How Patient-generated Data Enhances Patient-Provider Communication in Chronic Care: A Field Study in Design Science Research

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Table of Contents

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Abstract

Background: Modern approaches like patient-centered care ask health providers (e.g., nurses, physicians, and dietitians) to activate and include patients to participate in their healthcare. Mobile health (mHealth) is integral in this endeavor for more patient-centricity. However, structural and regulatory barriers have hindered their adoption. Existing mHealth apps often fail to activate and engage patients sufficiently. Moreover, such systems are seldom integrated well with health providers' workflow.

Objective: This study investigates how patient-provider communication behaviors change when introducing patient-generated data into patient-provider communication.

Methods: We adopt the design science approach to design the PatientHub, an integrated digital health system that engages patients and providers in patient-centered care for weight management. The PatientHub was developed in four iterations and was evaluated in a three-week field study with 27 patients and six physicians. We analyzed 54 video recordings of PatientHub-supported consultations and interviews with patients and physicians.

Results: PatientHub introduces patient-generated data into patient-provider communication. We observed three emerging behaviors when introducing patient-generated data into consultations. We name these behaviors emotion labeling, expectation decelerating, and decision ping pong. Our findings show how these behaviors enhance patient-provider communication and facilitate patient-centered care. Introducing patient-generated data leads to behaviors that make consultations more personal, actionable, trustworthy, and equal.

Conclusions: The results of this study indicate that patient-generated data facilitate patient-centered care by activating and engaging patients and providers. We propose three design principles for patient-centered communication. Patient-centered

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Conclusions: The results of this study indicate that patient-generated data facilitate patient-centered care by activating and engaging patients and providers. We propose three design principles for patient-centered communication. Patient-centered communication informs the design of future mHealth systems and offers insights into the inner workings of mHealth-supported patient-provider communication in chronic care.

Keywords: Patient-Provider Communication; Patient-generated Data; Field Study; Chronic Care; Design Science Research, Patient-centered Care, Integrated Care, Patient-Provider Collaboration

Introduction & Research Background

The quality of the patient-provider relationship is strongly linked to patients' increased adherence and better health outcomes [1–3]. Patient-provider communication requires exchanging accurate and relevant information to better understand patients, their preferences, and context [4,5]. However, provider instructions are complex and not communicated adequately to patients [3,6], as health providers often lack the time or communication training [7]. In turn, patients have difficulties recalling crucial information (e.g., their adherence to taking medication regularly), impeding providers' ability to quickly assess their medical condition and derive actions [8,9]. As a result, adherence and health outcomes are often subpar – especially in people with chronic conditions [6,10,11]. Due to its centrality, improving patient-provider communication is a topic of continued interest in medical research.

Patient-centered Care

Over the last decades, the understanding of good patient-provider communication has evolved. Historically, providers possessed most of the power in patient-provider communication [12]. These power dynamics mainly occurred due to the significant knowledge difference between providers and patients [13]. The resulting paternalistic model, in which the providers made all the decisions, led to poor adherence and increased healthcare costs [14,15]. Newer approaches, like shared decision-making and patient-centered care, ask providers to adopt more inclusive approaches focusing on the collaborative nature of patient-provider communication [4,5,16–18].

Patient-centered care proposes a holistic clinical method that centers around the patients, their preferences, and contexts [4,5,19]. It is defined as "respectful of and responsive to individual patient preferences, needs, and values and ensuring that patient values guide all clinical decisions" and is one of six key elements of high-quality care [16]. The clinical method of patient-centered medicine by Stewart et al. [4] is among the most frequently employed frameworks. It proposes a communication approach that suggests looking beyond a patient's acute problem and into their history and context. The framework suggests 1) *Exploring Health, Disease, and the Illness Experience*; 2) *Understanding the Whole Person*; and 3) *Finding Common Ground* to 4) *Enhancing the Patient-Clinician Relationship*. In the following, we describe each of those dimensions.

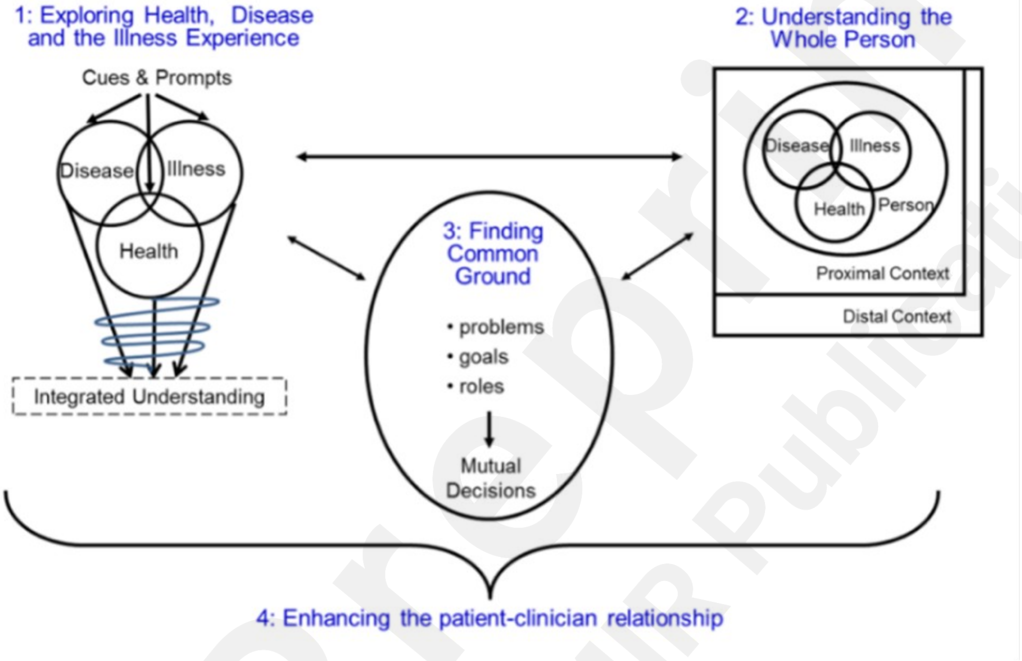


Figure 1: Patient-centered Care Framework by Stewart et al. [4]

Exploring Health, Disease, and the Illness Experience highlights the importance of understanding the patient's experience. People have different interpretations and unique experiences of health and illness. Someone with an asymptomatic disease may perceive themselves as healthy, while others feel ill without having a disease. Providers should seek to understand and support the patient's view of their situation and their experience of health and illness by listening to their concerns and feelings [4,20].

Understanding the Whole Person focuses on understanding the patient's proximal and distal context [4]. It enables meaningful conversations about the illness and treatment options, as providers know their patient as a person (e.g., what is currently important to them) [20]. Younger patients might struggle more with a diagnosis than older people. A patient's relationships, work, education, lifestyle, and culture play a significant role in their treatment.

Patients and providers work together to *Find Common Ground* regarding the problems and priorities, the goals of the therapy, and the roles of the patient and the provider [4]. It stresses the emotional engagement with the patient and the genuinely collaborative aspect of finding common ground to arrive at mutual decisions [4].

Enhancing the Patient-Clinician Relationship is the goal of every encounter in patient-centered medicine [4]. Healthcare becomes genuinely patient-centered through an integrated understanding of the patient's experience, understanding them as a whole person, and mutual decisions [20]. Stewart et al.'s framework conceptualizes patient-provider communication to achieve patient-centered care. It proposes a mindset that places patients at the center of clinical practice.

Patient-generated Data in Patient-Provider Communication

This shift in the mindset has attracted increasing interest in health informatics research that studies the effect of technology on patient-provider communication [21–27]. In face-to-face consultations, patient data generated on mobile health (mHealth) applications become increasingly important as they allow patients and providers to gain deeper insights into patients' routines and adherence to therapy plans. Patient-generated data is health-related data gathered or created by patients, usually through wearables and mHealth [28]. Studies in health informatics and related fields have demonstrated the potential of patient-generated data to increase patient-provider communication [22,29,30]. mHealth allows patients to generate abundant health information, such as dietary patterns, emotional conditions, or objective measures like blood pressure [22,23,31]. This data allows for insights into the patient's health experience and journey unlike ever before [32,33].

mHealth-supported approaches have significantly improved patient-provider communication, adherence, and health outcomes in chronic care [34–36]. Studies have shown how this patient-generated data allows patients and providers to engage in collaborative sensemaking that improves decision-making [23,30,31,37]. It allows deeper discussions about personal values [14,16] and improves patients' understanding of their condition and treatment [38]. Further, introducing patient-generated data into consultation affects the role dynamics of therapeutic sessions [34]. For example, sharing clinical notes shifts power in the patient-provider relationship [36]. Other studies report how sharing patient-generated data through mHealth leads to greater disclosure and better communication in consultation, resulting in better health outcomes [30,31].

These insights have been validated for different age groups [30,39,40] and chronic conditions (e.g., chronic kidney disease) [21,25,35,41]. This previous research shows the positive impact of introducing patient-generated data into consultations on adherence and health outcomes [35,36]. For example, Vitger et al. [35] describe the positive impact of generating data on a smartphone app on patient activation, communication confidence, and preparedness for decision-making in patients with schizophrenia.

