Managing My Bladder Dictates My Daily Routines – A Model for Design and Adoption of mHealth in Chronic Disease Management

Abstract. Urinary incontinence is a urological health issue affecting millions of people worldwide. While conventional aids have unhygienic and cumbersome attributes, mobile health (mHealth) interventions have the potential to significantly improve the quality of life. However, knowledge on how patients adopt mHealth interventions and how these solutions should be designed is scarce. In this study, we aim at presenting an adoption model to explain and derive design principles to support the adoption of mHealth solutions by chronic disease patients. We therefore followed an action design research approach, which held a systematic literature review of 67 papers and 16 expert interviews to build and evaluate the *ex-ante* model and another 16 interviews as well as a confirmative survey to further refine and evaluate the model. The *ex-post* model consists of five categories and 28 sub-categories of mHealth adoption.

Keywords: Action Design Research, Chronic Disease Management, mHealth, Sensor Data, Wearable.

1 Introduction

Urinary incontinence (UI) is a major urological health issue estimated to currently affect 423 million people worldwide [1]. The involuntary leakage of urine is characterized by various lower urinary tract symptoms (LUTS) [1–3]. Due to its widespread appearance, LUTS have a huge social and economic impact [4, 5]. Conventional aids predominantly contain unhygienic and cumbersome attributes [6, 7]. Mobile health (mHealth) interventions have the potential to significantly improve both the quality of life and the quality of care of those suffering from LUTS [8–10]. The mHealth market and the number and variety of mHealth solutions are rapidly expanding [9, 11]. Also, the amount and diversity of research concerning mHealth are quickly growing [8, 9]. However, mHealth applications regularly lack in user acceptance and fail when entering the market [12, 13], as a consequence of research and practice lacking knowledge of factors that influence the adoption of mHealth solutions through chronic disease patients, such as patients suffering from LUTS [11]. Designing such devices with the objective to ensure later user adoption needs further guidance and structure and could build upon such knowledge [8].

In this research-in-progress study, we aim at presenting a model for the adoption of mHealth solutions by patients suffering from LUTS and deriving principles for designing mHealth interventions. We, therefore, develop and evaluate the model along {blinded for review}, a mHealth device to support patients suffering from LUTS in their daily routines and prevent harmful incidents.

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At the outset, we conducted a systematic literature review to build an *ex-ante* adoption model. Subsequently, we applied an action design research (ADR) approach [14] to revise the adoption model in action and develop an mHealth solution, which noninvasively determines the filling level of the urinary bladder and displays the filling level to a digital end-device. For designing the mHealth solution both potential users and other relevant stakeholders must get involved in the design process [15, 16]. Equally split in the α- and β-cycle, we conducted 20 semi-structured interviews with patients suffering from LUTS and twelve with selected experts in various LUTS-related fields. To evaluate and validate our constructs in a larger setting, we currently conduct a survey as last part of the β-cycle of our ADR approach. On this base, we conclude with the *ex-post* adoption model that we call the Chronic Disease mHealth Adoption Model (CDmHAM) and derive principles for designing such mHealth.

2 Background

On a higher level, UI is a part of various LUTS. According to current definitions, the term LUTS comprises symptoms occurring in consequence of diseases affecting the urinary bladder and the urethra [17]. Depending on their characteristics, these symptoms can be divided into four categories: symptoms concerning UI, bladder storage, voiding, and post micturition [17]. Many patients suffer from perturbing symptoms that influence their health-related quality of life and life expectancy [1]. LUTS come along with high stigmatization and hence psychological problems for those affected [1, 4], and are still a source of morbidity and mortality [1, 18]. Conventional aids exist to manage LUTS, and they are as manifold as the symptoms themselves [6]. Amongst others, they include absorbent and draining UI aids, medicaments, surgical and minimally invasive therapy options, electrical stimulation or biofeedback, and strengthening training for pelvic floor muscles [4, 6]. They have in common that they contain unhygienic or cumbersome attributes [7].

