of resources to test interventions in broad, extensive, and more complex effectiveness trials, if these could have been rejected in efficacy trials. Nevertheless, efficacy trials need to be carefully and rigorously designed, executed, documented, and published to enhance utility and representativeness of results. The ePill evaluation can be classified as an efficacy trial: It is assessed whether ePill is suitable to improve medication compliance. To ease the assessment of gathered information and avoid analysis of unsuitable test subjects, we limit the study population to type-2 diabetics, who could benefit from improved medication compliance and have to take medication on a continuous basis.

Methods

Following the design science research paradigm (Gregor and Hevner 2013; Hevner et al. 2004; Purao 2002), ePill is developed with an incremental development approach consisting of multiple design cycles of artifact creation/refinement and qualitative/quantitative evaluation. Mixed methods evaluation (Ägerfalk 2013; Venkatesh et al. 2013) is employed to assess artifact quality, to inform artifact refinements with qualitative evaluation methods, and to demonstrate artifact utility and efficacy with quantitative evaluation. In the first design cycle, a graphical user interface (GUI) prototype was used to validate and refine early design decisions and directions. The GUI prototype can be classified as an exploratory, presentational prototype (Bäumer et al. 1996): It is executable and demonstrates a possible, fully functional GUI, but lacks further functionality not associated with the presentation layer. Reported deficiencies of PIL and guidelines as well as laws for the provision of information on pharmaceuticals served as basis for the design of the GUI prototype. Main purpose of the GUI prototype was to convey a good idea of ePill as well as its possibilities and limitations. This was advantageous to elicit useful, concise requirements and eased communication of the envisioned web application because the GUI prototype
offered a concrete, interactive representation of ePill. Requirements were elicited with qualitative, semi-structured interviews (n=12, female=6, male=6; min. age=20, avg. age=35, max. age=50), which have been reported to be among the most effective techniques for requirement elicitation (Davis et al. 2006). In order to avoid bias resulting from knowledge of the GUI prototype, it was not introduced until the end of the interview. Interviews served two purposes – elicitation of requirements and evaluation through observation. While interviewees explored and familiarized themselves with the GUI prototype, we observed their actions and reactions to discover weaknesses and strengths of the current implementation. In addition, interviewees were asked to assess and comment on the utility of the GUI prototype. Afterwards, newly elicited requirements and suggested improvements were consolidated, filtered, and used to refine the design of ePill as well as to implement the current artifact version in the second design cycle. In order to benefit from ePill, users must be able to operate it. A qualitative usability study (n=29, sessions=4, n/session=7-8, female=12, male=17; min. age=18, avg. age=35, max. age=63) to identify and access shortcomings of ePill’s usability concluded the second design cycle. At first, potential users performed fixed tasks testing ePill’s core functionality and features for one hour to familiarize themselves with ePill. Afterwards, strength and weaknesses of ePill’s usability were discussed in a focus group (Basch 1987).

To explain potential benefits of ePill use, the Information System (IS) Success Model by Delone and McLean (2003) is adapted. According to the IS Success Model, information quality, system quality, and service quality influence use of and user satisfaction with an IS (cf. Figure 1). Use and user satisfaction influence each other and the net benefits to be reaped through use of the IS. In the case of ePill, improved medication compliance and enhanced knowledge on medications taken represent the potential net benefits. System quality can be characterized by IS properties like adaptability, availability, reliability, response time, and usability. Service Quality can be characterized by factors like assurance, empathy, and responsiveness. While system quality and service quality remain constant across all treatments of our evaluation, information quality is changed across treatments. Information quality can be characterized by completeness, ease of understanding, personalization, relevance, and security. Information quality is changed by offering different degrees of personalization in treatment-specific versions of ePill (cf. section Evaluation Approach). Thereby, we also modify ease of understanding and security aspects.