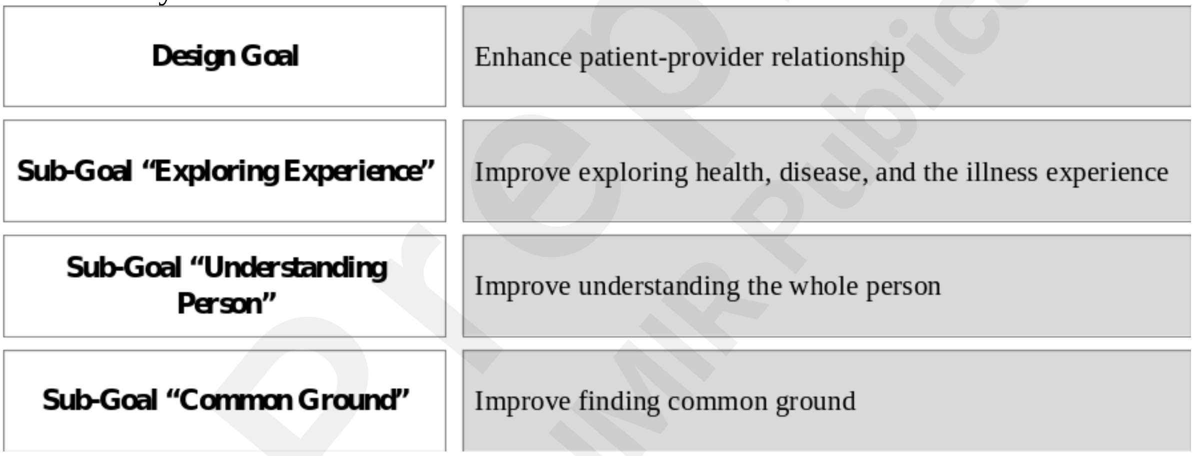
While existing research agrees on the vital role of patient-generated data in patient-provider communication [19,21,23], significant obstacles remain to leverage its potential. So far, structural and regulatory barriers have slowed advances [42,43]. mHealth applications seldom integrate with the provider's workflow, leading to a fragmentation of health data [44,45]. More importantly, Cozad et al. found that only a few mHealth applications engage and activate patients to participate in patient-centered care [46]. Finally, most studies report on the positive effects of patient-generated data on patient-provider communication. They often fail to investigate the communication behaviors that utilize patient-generated data. Accordingly, patient-provider communication remains a black box that receives patient-generated data as input and creates better communication as output (see Figure 2). Little to no research studies the design of systems that 1) integrate patient-generated data into the provider's workflow and 2) use this data in consultations to enhance patient-provider communication. This study aims to address this research gap by designing and evaluating an integrated digital health system that enhances the patient-provider communication.

Figure 2: The process of patient-provider communication as a black box.

Methods

This study addresses the research gap described above by developing PatientHub in a design science research (DSR) approach to enhance the patient-clinician relationship [47,48]. DSR is a suitable approach as it systematically solves important general problems and generates new knowledge in the form of design principles, theoretical models, approaches, and impacts of technology use [49]. DSR proposes to ground a solution's design in existing knowledge and theories, so-called kernel theories, to justify design decisions [50]. Due to these properties, design science is increasingly applied in medical informatics to study emerging technologies [48,51,52].

To address the research gap, we 1) designed PatientHub and 2) studied its impact on patient-provider communication by adopting patient-centered care proposed by Stewart et al. [4] as our kernel theory. PatientHub is an integrated digital health tool that introduces patient-generated data into consultations. We build on the strong correlation between patient-generated data and improved patient-provider communication established in recent work [34–36]. While the patient-centered care framework offers a holistic foundation for improving patient-provider communication, it lacks a clear operationalization of the three dimensions that offer mHealth designers and health providers guidance on implementing patient-centered care. Specifically, it is unclear how to integrate patient-generated data into the consultation process and how patients and providers utilize it for patient-centered care. Accordingly, we formulate the following design goal and sub-goals in line with our kernel theory:



Design Goal	Enhance patient-provider relationship
Sub-Goal "Exploring Experience"	Improve exploring health, disease, and the illness experience
Sub-Goal "Understanding Person"	Improve understanding the whole person
Sub-Goal "Common Ground"	Improve finding common ground

Figure 3: Design goal and sub-goals based on the patient-centered care framework [4]

The following sections present the PatientHub design, our field study approach, and the data analysis method.

PatientHub Design

The project team designed the PatientHub in four iterations. Our project team included a medical informatics company, a health institute specializing in chronic care, and two research institutions.

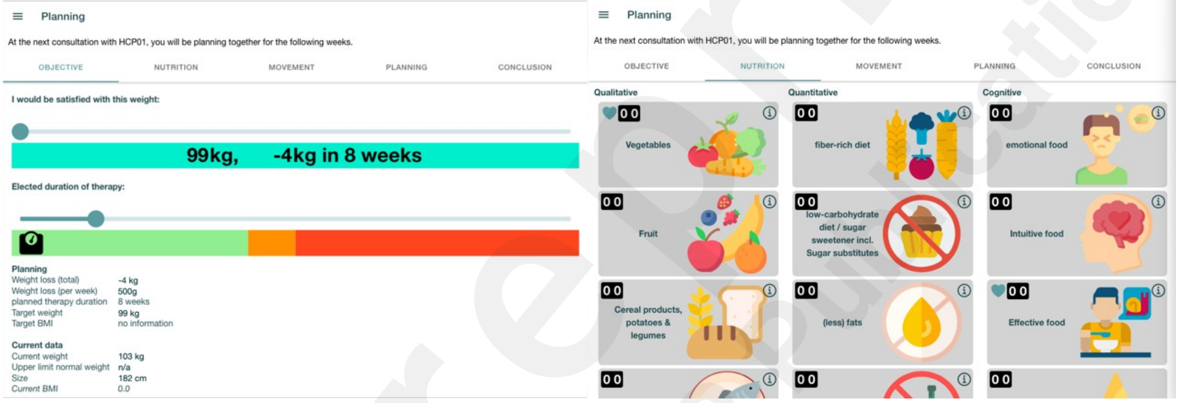
PatientHub's design is grounded in the patient-centered care framework [4] and leverages existing design knowledge [21–23,34,39,53]. Over the three preliminary iterations, we continuously evaluated and improved the design. We tested the first design iteration by applying the think-aloud method with seven participants acting as patients [54]. After refining the design in the second iteration, a focus group of five domain experts from software development, medicine, and research evaluated the revised PatientHub. In the third iteration, three health providers and five patients evaluated the design in role-plays of consultations. This paper reports on the field study evaluating the prototype with actual patients and physicians.

The PatientHub aims to enhance patient-provider communication by integrating patient-generated data into the consultation. It consists of a *patient app*, where patients generate data, and a *consultation app*, where patient-generated data provides a foundation for discussion in the consultation. Below, we describe the design implementation using a scenario and screenshots of the PatientHub. It represents a potential user story of the PatientHub during the field study.

PatientHub Scenario:

John is a patient at Laura's clinic struggling with obesity. Last week, Laura proposed that John try the PatientHub to help them advance John's journey to better health. In the patient app on his smartphone, John tracked his dietary and activity habits in daily notes in a digital journal, filled out a general health questionnaire, and selected favorites for behavior change interventions as part of a one-week preparation phase.

In the initial consultation, Laura and John review the journal entries, questionnaire answers, and intervention favorites in the consultation app on a tablet. The consultation app consists of four screens: goal setting, defining dietary and activity interventions, planning, and closing. For goal setting, John and Laura discuss target weight and therapy duration with an interactive visualization using sliders (see Figure 4, left). As the visualization relates weight loss and duration to each other, they can discuss healthy weight loss and set realistic goals. To define dietary and activity interventions, John liked three interventions he would like to explore. John and Laura can discuss additional interventions from a list of obesity-friendly interventions (see Figure 4, right, selected by medical professionals).