Due to their widespread appearance and insufficient means to counteract their symptoms, LUTS have a huge socio-economic impact [4, 5]. In Germany, solely UI was estimated to cause total costs of €4 billion for the entire health system in 2002 [4]. Furthermore, costs are predicted to rise to more than €6 billion until 2050 due to the demographic change [4]. However, experts also predict that the use of digital technologies such as wearables and sensors has the potential to reduce the overall health care costs [10], and will further extend life expectancy and improve the quality of life of those affected [19]. Such wearable health technologies can be categorized as ”mHealth", which is defined as a “medical and public health practice supported by mobile devices” [10].

As multiple LUTS result from missing knowledge on the filling level of the urinary bladder, an mHealth solution to digitally output that information would be of significant value. On the one hand, unwanted spontaneous micturition or backflow of urine can be avoided, which occur due to an unnoticed exceeding of the filling level of the urinary bladder. On the other hand, daily planning of micturition can be significantly improved. Yet, under which conditions patients would adopt such an mHealth solution and how it

should be designed remain unclear. For this reason, we investigate the adoption and design of such a sensor system throughout the study at hand.

3 Research Approach

We first conducted a literature review to develop an *ex-ante* model of factors that positively affect the intention of patients suffering from LUTS to adopt the intended mHealth solution as a foundation for our ADR project, which will bring the adoption model and the sensor system for supporting LUTS as artifacts. Within the α-cycle of our ADR approach, we developed large parts of the *ex-post* model as well as the sensor system. The ongoing β-cycle will help us further to evaluate, incrementally enhance, and confirm the results of the α-cycle to finally conclude with the CDmHAM and derive design principles from the so-built sensor system.

4 Developing a Chronic Disease mHealth Adoption Model

4.1 A Literature Review to Build the *Ex-ante* Model

To build the *ex-ante* adoption model, we conducted a systematic literature review [20–22]. We searched and screened titles, abstracts, and keywords of 302 papers in the interdisciplinary online databases PubMed, IEEE Xplore, AISeL, Epistemonikos, Web of Science, ScienceDirect, and EBSCOhost [23, 24]. As search terms, we selected “mHealth”, ”mobile health”, ”noninvasive”, “chronic disease”, ”chronic illness”, and ”health care”. Further operationalizing our selection by implementing a four-point Likert scale, we allocated 60 papers and added another seven papers during forward and backward search to conclude with 67 papers for in-depth analysis [25].

We analyzed the 67 papers identified with open, axial, and selective coding borrowed from Grounded Theory [20–22]. During the iterative coding process, constructs, sub-categories, and categories changed dynamically. Finally, the *ex-ante* adoption model consisted of five categories (i.e., users, perceived benefits, hard- and software, data, external conditions) and 21 sub-categories.

4.2 Action Design Research to Build the *Ex-post* Model

Our ADR project consisted of the four regular stages [14]. First, we *formulated the problem*, and explained the methodical setting of our *building, intervention, and evaluation* stage, in which we involved researchers, practitioners, and users and carried out four design and evaluation cycles. In parallel, we followed *reflection and learning* to conceptually evolve from building an artifact for a specific purpose to deploying the emerging understanding to a broader class of problems [26]. Finally, we close with stage four that is *formalization and learning* generalizing our findings to receive superordinate knowledge.

The α-cycle

To gain an in-depth understanding of the intention of potential users to adopt our mHealth solution, we conducted semi-structured interviews with potential users and practitioners. In the α-cycle, we iteratively interviewed ten patients that suffer from multiple sclerosis, paraplegia, Parkinson's disease, spina bifida, or stroke. Furthermore, we interviewed six practitioners from urology, neuro-urology, paraplegiology, or physiotherapy. We stopped the interview process in the α-cycle after these overall 16 interviews since we realized that only marginally new knowledge emerged and conceptional saturation had been achieved [27].

The β-cycle

To ensure generalizability of our findings and their applicability in practice, we added new interviewees in the β-cycle. The ten new patients suffer from inborn LUTS, multiple sclerosis, paraplegia, Parkinson's disease, prostate cancer, stroke, or various neurological damages. Furthermore, we interviewed six practitioners from day care of demented patients, paraplegiology, physiotherapy, or urology. We again stopped the interview process in the β-cycle since we realized conceptional saturation [27]. At the outset, all interviewees had time to analyze the α-version of the sensor device. Interviews in the β-cycle were largely of confirmatory nature, though we still gave all interviewees the opportunity to complement new insights [14].