Following Burton-Jones and Straub (2006), use is assessed according to a context-specific definition. We define use as: employment of ePill web application functionality to perform tasks by users. Use is measured through automated measurements and self-reports. Measurements of usage can include the domains of the user, the system (ePill), and tasks (functionality) performed with the system (Burton-Jones and Straub 2006). User-specific automated measurements are not employed to avoid influences on users’ system usage. Privacy concerns regarding monitoring might lead to decreased usage and, contrarily, users might feel compelled to use the system if they know they are monitored. Thus, only aggregated ePill usage is assessed during the evaluation period with automated measurements so that treatment-specific measurements of ePill use and tasks performed are obtained. Since user-specific assessments of use can

![Figure 1: Adaption of information system success model (DeLone and McLean 2003). Greyed-out concepts remain constant throughout evaluation.](image)
also hold valuable insights and to validate the aggregated assessments of use, user-specific information is elicited at the end of the ePill evaluation through self-reporting in questionnaires. User satisfaction assessment is mainly accomplished through the final questionnaires, but will be complemented with submitted bug reports and other feedback submitted during use.

To improve utility of the quantitative evaluation corresponding recommendations are followed. Tunis et al. (2003) made a case for the conduction of practical clinical trials (PCTs). Characteristics of PCTs fit our purposes since these are designed to elicit information required by practitioners to make decisions and are thus conducted in a quite realistic setting. PCTs are not designed to maximize discovery of new effects, approaches, or causalities. This is suitable since the primary objective is to evaluate whether medication compliance can be improved through use of ePill; further possible results are of secondary importance. PCTs have four core features: comparison of clinically relevant alternatives, enrolment of a diverse study population, recruitment from a variety of practice settings, and measurement of a broad range of relevant health outcomes. Glasgow et al. (2005) built on the propositions of Tunis et al. (2003) and added design and measurement recommendations. Along with the actual evaluation process the adaptation of these recommendations to our IS research undertaking is described in section ‘Evaluation Approach’.

Artifact Description

Requirement elicitation identified availability, extensibility, reliability, scalability, security and usability as objectives for ePill design (URI of latest prototype version: http://epill.uni-koeln.de). Three basic tasks are performed by ePill: Search for pharmaceuticals – enable users to specify parameters and search pharmaceuticals in the underlying database (1). Display of information on pharmaceuticals – enable users to view PIL information (2). Provision of supplementary services – refine the displayed information, link to similar information on other pharmaceuticals, or aggregate the information on pharmaceuticals (3). Further features of ePill are addressed in section ‘Evaluation Approach’. Architecture and design of the artifact as well as selected implementation issues are described in detail in (Dehling and Sunyaev 2012).

Main advantages of ePill are patient-centered provision of information and improved understanding due to employment of adapted digital content. Comprehensibility issues can be improved by ePill, but these should be primarily tackled on the data level instead of the presentation level. Supplementary services provide mostly aggregation features like detection of adverse drug reactions, determination of alternative dosage forms, or listing of pharmaceuticals with the same active pharmaceutical agent(s). In contrast, supplementary services cannot easily be offered by PIL or physical supplements. ePill can be considered patient-friendly because it provides functionality elicited from potential users and was designed to be easy to use and adaptable to users’ needs. The qualitative usability study substantiated posited benefits of ePill: Test subjects assessed ePill’s usability as acceptable after one hour of use without any guidance besides ePill’s internal support functionality (System Usability Scale score of 65 (Brooke 1996)). Only minor usability issues were identified, which will be weeded out in the next artifact increment. Identified shortcomings of ePill include a missing option that enables recommendation of available features based on user activity and a tutorial introducing ePill functionality. Some terminology needs to be changed: For instance, some test subjects mistook the ‘expert’ preset as preset for medical professionals instead of preset for experienced users. Information should be provided visually where applicable: Instead of indicating the dangerousness of known adverse drug reactions with the terms ‘low’, ‘contact physician’, and ‘high’, test subjects proposed to add a traffic light system to convey this information. Interestingly, test subjects desired functionality to save application state for later session. Such features were intentionally not implemented in basic ePill versions to avoid privacy invasions through profiling (Slamanig and Stingl 2008), but will be made optionally available in the next design cycle. Further usability studies will be conducted to ensure a pristine usability of ePill prior to the quantitative evaluation. Advantages of ePill pointed out by focus group participants include the possibility to select what information is displayed, 24/7 access, usefulness of offered supplementary functionality, access to information without the need to buy the pharmaceutical, comfortable discovery of desired information, provision of up-to-date information, ability to change font sizes, and good structuring of information.
Evaluation Approach