Planning

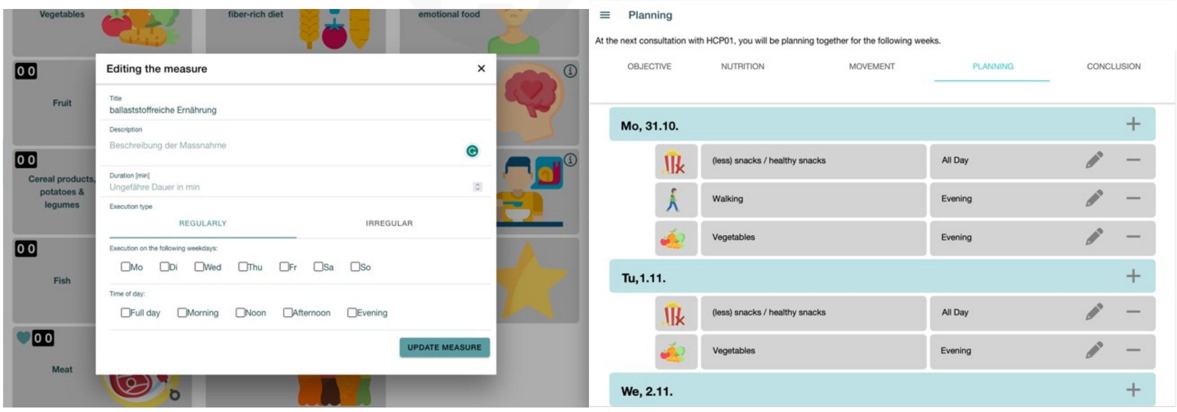
Weight loss (total)	-4 kg
Weight loss (per week)	500g
planned therapy duration	8 weeks
Target weight	99 kg
Target BMI	no information

Current data

Current weight	103 kg
Upper limit normal weight	n/a
Size	182 cm
Current BMI	0.0

Figure 4: Goal Setting (left) and Dietary Interventions (right)

To create an intervention, they specify a name, a description (e.g., 8'000 steps/day), a duration (if applicable), recurrence (i.e., regular or irregular), and preferred days and times (see Figure 5, left). The consultation app allows them to discuss the interventions to arrive at a patient-centered therapy plan considering John's specific context. In planning, John and Laura see an overview of the interventions in calendar form (see Figure 5, right). They can adjust the therapy plan if necessary (e.g., move an intervention from Monday to Tuesday). Once the therapy plan is finalized, all information is automatically shared with John in the patient app.



Title: ballaststoffreiche Ernährung

Mo, 31.10.

(less) snacks / healthy snacks	All Day
Walking	Evening
Vegetables	Evening

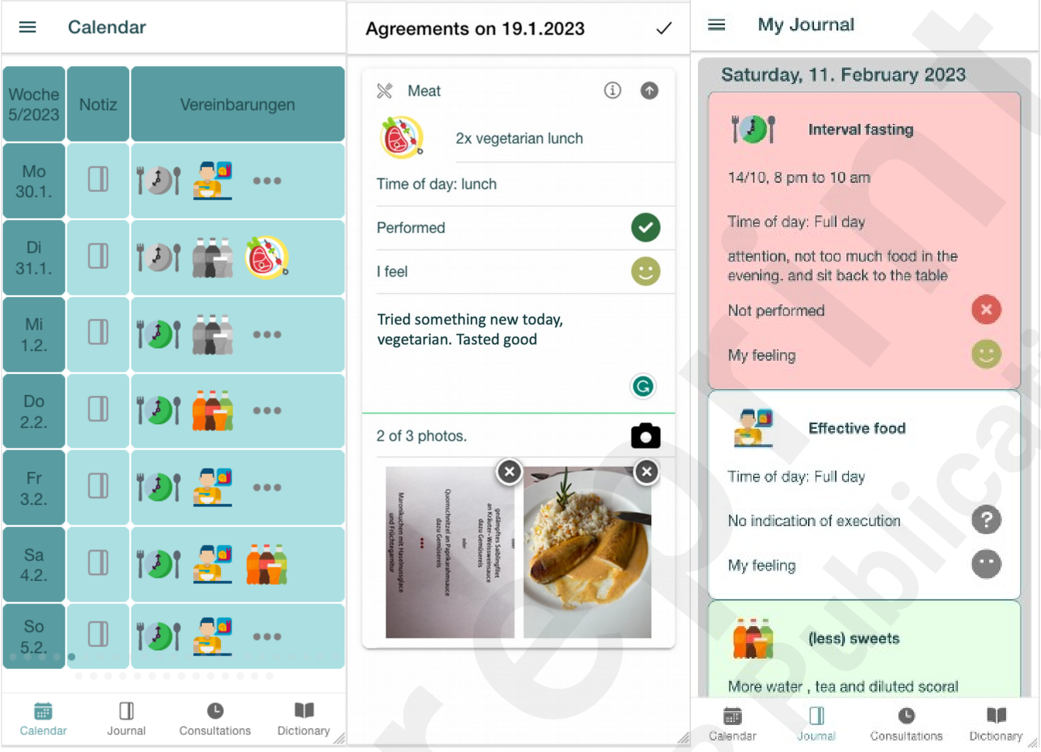
Tu, 1.11.

(less) snacks / healthy snacks	All Day
Vegetables	Evening

We, 2.11.

Figure 5: Measure Specification (left) and Planning (right)

John tracks his health journey in PatientHub's journal for two weeks. He tracks his adherence to the therapy plan and his experience while executing it. John sees each intervention in the calendar, where open interventions are greyed out and become colored once completed (see Figure 6, left). For example, John had to limit carbohydrate-dense foods today. He clicks on the grey task icon to create a task-specific entry. He marks the task completed and sets his emotional state to medium, as he missed out on dessert today. John then uploads a picture of his lunch and writes a note (see Figure 6, middle). He can now review his entries in his journal (see Figure 6, right). John carried out the therapy plan and kept his digital journal during the two-week implementation phase, leading to the follow-up consultation with Laura.



Agreements on 19.1.2023

Meat

2x vegetarian lunch

Time of day: lunch

Performed ✓

I feel

Tried something new today, vegetarian. Tasted good

2 of 3 photos.

My Journal

Saturday, 11. February 2023

Interval fasting

14/10, 8 pm to 10 am

Time of day: Full day

attention, not too much food in the evening. and sit back to the table

Not performed

My feeling

Effective food

Time of day: Full day

No indication of execution

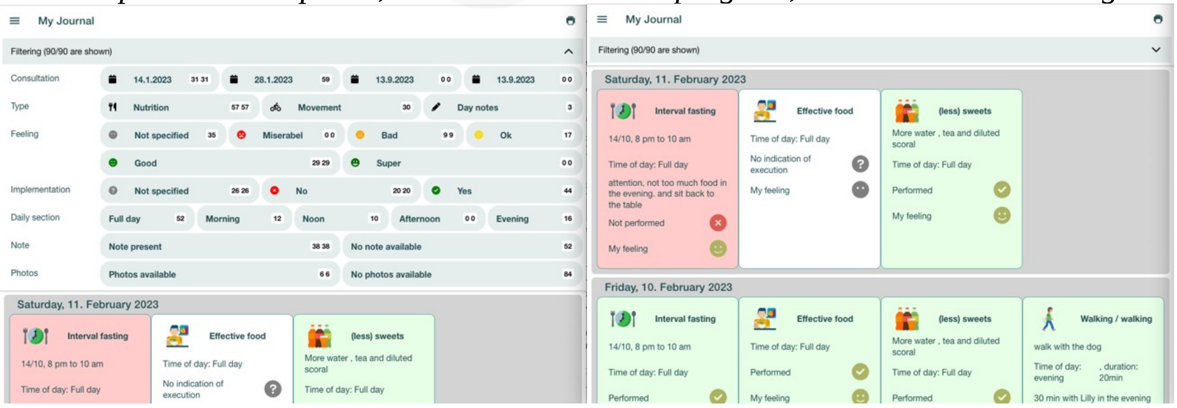
My feeling

(less) sweets

More water , tea and diluted scoral

Figure 6: Calendar (left), Journal Entry (middle), and Journal Overview (right)

The follow-up consultation focuses on reviewing John's journal. Laura and John apply different filters to the journal entries, like task type (i.e., diet, activity, and daily note), emotions, execution, and media type (see Figure 7, left). This way, they can review interventions that were not completed or completed but not enjoyed by John (see Figure 7, right). Through this discussion, they identify opportunities to improve the therapy plan and adherence. They adjust interventions as in the initial consultation by going through diet, activity, and planning before closing the consultation. Again, all data is shared across the PatientHub apps, and the loop between consultations is closed. John enters a new implementation phase, where he records his progress, which he will review again with Laura.



Consultation	14.1.2023	31 31	28.1.2023	59	13.9.2023	0 0	13.9.2023	0 0	
Type	Nutrition	57 57	Movement	30	Day notes	3			
Feeling	Not specified	35	Miserabel	0 0	Bad	9 9	Ok	17	
	Good	29 29	Super	0 0					
Implementation	Not specified	26 26	No	20 20	Yes	44			
Daily section	Full day	52	Morning	12	Noon	10	Afternoon	0 0	Evening 16
Note	Note present	38 38	No note available	52					
Photos	Photos available	6 6	No photos available	84					

Saturday, 11. February 2023

Interval fasting

14/10, 8 pm to 10 am

Time of day: Full day

attention, not too much food in the evening. and sit back to the table

Not performed

My feeling

Effective food

Time of day: Full day

No indication of execution

My feeling

(less) sweets

More water , tea and diluted scoral

Time of day: Full day

Performed

My feeling

Friday, 10. February 2023

Interval fasting

14/10, 8 pm to 10 am

Time of day: Full day

Performed

Effective food

Time of day: Full day

Performed

My feeling

(less) sweets

More water , tea and diluted scoral

Time of day: Full day

Performed

Walking / walking

walk with the dog

Time of day: evening , duration: 20min

30 min with Lilly in the evening

Figure 7: Filter Options (left) and Journal Overview (right)

Data Collection

In line with the "human risk & effectiveness" strategy [55], we evaluated PatientHub in a naturalistic setting to evaluate the effects of PatientHub on patient-provider communication. For this purpose, we collected data in a three-week field study. The data set contained video recordings of each consultation and interviews with each participant after both consultations. We analyzed 27 initial and follow-up consultations (54 recordings) to study emerging behaviors when integrating patient-generated data into the consultations. Further, we analyzed interviews with all participants to study how patient-generated data enhances patient-provider communication (66 interviews in total; physicians were interviewed once per phase). In the interviews, the participants reflected on their experiences throughout the field study. The authors and the project team developed the interview guides based on the kernel theory (i.e., patient-centered care). The interview guide further included questions about the participants' experience using PatientHub and their implementation of the therapy plan. There were separate interview guides for patients and physicians and initial and follow-up consultations. An English translation of the interview guides can be found in the appendix. The interviews were held either in Swiss German or German by the lead author and experienced project members with digital health backgrounds. They were transcribed verbatim and anonymized. The combination of video recordings and interviews provided us with a rich data set to evaluate the impact of PatientHub on patient-provider communication behaviors. Further, evaluating in the field offered us valuable insights into the experience of patients and physicians when engaging with PatientHub.