On the base of these findings, we currently build the *ex-post* model (i.e., the CDmHAM) and finalize the sensor system. We found five categories and in total 28 sub-categories. First, the category users is characterized by accessibility, customization, initial user briefing, and constant user consulting. Second, perceived benefits split into usefulness, autonomy, convenience, comfort, mobility, and unobtrusiveness. Third, hardware and software build upon safety, reliability, performance, durability, hardware fixation, design, interoperability, and connectivity. Fourth, in terms of data, generation and integration, storage and access, analysis, feedback on usage, transfer, and privacy are relevant. External conditions, fifth, are determined by ongoing maintenance, costs, health insurance involvement, and provider involvement. Furthermore, we identified following pivotal principles for the design to be adopted so far: miniaturization, flexibility, light weight construction, and smooth surface, e.g., to provide mobility, unobtrusiveness, and comfort. Since our work is still in progress, we aim at complementing these principles to a more comprehensive catalog of design principles.

Additionally, we currently conduct a survey to evaluate and assess our findings in a larger setting. Thereby, we aim at understanding the relevance of our sub-categories identified [28, 29]. In the survey, we asked participants to rate our sub-categories concerning their relevance. Here, we extended the scope by recruiting patients as well as assistants that support individuals suffering from LUTS. A total of 361 individuals took part in the survey, yet.

The CDmHAM and its derived design principles could contribute to theory and offer practical insights to successfully establishing mHealth interventions. As a research-in-progress project, we look forward to receiving valuable comments and suggestions to improve this work in the future.

References

1. Irwin, D.E., Kopp, Z.S., Agatep, B., Milsom, I., Abrams, P.: Worldwide prevalence estimates of lower urinary tract symptoms, overactive bladder, urinary incontinence and bladder outlet obstruction. BJU international 108, 1132–1138 (2011)
2. DeMaagd, G.A., Davenport, T.C.: Management of Urinary Incontinence. Pharmacy and Therapeutics 37, 345-361H (2012)
3. Rizvi, R.M., Ather, M.H.: Assessment of Urinary Incontinence (UI) in Adult Patients. In: Alhasso, A., Bekarma, H. (eds.) Synopsis in the Management of Urinary Incontinence. InTech (2017)
4. Neubauer, G., Stiefelmeyer, S.: Economic Costs of Urinary Incontinence in Germany. In: Becker, H.-D., Stenzl, A., Wallwiener, D., Zittel, T.T. (eds.) Urinary and Fecal Incontinence, pp. 25–31. Springer-Verlag, Berlin/Heidelberg (2005)
5. Nitti, V.W.: The prevalence of urinary incontinence. Reviews in Urology 3, S2-6 (2001)
6. German Continence Society: Heil- und Hilfsmittel, https://www.kontinenz-gesellschaft.de/Heil-und-Hilfsmittel.187.0.html?&L=872
7. Toye, F., Barker, K.L.: A meta-ethnography to understand the experience of living with urinary incontinence: 'is it just part and parcel of life?'. BMC urology 20, 1 (2020)
8. Dou, K., Yu, P., Deng, N., Liu, F., Guan, Y., Li, Z., Ji, Y., Du, N., Lu, X., Duan, H.: Patients' Acceptance of Smartphone Health Technology for Chronic Disease Management: A Theoretical Model and Empirical Test. JMIR mHealth and uHealth 5, e177 (2017)
9. Silva, B.M.C., Rodrigues, J.J.P.C., La Torre Díez, I. de, López-Coronado, M., Saleem, K.: Mobile-health: A review of current state in 2015. Journal of biomedical informatics 56, 265–272 (2015)
10. World Health Organization: mHealth. New horizons for health through mobile technologies. World Health Organization, Geneva (2011)
11. Jiang, Y., West, B.T., Barton, D.L., Harris, M.R.: Acceptance and Use of eHealth/mHealth Applications for Self-Management Among Cancer Survivors. Studies in health technology and informatics 245, 131–135 (2017)
12. Nilsen, W., Kumar, S., Shar, A., Varoquiers, C., Wiley, T., Riley, W.T., Pavel, M., Atienza, A.A.: Advancing the science of mHealth. Journal of health communication 17, 5–10 (2012)
13. Pan, A., Zhao, F.: User Acceptance Factors for mHealth. In: Kurosu, M. (ed.) Human-computer interaction. Interaction in context : 20th International Conference, HCI International 2018, Las Vegas, NV, USA, July 15-20, 2018 : proceedings, part II, 10902, pp. 173–184. Springer International Publishing, Cham (2018)
14. Sein, M.K., Henfridsson, O., Purao, S., Rossi, M., Lindgren, R.: Action design research. MIS Quarterly 35, 37–56 (2011)