To justify that ePill features can contribute to the improvement of medication compliance, ePill, which was continuously refined based on the results of the qualitative evaluations, will be rigorously evaluated in a practical clinical trial – quantitative evaluation – in a further design cycle. Test subjects are split into four treatments (cf. Figure 2): The first group (Intervention Group I) has access to a basic version of ePill (ePill-IG1) providing only information on pharmaceuticals and offering no supplementary functionality. Intervention Group II has access to a more advanced version (ePill-IG2) offering supplementary services (cf. section Artifact Description) besides provision of PIL information. Intervention Group III has access to the version with the highest degree of personalization (ePill-IG3). While ePill-IG2 only lets users manually tailor ePill, ePill-IG3 is integrated with a personal health record (PHR) (e.g. Adida et al. 2010) allowing for automatic tailoring according to patients’ information stored in their PHR. The control group has no access to ePill. Comparison of medication compliance development in control group and intervention groups allows for testing of the main hypothesis that intervention groups have a more positive medication compliance development. If the hypothesis can be verified, positive development can be attributed to ePill since access to it discriminates intervention groups from the control group.

Hypothesis 1: Patients with access to ePill exhibit higher medication compliance than patients without access to ePill.

The second hypothesis is quite similar. Instead of focusing on the comparison of medication compliance between subjects, hypothesis 2 posits that a within-subject assessment of medication compliance with respect to use of ePill will show an improvement of medication compliance.

Hypothesis 2: After use of ePill patients will exhibit improved medication compliance.

ePill evaluation uses a two-factorial design (cf. Table 1). Test subjects are either provided with information on pharmaceuticals (intervention groups) by being granted access to ePill or have no access to provision of information on pharmaceuticals through ePill (control group). The other discriminating factor is the degree of offered functionality/personalization. ePill-IG1 offers only access to PIL information. ePill-IG2 offers supplementary services in addition to ePill-IG1 functionality and ePill-IG3 offers additional personalization through PHR integration. The remaining two treatments are omitted since provision of supplementary services or personalized services without access to ePill is contradictory. Discriminating degree of offered functionality/personalization, allows us to ascertain the effect of different design decisions on medication compliance. With ePill-IG2 users can, for example, specify a list of medications to run a check for adverse drug reactions or compile an aggregated list of side effects. ePill-IG2 can also be used to discover alternative medications with the same active ingredient or the same application areas that have more desirable dosage forms or different side effects. ePill-IG3 enhances offered services even...
further by allowing for automatic tailoring. This allows for functionality like automatic display of information on a patient’s medication or an automatic check for adverse reactions of medications a patient is taking. Moreover, ePill-IG3 can display automated warnings if patients are viewing information on medications having contraindications for or adverse reactions with medications they are currently taking. Hence, intervention-group-specific versions of ePill are characterized by a rising amount of functionality in combination with a rising degree of personalization.