The three-week field study contained five phases: 1) *Onboarding*, 2) *preparation phase*, 3) *initial consultation*, 4) *execution phase,* and 5) *follow-up consultation*. Patients were asked to engage with the patient app of the PatientHub during the *preparation* and *execution phase*. Below, we outline the study design in detail, depicted in Figure 8.

1) Onboarding

Patients: The study team explained the study design to the patients, including the process for the three weeks and the study aim, and answered any questions. All patients were interviewed and completed a survey regarding their prior experience in chronic care. The patients installed and logged into the system with help from the study team. Finally, they received instructions for the upcoming week, the so-called preparation phase.

Physicians: The physicians were introduced to the study design and goal. They received training on the PatientHub before the initial consultations. While the training focused on the consultation app, we also introduced the patient app to the physicians.

2) Preparation phase

Patients: Patients kept a journal regarding diet and physical activity as daily notes in the patient app. They were asked to complete a general health questionnaire and select three favorite dietary and activity interventions.

3) Initial Consultation

Patients and Physicians: The goal of the *initial consultation* was for the patients and physicians to create a therapy plan with dietary and activity interventions. They reviewed the patient-generated data (i.e., questionnaire and journal entries). Further, they discussed a desired weight loss goal and therapy duration. Finally, they created a therapy plan for the following two weeks. During the consultation, patients and physicians could use the consultation tool (see description above). Physicians saw four to five patients throughout the field study, and the patient-provider matching stayed the same.

4) Execution phase

Patients: Over two weeks, patients implemented the therapy plan and generated data on their progress in the journal. Before the follow-up consultation, they filled out a reduced health questionnaire.

5) Follow-up Consultation

Patients and Physicians: The goal of the *follow-up consultation* was to tailor the therapy plan to the individual patients. Patients and physicians reviewed the patient's adherence to the therapy plan together. Insights from the discussion led to adjusting the therapy plan for the next execution phase. This marked the end of the field study.

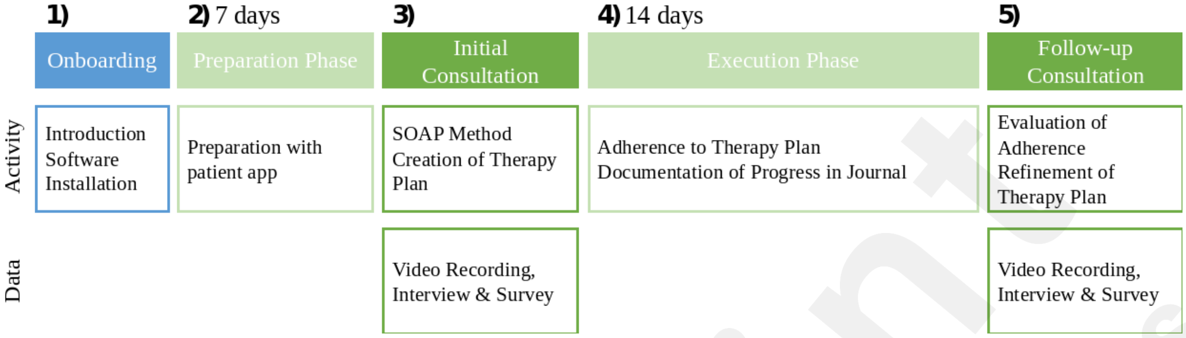


Figure 8: Field Study Design

Participants

The field study included 28 patients and six health providers (i.e., physicians in this study). Only one patient dropped out after the initial consultation (Patient 24), while all physicians completed the three-week study. Before the field study, we conducted a pre-test in December 2022 with two participants to uncover and resolve software bugs and flaws in the study design. The actual field study took place in two clinics in Switzerland in two rounds between January and April 2023 for logistic reasons. The first round was conducted in January with 18 patients and four physicians, and the second round started in March, involving 10 patients and two physicians. We maintained the same study design and evaluated the same prototype.

While the ethics committee of the canton of Zurich confirmed that this study is not subject to the Swiss Human Research Act (BASEC-Nr. Req-2018-00847), we still decided to obtain written consent from all patients and physicians before the field study. The informed consent form educated participants about their rights, responsibilities, data usage, and privacy measures following the World Medical Association Declaration of Helsinki [56].

To evaluate the effects of PatientHub on patient-provider communication in the most realistic setting, the inclusion criteria for patients were: 1) at least 18 years old, 2) a body mass index (BMI) over 25, or specific medical indications for weight loss (e.g., diabetes), 3) able to communicate in written and verbal German, and 4) own a computer and smartphone, and handle both adequately. The participating clinics selected patients using a purposeful sampling approach [57]. The compensation for patients was CHF 50 (approx. USD 60), and a raffle ticket for a restaurant voucher worth CHF 200. Physicians were selected through personal contacts and had to meet the following inclusion criteria: 1) licensed physicians in Switzerland, 2) experience counseling overweight patients, 3) speaking German, and 4) familiar with computers and tables in consultations. Table 1 and Table 2 present the demographic data of the participating patients and physicians, respectively.

Table 1: Demographic Data of Participating Patients

Participant	Sex	Age	BMI	Occupation
Patient 01	m	63	36.8	Electrician
Patient 02	w	72	35.4	Retired
Patient 03	w	81	34.4	Retired
Patient 04	m	41	27.6	Lecturer
Patient 05	w	72	29.3	Librarian
Patient 15	w	65	30.7	Retired
Patient 16	m	58	36.8	Driver
Patient 17	m	60	22.3	Teacher
Patient 18	w	61	35.3	Chairwoman
Patient 19	m	56	30.5	Lecturer

Participant	Sex	Age	BMI	Occupation	Participant	Sex	Age	BMI	Occupation
Patient 06	m	84	30.8	Retired	Patient 20	m	57	36.6	Scientific Assistant
Patient 07	w	78	30.5	Retired	Patient 21	w	71	40.4	Retired
Patient 08	m	62	31.9	Auditor	Patient 22	w	58	37.6	Depositary
Patient 09	m	81	32.5	Production Manager	Patient 23	m	66	31.1	Retired
Patient 10	w	37	46.3	Bank Clerk	Patient 25	w	59	41.1	Office Clerk
Patient 11	m	65	25.7	Electrician	Patient 26	m	53	27.2	Remedial Teacher
Patient 12	w	55	41.5	Office Clerk	Patient 27	m	75	39.5	Office Clerk
Patient 13	m	76	30.6	Musician	Patient 28	w	65	26.7	Architect
Patient 14	w	84	35.6	Homemaker					

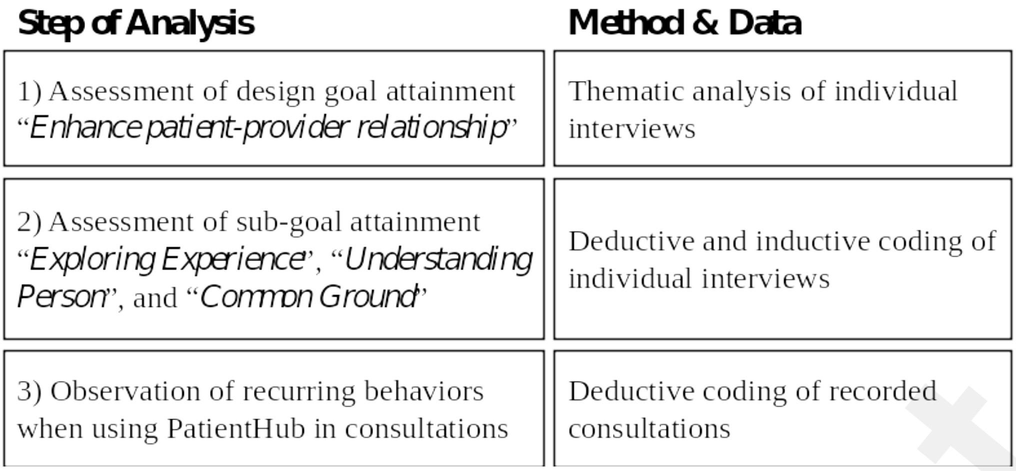
Table 2: Demographic Data of Physicians

Participant	Sex	Age	Workplace	Discipline
Provider 01	w	28	Hospital	Surgery
Provider 02	w	27	Hospital	Psychosomatics
Provider 03	m	59	Hospital	General medicine
Provider 04	w	58	Private Clinic	General internal medicine
Provider 05	m	52	Private Clinic	General medicine
Provider 06	w	44	Private Clinic	General internal medicine

Data Analysis

The framework for evaluation in design science research (FEDS) proposes a continuum from formative to summative evaluation [55]. The framework offers four evaluation strategies, from which this study adopts the "human risk & effectiveness" strategy as the addressed problem is social and user-centered [55]. Our analysis consists of summative and formative elements as the study aims to improve on the process under evaluation (i.e., patient-provider communication). Accordingly, we applied deductive and inductive coding methods in three steps for the data analysis, as depicted in Figure 9.