15. Zhang, L., Babu, S.V., Jindal, M., Williams, J.E., Gimbel, R.W.: A Patient-Centered Mobile Phone App (iHeartU) With a Virtual Human Assistant for Self-Management of Heart Failure: Protocol for a Usability Assessment Study. JMIR research protocols 8, e13502 (2019)
16. Noorbergen, T.J., Adam, M.T.P., Attia, J.R., Cornforth, D.J., Minichiello, M.: Exploring the Design of mHealth Systems for Health Behavior Change using Mobile Biosensors. CAIS, 944–981 (2019)
17. International Continence Society: Fact Sheets. A Background to Urinary and Faecal Incontinence (2015)
18. Ethans, K.D., Casey, A.R., Bard, R.J., Namaka, M.P.: Neurogenic overactive bladder in spinal cord injury and multiple sclerosis: role of onabotulinumtoxinA. Degenerative neurological and neuromuscular disease 4, 65–75 (2014)
19. Cajita, M.I., Hodgson, N.A., Lam, K.W., Yoo, S., Han, H.-R.: Facilitators of and Barriers to mHealth Adoption in Older Adults With Heart Failure. Computers Informatics Nursing (CIN) 36, 376–382 (2018)
20. Wolfswinkel, J.F., Furtmueller, E., Wilderom, C.P.M.: Using grounded theory as a method for rigorously reviewing literature. European Journal of Information Systems (A) 22, 45–55 (2013)
21. Wiesche, M., Jurisch, M.C., Yetton, P.W., Krcmar, H.: Grounded Theory Methodology in Information Systems Research. MISQ 41, 685–701 (2017)
22. Corbin, J.M., Strauss, A.: Grounded theory research: Procedures, canons, and evaluative criteria. Qual Sociol 13, 3–21 (1990)
23. Bandara, W., Furtmueller, E., Gorbacheva, E., Miskon, S., Beekhuyzen, J.: Achieving Rigor in Literature Reviews: Insights from Qualitative Data Analysis and Tool-Support. CAIS 37 (2015)
24. vom Brocke, J., Simons, A., Riemer, K., Niehaves, B., Plattfaut, R., Cleven, A.: Standing on the Shoulders of Giants: Challenges and Recommendations of Literature Search in Information Systems Research. CAIS 37 (2015)
25. Webster, J., Watson, R.T.: Analyzing the Past to Prepare for the Future: Writing a Literature Review. MIS Quarterly 26, xiii–xxiii (2002)
26. van Aken, J.E.: Management Research Based on the Paradigm of the Design Sciences: The Quest for Field-Tested and Grounded Technological Rules. Journal of Management Studies 41, 219–246 (2004)
27. Briggs, R.O., Schwabe, G.: On Expanding the Scope of Design Science in IS Research. In: Jain, H.K., Sinha, A.P., Vitharana, P. (eds.) Service-oriented perspectives in design science research. 6th international conference, DESRIST 2011, Milwaukee, WI, USA, May 5-6, 2011 ; proceedings, 6629, pp. 92–106. Springer, Heidelberg (2011)
28. Malterud, K.: Qualitative research: standards, challenges, and guidelines. The Lancet 358, 483–488 (2001)
29. Venkatesh, V., Brown, S.A., Bala, H.: Bridging the Qualitative-Quantitative Divide: Guidelines for Conducting Mixed Methods Research in Information Systems. MISQ 37, 21–54 (2013)