Increased personalization comes at a price; if patients want access to tailored information and services they need to allow the application to access their personal, medical information, which might raise privacy concerns. Medical information is very sensitive and should not fall into the wrong hands (Rindfleisch 1997). Patients are concerned with information security and privacy issues and want to control access to their information (Pyper et al. 2004; Simon et al. 2009). Furthermore, information security and privacy concerns impede patients’ willingness to share information (Bélanger and Crossler 2011). Thus, increased benefits derived from increased personalization might be negated by the need to share more information to facilitate tailoring of offered services and information to patients’ needs. However, increasing the range of functionality offered to users through an increase of personalization, allows patients to reap more benefits through tailored services (Detmer et al. 2008; Johansson et al. 2012; Kerr et al. 2006; Silfvernagel et al. 2012). Users are not only empowered to take an active part in managing their health, but can also benefit from functionality specifically tailored to their needs, environment, and individual situation. Moreover, patients deem access to health information and related services beneficial and extant research shows that even the prospect of small benefits can bring users to share information (Wilson and Valacich 2012). Thus, we posit that an increased degree of personalization will lead to increased information quality. Hence, personalization indirectly affects medication compliance because increased information quality leads to increased use and user satisfaction (DeLone and McLean 2003; Petter et al. 2008), which in turn affect the net benefits (i.e. enhanced knowledge on medication taken and improved medication compliance).

Hypothesis 3: Versions of ePill with higher degree of personalization exhibit higher information quality than versions of ePill with lower degree of personalization.

During the evaluation, test subjects can keep on using any other sources of information. Members of the intervention groups just additionally have access to ePill. The evaluation focuses on type-2 diabetics; participants are not excluded for other personal characteristics. It is rather desirable to acquire test subjects with varying demographic characteristics, wide range of computer proficiency and attitude toward computer use, varying severity of illnesses, varying duration of illness, and diverse comorbid conditions to enhance the representativeness of the sample. This fits the intention of ePill, which was designed to be adaptable to a diverse range of user preferences (Dehling and Sunyaev 2012).

For MPR application, it is necessary to track refills made by test subjects. One limitation of MPR is that, when tracking refills in pharmacies, patients might obtain their pharmaceuticals in multiple pharmacies so that refills might be missed if patients visit pharmacies not participating in the study (Steiner et al. 1988). This problem is usually addressed with monetary incentives to frequent particular pharmacies, but this is not necessarily a fail-safe solution. Since our evaluation will be conducted in Germany, where diabetes medication is usually not available without prescription, MPR data collection can be based on prescriptions and their fulfillment. Thus, test subjects can obtain pharmaceuticals in any pharmacy and fulfillment of a prescription is recorded by health insurers. These cover a large fraction of the expenses for diabetes medication and patients are unlikely to unnecessarily pay for their medication themselves.
Participating medical practitioners can report issued prescriptions and participating health insurers can report on fulfillment of prescriptions. Obviously, the MPR measurement approach frames the selection of test subjects: Patients suitable for participation need to be diagnosed with type-2 diabetes, be patients of participating medical practitioners, and be insured with a participating health insurer (cf. Figure 2). From the pool of patients who give consent for use and recording of their relevant information, the equally sized intervention and control groups are randomly drawn. Behavioral change does not happen overnight and the observation period should not be that long to reduce attrition and adapt to the fast-paced IT environment. Therefore, we expect to detect only a rather small effect. Similar studies focus mainly on cognitive behavioral therapy. Since similar studies focusing solely on information provision could not be identified to derive an expected effect size, we used a value of 0.2 for Cohen’s d as proposed by Cohen (1988) for effect sizes expected to be small. In combination with commonly chosen values for likelihood of a type-I error (α = 0.05) and likelihood of a type-II error (β = 0.2), this leads to a required sample size of 393 users per treatment. Thus, a total sample size of roughly 1600 participants will be obtained, which should be large enough to represent a diverse spectrum of test subjects and to cope with potential dropouts (Eysenbach 2005). Along with selection of a diverse study population, we strive to motivate medical practitioners from diverse practice settings to participate. This should additionally influence sample variety and, due to more realism, works towards more representative results since patients obtain a varying degree of services with different quality from medical practitioners.