To study the effect of PatientHub on patient-provider communication, we analyzed individual interviews with patients and physicians and 54 video recordings of face-to-face initial and follow-up consultations (27 recordings each). This three-step analysis allowed us to assess 1) if and 2) how PatientHub enhances patient-provider communication (interviews) and 3) observe recurring behaviors when engaging with patient-generated data in consultations (video recordings). The research team consisted of a graduate student with a medical and information systems background (coding author), a PhD student in digital health (lead author), and two senior researchers in design science research.



Step of Analysis	Method & Data
1) Assessment of design goal attainment "*Enhance patient-provider relationship*"	Thematic analysis of individual interviews
2) Assessment of sub-goal attainment "*Exploring Experience*", "*Understanding Person*", and "*Common Ground*"	Deductive and inductive coding of individual interviews
3) Observation of recurring behaviors when using PatientHub in consultations	Deductive coding of recorded consultations

Figure 9: Data analysis approach

First, we assessed the design goal attainment "Enhance patient-provider relationship" by analyzing the interviewees' accounts regarding their perception of their relationship with the physicians (summative). After determining if PatientHub has enhanced the patient-provider relationship, the coding author conducted a thematic analysis of the interviews [58]. This allowed us to identify the aspects that characterize high-quality patient-provider communication when using PatientHub (formative). She created in-vivo codes focusing on the effects on patient-provider communication attributed to patient-generated data in the consultation. The lead author conducted quality assurance by reviewing and revising the codes. In an iterative process, the lead and coding authors then grouped the codes into four characteristics of high-quality patient-provider communication: *personalization*, *actionability*, *trustworthiness*, and *equality*.

Second, we assessed the attainment of our sub-goals "Exploring Experience", "Understanding Person", and "Common Ground" by applying a mixed deductive and inductive analysis [59,60]. We developed an initial coding scheme from related work on our kernel theory, patient-centered care [4,20]. We complemented the coding scheme with codes derived from literature on patient-provider communication [22,23,38,39,61]. Again, the coding author created in vivo codes to capture emerging phenomena. She coded approximately 20% of the interviews before discussing the results with the lead author to refine the coding strategy. The coding author then completed coding all interviews. Finally, the lead author reviewed and refined the coding by discussing discrepancies with the coding author. In a workshop, the author group synthesized how PatientHub improved each dimension of patient-centered care.

Third, we deductively analyzed the video recordings regarding emerging behaviors [60]. The coding author analyzed the recordings based on the coding scheme applied and refined in the interview analysis. The coding schema sensitized us for patient-centered behaviors enabled through PatientHub. During the coding of the videos, the coding scheme was expanded with in-vivo codes to include emerging phenomena [60]. The video recordings were analyzed in two rounds on-site at one of the clinics (to ensure data privacy). We extracted emerging behaviors from the first coding round by drawing sequential processes. Initial drafts of these processes were discussed in a workshop, including the author group and members from the project consortium. In the second coding round, we iterated on all video recordings based on the identified behaviors to refine our understanding and transcribed relevant sequences from the recordings. This step allowed us to formalize the three communication behaviors described in the results.

Results

In this section, we present our findings. First, we examine the attainment of the design goal (i.e., enhance the patient-provider relationship) and discuss the four characteristics of high-quality patient-provider communication identified in the analysis. We then examine how patients and providers perceive patient-centered care in these consultations (i.e., sub-goals). Finally, we introduce three emerging communication behaviors when engaging with patient-generated data.

Enhancing the Patient-Provider Relationship with PatientHub

When asked about their relationship with the providers, the patients reported high satisfaction with their interaction compared to prior experiences. They often describe an intimate connection that would feel significantly older than the three weeks of the valuation. Four central characteristics emerged from our data analysis that explain this enhanced patient-provider communication. Patients and providers commonly raised these characteristics when asked about their perception of the new approach supported by PatientHub compared to prior experiences. In the following, we explore each characteristic in more detail. Table 3 provides quotes from patients and providers for each characteristic.

Table 3: Characteristics of enhanced patient-provider communication with exemplary quotes

Characteristics	Exemplary quotes
Personalization of healthcare	*She has tried to address the fact that I am not allowed to be overburdened with walking because the knees just do not work." Others highlight the enriching discussions they had with the physicians "because I noticed that these are not standard answers. […] He looks at you [the patient] as a human being, as an individual* (Patient 25).
Actionability of interventions	*It is simply a clean data basis. Now we're talking facts and not "How did you perceive it?" or "How was it for you?" but Bam! There! Suddenly, "how many times did you go on the cross trainer?", "how many times did you get the interval fasting done?* (Patient 04).
	I was really happy to see the results. Because I remember the last time you said that you do so much, and you don't see any results, and now we have the result (Provider 01).
Trustworthiness of communication	*She was prepared. So, she read my brainy entries (laughs). […]. So, she obviously prepared for me. She looked at the questionnaire that I filled out [during the preparation phase]. She wrote down questions about it. That really feels good* (Patient 17).
	They were unbelievably more trusting. They revealed so many, many things. So, I think it was a very different level of trust already compared to last time (Provider 05).
Equality of partners	*I came here prepared and I already had ideas. If I had to choose favorites now [in the consultation], I would have come and I would have accepted [the physician's proposal]. Then you are externally steered* (Patient 26).

Personalization of healthcare: Patient-generated data supports patients and providers in personalizing healthcare as it facilitates in-depth discussions about the patients, their context, and their experience with their health. The data provides a solid foundation based on facts instead of gut feelings and memory. As a result, the mutually agreed therapy plans consider the patient to be a person with their preferences, needs, and limitations. The physicians were understanding when proposing interventions and considered the patient's circumstances. All patients in the interviews highly appreciated this (see Table 3).

Actionability of interventions: Patients and providers appraised the concreteness of the discussions facilitated by the consultation tool with the intervention screens (see Figure 4, right). Many patients report previous frustrating experiences where providers stayed abstract in their recommendations (e.g., "eat less sweets"). Due to the more integrated and holistic understanding of the patients, providers and patients could concretely discuss problems and priorities, goals, and expectations toward each other's roles. Many specifically highlight how the patient-generated data allowed them to agree on actionable interventions. As a result, patients perceived providers as more empathic and engaged in their health journey. For example, Patient 26 '*felt joy from the provider. […] I think she was very motivating and also praised that I had done well.*' The providers proved the perception right, as many were pleased with their patient's progress, such as Provider 01 and Patient 02 (see Table 3).

Trustworthiness of communication: Patients and providers believe that sharing patient-generated data requires trust in the first place and creates trustworthy communication. Patients perceive it as appreciation (see Table 3, Patient 17). The providers reciprocate this appreciation. When asked about the relationship between her and the patients after only two consultations, Provider 05 highlighted how PatientHub created a trusting foundation that made the discussions in the consultations much more meaningful (see Table 3, Provider 05).

Around half of the patients raised the topic of surveillance concerning sharing their data. However, most patients appreciated the subtle surveillance as it made the therapy plan more binding. Only five patients felt uncomfortable sharing too much personal information. Accordingly, they only shared what they felt comfortable with in the journal.

Equality of partners: Finally, PatientHub leads to a shift in the perceived roles of patients and providers. Many patients perceived control over the decisions made in the consultation. This perceived control leads to the feeling of cooperation between equal parties in the decision-making process. The patients feel strengthened in their position as they are the experts on their data (see Table 3, Patient 26).

The preparation allowed Patient 26 to have an opinion instead of mindlessly accepting the provider's proposition. Further, in the follow-up consultations, patients defended their standpoints and argued for changes in the therapy plan. For example, Patient 18 demanded the re-introduction of carbohydrates to her diet due to her physically demanding job. As a result, Patient 23 experienced the consultation as "*an open conversation and not somehow top-down. On the same level and friendly*." Many providers, too, remarked on the shift in power balance.

The Process of Patient-centered Care

Our analysis elicited the four characteristics of high-quality patient-provider communication. In the following, we explore the process of enhancing patient-provider communication by discussing the three dimensions of patient-centered care (i.e., sub-goals)

Finding Common Ground

Overall, we observed that the consultations centered around the three aspects of Finding Common Ground: Problems and priorities, goals, and roles. PatientHub introduced patient-generated data into the natural consultation process through screens for goal setting, interventions, and planning. Patients and providers reported that the tool is a significant part of the consultation as it formed the starting point for exploring problems, priorities, and roles. The data also served as a reference to argue for or against a proposition, thereby shaping the individual roles. As a result, patients and providers arrived at mutual decisions regarding all three aspects of finding common ground. When asked about the reasons for the positive impact of PatientHub, Provider 01 answered:

> *You are pulling in the same direction. And are in the same reality. And that makes a much better team. And just have a more balanced, I do not want to say power balance, but a more balanced decision-making.*

However, patient-generated data did not solely support finding common ground directly. Each behavior explored the other two components to indirectly inform mutual decisions taken in the consultations.

Exploring Health, Disease, and the Illness Experience

The general health questionnaire and journal entries allowed patients and providers to discuss the patients' unique perceptions of their health in both consultations (i.e., sub-goal "Exploring Experience"). For example, Provider 02 recognized in the journal overview (see Figure 7, right) that Patient 08 eats too little vegetables and drinks too much alcohol, to which the patient agreed. Instead of staying abstract about the consumed amount of alcohol, they had a clear impression of the number of alcoholic beverages the patient drinks in a week. Several patients realized during the consultation that they were emotional eaters. The patient-generated data prompted the provider or patient to highlight such experiences. In addition to behaviors, they often discussed emotional aspects of the patient's experience. For example, two patients said they do not like swimming because they do not want to show themselves in bathing suits. Patient 11 mentioned in the questionnaire that he fears the health problems associated with obesity. During the consultation, Provider 03 could follow up on this answer by asking why the patient was afraid. Patients and providers explored the target weight reported in the questionnaire during goal setting. Often, they discussed the origin of this specific target, such as a feeling of well-being or a historic weight they had during a significant part of their life (e.g., before they became parents).

Patient-generated data had an even more profound impact during the follow-up consultation. Patients and providers could gather an integrated understanding of the patient's experience in the execution phase. The patients documented their emotions and thoughts with emojis, pictures, and text in journal entries (see Figure 6). This data provided patients and providers with a rich foundation for discussions in the follow-up consultation. Instead of relying on the patient's memory and accuracy, providers had in-depth insights into the adherence and patient experience. Sometimes, patients highlight a journal entry because they believe it is significant for their (lack of) success in following the therapy plan. For example, Patient 07 refers to the picture of an icy peer to explain her non-adherent behavior to the "walking" intervention. Most providers emphasize the benefit of recording a patient's emotional state. This way, they could inquire about negative feelings related to a specific intervention. For example, Provider 01 could identify a potential correlation between Patient 01's emotional state and his adherence to intermittent fasting. Together, they explored that Patient 01 was under pressure at work during the execution phase. This led to him feeling tense and not sleeping well. As a result, he was not motivated to adhere to intermittent fasting. However, they realized that the patient indeed felt better on days when he could adhere to the intervention, as Provider 01 recalled in the interview:

> *And then you could break that down nicely and say, hey, you did it. The mood was good. Look at the app. It was ALWAYS good for you to do [intermittent fasting]. And then it really came back from the patients like this: Yes, that's right.*

Understanding the Whole Person

Traditionally, consultation time is limited to a few minutes per patient. This limited time often does not allow providers to ask questions not directly associated with the presented problem. Consequently, understanding the whole person often falls victim to other, more pressing matters. However, the journal entries and the corresponding overview and filters allow providers to understand the patient's daily life (sub-goal "Understanding Person"). In addition, the journal entries served as the foundation to further gain a better understanding of the whole person during the consultation (see Figure 7). For example, Provider 03 and Patient 12 discussed her consumption of vegetables, where she said:

> *Probably too little in proportion. Because I have to be honest, I don't like to cook. […]. And many times, it is so my partner works irregularly. And when we come home in the evening, something should just quickly be on the table. And I don't want to stand two hours in the kitchen when I have worked all day.*

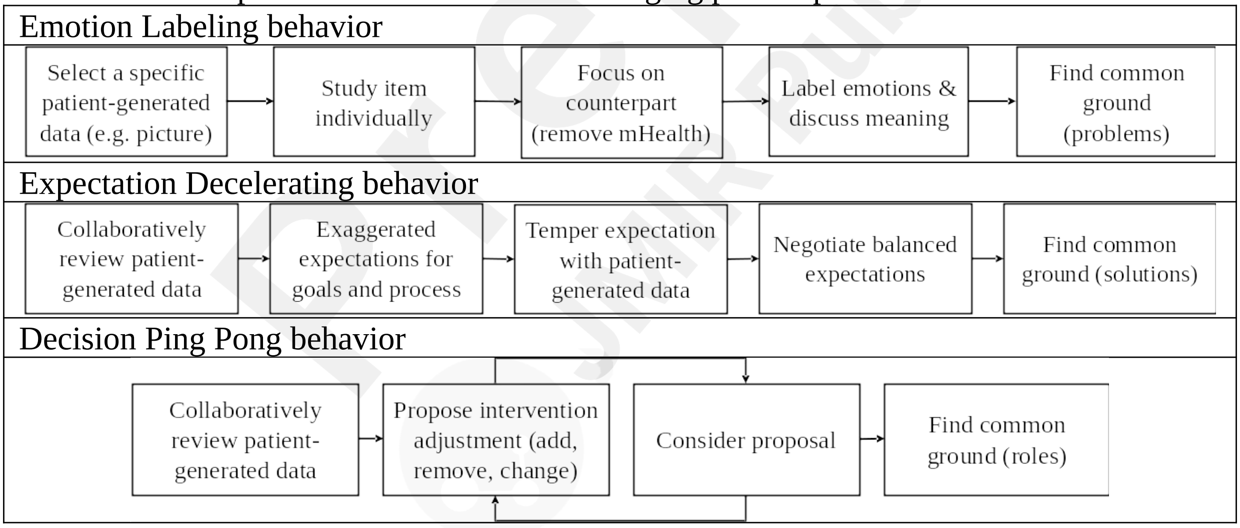
This quote illustrates how patient-generated data prompted Provider 03 to learn about Patient 12's experience and her proximal context: her partner working shifts might interfere with regular habits. In general, the available information and the subsequent discussion yielded interesting insights providers usually would not get, as they all said during the interview. For example, it became evident that chocolate yogurt is a central piece of Patient 18's diet. Patient 28 prefers to walk alone as he is an only child. Patients 01 and 25 have dogs, but another household member usually walks them. Patient 03 cooks for her husband and does not think he would want to eat less meat or try different grains. Also, she drives him to therapy and, therefore, has less time for cooking.

In general, patients believe that their data helps providers to get a better understanding of them. For example, Patient 16 liked that the provider had more background information before the initial consultation. Patient 10 shared this opinion as she believed it would be impossible to get such a deep understanding in such a short time. The providers agreed with the patients and explicitly mentioned PatientHub's advantages to understand the whole person better. Providers 01 and 04 referred to "look beneath the patient's surface" as a significant advantage.

Emerging Patient-Provider Communication Behaviors

In the following, we outline three behaviors we could repeatedly observe across consultations when using PatientHub. First, we describe each behavior. Then, we provide examples of the behaviors and highlight how patients and providers perceive them. Table 4 provides visual representations of the sequential activities of the behaviors.

Table 4: Visual representations of the three emerging patient-provider communication behaviors



Emotion Labeling

This behavior is called emotion labeling, as patients and providers discuss patients' experiences based on patient-generated data and attach a label to it (see Table 4). The behavior occurs at the beginning of each consultation (initial and follow-up). Patients and providers sit around the table's edge so both have visual access to the tablet facing them. The tablet shows the journal overview with patient-generated data (see Figure 7, right). The two variations of this behavior differ in the person who initiates the behavior. Providers commonly select specific patient-generated data to start the behavior (e.g., a journal entry or a questionnaire response). Often, providers refer to pictures shared by the patients. They are picked due to the client's reported (non-) adherence, emotional state, or uploaded pictures. Less often, patients initiate the behavior by referring to a specific item that represents a problem or priority. The initiator points toward the specific item and sometimes opens the journal entry. After both acknowledge the item, they move the focus from the tablet to the other person, adjusting their seating position and turning their bodies and heads toward one another. The provider even moves the tablet out of the shared interaction space in some consultations. Now, patients and providers label the patients' emotions regarding the matter represented by the selected item. They discuss the item and its meaning for the patient's experience or context to arrive at a common understanding of the patient's problems and priorities.

One example of Emotion Labeling is Patient 18, who craves chocolate yogurt. The photos and text in the journal allowed Provider 04 to elicit the issue and sensibly raise the topic of the large amount of sugar in chocolate yogurt. During the discussion, they explored this craving to discover two reasons. First, chocolate yogurt is a fast and enjoyable meal after a long and stressful workday. Second, the yogurt satisfies an emotional need as it is something to look forward to. As a result, Provider 04 proposed reducing the quantity of chocolate yogurt and adding plain yogurt with fruits or jam as a low-sugar alternative. This resonated well with Patient 18:

> *Ah, I'm allowed to eat chocolate yogurt (laughs). I noticed right away that she was not telling me: You're not allowed to do that anymore; from now on, there's only this and that. It's often restrictions that make things difficult. I have seen that I should lose weight over a long time, and then it doesn't have to be as radical. This way, we can mix it up.*

Patients also raised issues on their own. Patient 02 believed one of her core problems was drinking too much alcohol, which she documented in the journal. During the interview, Provider 01 explained that the journal helped her assess the quantity as unproblematic and that she would have reacted differently without the patient-generated data. They identified the guilt associated with drinking alcohol as a constant stressor.