Since a web application is studied, outcomes like severity of symptoms, morbidity, or mortality are not appropriate. Instead additional aspects (outcomes) related to IS are measured. Still, the primary indicator for the utility of ePill is its effect on medication compliance. At first, medication compliance in the intervention and control groups is appraised while no group has access to ePill. If available, historic data can be used for baseline establishment; otherwise, an additional timeframe for baseline establishment will be prepended to the observation period. Subsequently, test subjects in the intervention groups are given access to the respective version of ePill and the effect on medication compliance is measured with MPR. The observation period is scheduled to be roughly a year depending on ease of baseline establishment and the refill interval length. If mean refill intervals are rather long, it will be necessary to extend the observation period accordingly to reduce influences of random, temporal deviations.

To motivate and illustrate use of ePill, test subjects in the intervention groups are provided with a flyer presenting main features and benefits of ePill and possible usage scenarios. To support interpretation of results additional information like daily doses per refill, number of visits to physicians, medication changes, complications, or use of other sources providing information on pharmaceuticals is collected. Performance characteristics of the system are monitored and support requests or reported problems related to ePill are tracked. Two questionnaires are issued to participants to validate MPR measurements and to elicit additional information. At least two questionnaires are necessary to allow for comparison of answers before and after ePill is made available to participants. Employment of questionnaires is reduced to a minimum because subjects might feel compelled to more compliant behavior through respective questions in a questionnaire. To avoid such bias, the first questionnaire is issued long before ePill is made accessible at the beginning of baseline establishment and the second questionnaire is issued at the end for the intervention phase. The questionnaires elicit information regarding participants knowledge on medications they are taking, beliefs regarding taking of pharmaceuticals, comorbidity, duration and severity of illness, internet usage and preferences, PHR use, socio demographics, diabetes medication taken, procurement of diabetes from 'alternative' sources, self-assessment of medication compliance, use of ePill, satisfaction with ePill, utility of ePill, and tasks performed with ePill.

Obtaining the required data to provide sophisticated information on many pharmaceuticals is a complex task (Dehling and Sunyaev 2012). For the purposes of the evaluation, ePill can provide a satisfying amount of information with satisfactory quality. We are still working on an efficient way to collect, maintain, and rectify required data and presented information. Data base enhancement is challenging since ePill needs to provide reliable information. Providing patients with wrong information could lead to serious and harmful consequences. Since software is usually not without defects automatic refinement of the data requires additional manual verification – an extensive, laborious task requiring expert knowledge on pharmaceuticals. Similar challenges impede employment of other techniques, like human computing (Quinn and Bederson 2011).
An approach to effectively and reliably improve the data base would facilitate further extensions: ePill could be extended to address cognitive limitations of patients with electronic media like pictures, sound files, or video based on the currently displayed information. For instance, pictograms could be used to convey the information not only textual, but also pictorial (Dowse and Ehlers 2005). The evaluation might also generate ideas for improving the underlying data base.

**Conclusion**

This paper presents development, design and mixed methods evaluation of ePill. ePill provides information on pharmaceuticals and supplementary services, avoiding drawbacks of PIL, and targets patients. According to the design science research paradigm, patients’ requirements and needs were incorporated into ePill in multiple design cycles. ePill has the potential to improve medication compliance; this assumption is to be verified by continuing evaluation and refinement of ePill as described above. Besides contributing to the solution of the prevalent problem of medication compliance, this research adds to the knowledge base by demonstrating application of the design science research paradigm in a sound development process of a patient-centered health IT service and applying mixed methods evaluation to assess the utility of ePill design and offered functionality. Special focus is on the tradeoff between offered functionality and information security and privacy concerns. Once proven useful and sufficiently refined, ePill can also serve as supplement for other services. The creation and evaluation processes represent a fusion of practices from IS research and medical sciences. Experiences gained from applying our evaluation approach can provide new insights for health IT research by combining the merits of multiple facets of this interdisciplinary domain. ePill represents an orchestration of various, established foundations, methods, and approaches to empower and be of use to a diverse range of patients.

**References**