Expectation Decelerating

Expectation Decelerating (see Table 4) occurs when one party needs to reduce the momentum the other is exhibiting. The behavior follows the Emotion Labeling behavior, where patients and providers mutually agree on the patients' problems and priorities regarding weight management.

Expectation Decelerating varies between the initial and follow-up consultation. In the initial consultation, the providers changed the topic to discuss target weight. They reviewed the patient's desired weight and therapy duration before the consultation. However, they first invite patients to talk about their target weight and the reason for this specific target. When understanding the patient's reasoning, they focus on the goal-setting screen (see Figure 4, left), where the patient-generated data is prefilled (i.e., target weight and therapy duration). Providers propose an intermediate goal and explain their reasoning depending on the targeted weight loss and therapy duration. To illustrate the proposal, providers move the weight and time slider to the proposed goal. A scale icon indicates the sustainability of the target weight and timeframe on a color scale from green to red. A 500-gram weekly weight loss is considered sustainable [62]. If the chosen target is beyond this limit (i.e., the scale icon is in the red area), the providers would highlight this and explore the relation between weight and time with the patient. They simulate different scenarios to understand sustainable weight loss. In the end, they leave the decision up to the patients. The exploration either leads to a prolonged therapy duration or setting an intermediate goal.

In the follow-up consultation, Expectation Decelerating occurs after reviewing the patient's adherence using the journal entries. To conclude the Emotion Labeling behavior, patients or providers often propose adding new interventions or increasing their frequency (e.g., running more often). While substituting ineffective interventions usually finds mutual agreement, adding to the existing interventions was often more intensely debated. Frequently, the providers advise against a patient's request, referring to patient-generated data to highlight the continued effectiveness of the existing interventions. However, patients also had to decline similar propositions by providers. Similarly, they refer to their journal entries or insights based on this data to argue their position. The following excerpt shows a discussion excerpt regarding the therapy duration in the initial consultation between Patient 06 and Provider 02:

Provider 02: I have seen your target weight or desired weight would be 76 kg.

Patient 06: I am also already satisfied with 77 to 78 kg.

Provider 02: So, let's say we want to aim for 78 kg (sets target weight with slider). What is your wish when you want to reach it?

Patient 06: Yes, that's what I am like. I want it as soon as possible. But then you gain it back again soon, right?

Provider 02: Yes exactly. So, what does soon mean concretely? We can now play it through virtually what that means as a weekly goal. So that would be 4 kg if we say 78 kg. When do you want to have that?

Patient 06: I don't know, I say in two months it should be possible.

Provider 02: In two months, that would be eight weeks (Provider adjusts the slider on the tablet). That is not completely unrealistic for 4 kg, but it is relatively strict. So, if you actually don't want it to be an extra burden, an additional task, then it's too ambitious. Then I would rather put it at three months, right? (adjusts slider). Then you see, there is the scale that shows how much weight you would have to lose or how ambitious that it is. We are now well in the green zone. Concretely that would mean a little more than 300 grams decrease per week.

Often, patients enter the consultation with over-ambitious goals as they recall themselves in the interviews. Further, they are enthusiastic after the two-week execution phase as they could follow most interventions and propose including more interventions. Providers use patient-generated data to decelerate the patients' drive to maintain sustainable progress and prevent setbacks. While deceleration might be negatively connotated, most patients drew motivation from this behavior. For example, Patient 02 mentioned that the five kilos they decided on motivated her more than if she had tried to lose the initial fifteen kilos. Further, Patient 12 summarized:

> *Yes, and what really stuck with me was that he took a little bit of the pressure off. When you always have the feeling that you have to lose as much weight as possible as quickly as possible. That he then said: It's good and healthy to lose 500 grams a week. That has stayed with me very much, and has also motivated me, so that I did not think: Oh in 14 days I should be 10 kg lighter.*

Patient 16 agrees and mentions the sliders, visualizing the relationship between weight loss and time, as essential for setting realistic goals. The providers agree with this perception as the patient-generated data would provide a solid foundation to assess the therapy plan's effectiveness, which is usually missing in conventional consultations. Provider 06 highlights:

> *Yes, I always have the feeling that I always have to make suggestions. And [with the patient-generated data] you could say, we've done a good job. We are good. We continue to do so. Done.*

Provider 02 agrees that patients usually quit because they want to achieve overly ambitious goals. With patient-generated data, they could credibly show that it is possible to lose weight with small and sustainable changes.

Decision Ping Pong

Decision Ping Pong refers to the back-and-forth process of mutual decision-making (see Table 4). It occurs when creating and adapting the therapy plan. The input for this behavior is patient-generated data created outside the consultations. During the preparation phase, patients select favorites from a list of dietary and activity interventions and document their daily lives in journal entries.

In the initial consultation, providers initiate the behavior by moving to the interventions screen to display the patient's favorites marked with a "heart" icon (see Figure 4, right). Providers ask the patients why they selected the specific interventions to start the Decision Ping Pong. Often, patients chose the interventions as they previously engaged in an activity or started the intervention themselves only recently. Next, providers ask patients which favorites to add as an intervention. After the patients decide on an intervention, they discuss the details like frequency and duration. A back-and-forth follows to first agree on a frequency and duration (if applicable). Once agreed, patients and providers negotiate the timing of this intervention (i.e., days and time of the day). While providers often propose frequency and duration, the patients usually initiate the discussion on timing according to their professional and private situations. This ping pong is repeated until both are satisfied with the therapy plan. Interestingly, patients start proposing interventions themselves after some repetitions (e.g., after adding two interventions).

In the follow-up consultation, the behavior occurs slightly differently. First, patients or providers initiate the behavior to discuss the necessity of exchanging ineffective interventions based on the journal entries crafted by the patients in the execution phase. The behavior ends if they mutually agree not to adjust the therapy plan. If they decide to adjust, the behavior continues as in the initial consultation.

The following excerpt shows a discussion excerpt between Patient 10 and Provider 03 about an activity intervention:

Patient 10: Or aerobics would be something I would like to do.
Provider 03: So once in the evening?
Patient 10: Yes.
Provider 03: Thursday is busy [with other interventions].
Patient 10: Then we will take Monday.
Provider 03: Or after cleaning (both laugh).
Patient 10: No, thank you.
Provider 03: Monday?
Patient 10: Yes.
Provider 03: In the evening?
Patient 10: Mhm.
Provider 03: How long?
Patient 10: Half an hour.
Provider 03: Half an hour. I think so too. We will just put that in now.

Eight patients explicitly mentioned their appreciation for the realistic goals as an outcome of this process. Patient 21 liked that the provider said: "*You cannot just cancel everything overnight. Then you just stop again."* After two weeks, Patient 16 compares the results to other diet regimes he followed in the past:

> *The whole thing is calmer and less stressful. It feels easier. It goes on for a longer time, but it is more pleasant to get through the day that way.*

The provided selection of tasks and the talk with the physician helped produce ideas the patients usually would not have. Patient 04 says he would not have chosen intermittent fasting, but he did because a professional explained it. The decision ping pong showed that it could be adapted to his situation. The process also inspired the providers, as Provider 05 said he would not have all these ideas spontaneously.

Discussion

Supporting patient-provider communication with patient-generated data is a growing topic of interest in health informatics and related fields. However, existing literature often overlooks the processes (i.e., communication behaviors) when enhancing patient-provider communication with patient-generated data. More importantly, existing mHealth applications are seldom integrated into the provider's workflow and do not sufficiently engage and activate patients in patient-centered care [44–46]. Through a design science approach, we explored how to design an integrated digital health system and its impact on the communication behaviors of 27 patients and 6 providers.

Previous works demonstrated the benefits of integrating patient-generated data into consultations [32,35,38,45,63,64]. We expand on this work by studying the effect of patient-generated data on patient-provider communication behaviors. As argued in the introduction, current research studies the input (patient-generated data) and output (enhanced patient-provider communication, see Figure 2). Our analysis elicited three emerging behaviors that open the black box of patient-provider communication. Based on our theoretical foundation and empirical findings, we propose patient-centered communication in three design principles to operationalize the patient-centered care framework.

Facilitate emotion labeling to explore health, disease, and the illness experience and understand the whole person

The Emotion Labeling behavior highlights how the input is initially processed. Patient-generated data enables patients and providers to reflect on patients' emotions related to their health. For example, patients speak about their insecurities when engaging in physical activities in public due to being overweight. Prompted by photos, emojis, and text, patients and providers explore a patient's unique experience with their health and disease (sub-goal "Exploring Experience"). Further, Emotion Labeling uncovers obstacles in the patients' journeys to better health. As described in the results, journal entries allowed Patient 03 and Provider 01 to uncover and discuss the reason for the patient's non-adherence. Patient-generated data allowed the patient and provider to understand the patient as a whole person and their proximal context (sub-goal "Understanding Person").

Existing research has shown how visualizations of health data increase health literacy in patients [38]. Our results show how patient-generated data is not only used to educate patients but also collaboratively generate new insights. We argue that patient-generated data enhances patient-provider communication by stimulating the exploration of a patient's experience and context. Providers can usually only scratch the surface of a patient's story in consultations. PatientHub introduces them to their patients' world, allowing them to dive below the surface and gain an integrated understanding. The patients themselves also profit from their data. Our results show that generating data often initiates self-reflection that fosters their understanding of themselves. As a result, patient-provider communication becomes more patient-centric. They explore the patient's experience and context to find common ground regarding problems and goals.

Facilitate expectation decelerating to find common ground on problems and solutions

The Expectation Decelerating behavior processes patient-generated data differently. Instead of beginning with a patient's experience or context, patients and providers use patient-generated data to assess problems or goals. Our results show two areas where patient-generated data decelerates patients and providers: setting goals and developing therapy plans. Providers refer to this data in the former to decelerate the patients’ ambitions. They suggest either more long-term planning or a more achievable intermediate goal. When developing therapy plans, patients and providers resist the urge to add more or exchange interventions too quickly due to patient-generated data (sub-goal "Common Ground"). As seen in the results, Patient 01 could successfully argue his standpoint on keeping intermittent fasting in his therapy plan due to his data. The data allows them to assess the therapy plan's effectiveness, resulting in the mutual decision not to adapt it if the effectiveness persists. Existing research demonstrates the value of patient-generated data for problem-solving and decision-making [23,64]. While we agree with their findings, the saying "It's a marathon, not a sprint" highlights the importance of Expectation Decelerating. Our results show how patient-generated data is applied in consultations to resist the urge to hurry long-term behavior change. Accordingly, Expectation Decelerating might counteract the common pressure of a quantified self to always strive for more [65]. Quantified humans utilize data to continuously find inefficiencies and improve on those, often resulting in unhealthy pressure. Instead of expanding the therapy plan, patients and providers could assess the effectiveness of the current plan in the follow-up consultation. They have a reliable foundation for decision-making instead of hampering long-term success with impulsive actions. They define achievable targets with a personalized therapy plan tailored to the patient. As a result, patients might have more endurance in their marathon race to change their lifestyle.

Facilitate decision ping pong between patients and providers to find common ground on their roles

Decision Ping Pong reflects on how patient-generated data affects the dynamics of patient-provider communication. Existing research in medicine and HCI postulates the importance of shared decision-making [4,17,21,23,53]. Our results expand these insights by examining how patient-generated data includes the patient in decision-making as an expert and how this changes the consultation dynamics (sub-goal "Common Ground"). Many patients noticed how their position had changed in the initial consultation compared to their previous experience. We argue that introducing patient-generated data goes beyond facilitating informed decision-making. With this data, patients provide "proof" of their adherence, for example, through pictures. Moreover, they have a much deeper knowledge of the Patient Hub's content. It contains patient-generated data and evokes memories that might not be documented in the system. Equipped with this knowledge, patients become experts in their own domain: their health journey.

In shared decision-making, the implicit understanding is that providers assess the patient's state and offer options [17]. Existing research often sees patient-generated data as crucial information for providers to offer better health services [22,64]. Studies explore ways to design technology to make large amounts of patient-generated data consumable for providers [23]. Implicitly, this focus places the responsibility for data interpretation on the providers. However, we believe patient-generated data could partially relieve providers from this burden. Patient-centered care emphasizes mutual decisions; therefore, patients should carry this burden with their providers.

Our results show that most patients willingly accept such a role as they feel taken more seriously, can defend their position, and perceive having control over the decision-making process. Integrating patient-generated data into the consultation empowers patients to assume a more active role in their healthcare. We argue that providers must not be solely responsible as our results highlight how patients become experts in their health journey. Instead, the responsibility is shared between patients and providers according to their expertise. While providers assess the data against their medical knowledge, patients interpret the data in the context of their lives and experiences. As a result, their communication becomes truly "respectful of and responsive to individual patient preferences, needs, and values and ensuring that patient values guide all clinical decisions" [16].

Conclusions

This paper studies communication behaviors that emerge when introducing patient-generated data into patient-provider communication. We study how these behaviors in patient-provider communication actualize the potential of patient-generated data to increase patient-centricity. Our analysis uncovers three communication behaviors in medical consultations when using PatientHub. Further, we demonstrate how enhanced patient-provider communication is necessary for patient-centered care. Based on our findings, we believe this study contributes to research in two ways: First, we emphasize the value of patient-provider communication. The identified behaviors demonstrate how data-supported patient-provider communication creates value, not the technology and data itself. Second, the behaviors offer actionable insights into implementing patient-centered care.

However, this study does not come without limitations. First, while we evaluated PatientHub in the most realistic setting, its applicability in the real world depends on regulatory and security frameworks. Second, the generalizability could be further increased with a larger sample size and a randomized control trial. Future research could also investigate how patient-generated data empowers patients individually to study the changing role dynamics in medical consultations.

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blinded

Conflicts of Interest

None declared

Abbreviations

BMI: body mass index
DSR: design science research
FEDS: framework for evaluation in design science research
mHealth: mobile health

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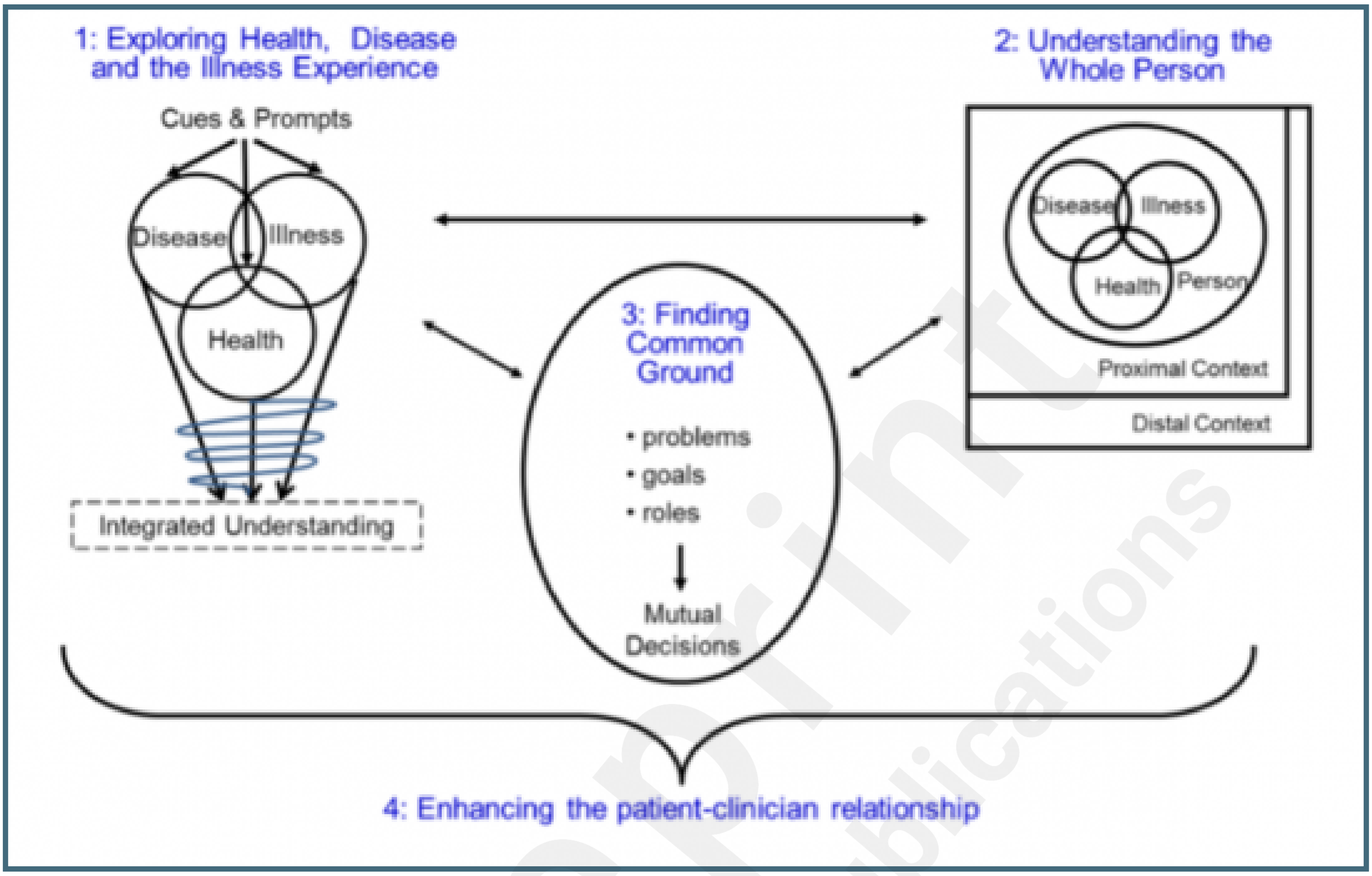
Supplementary Files

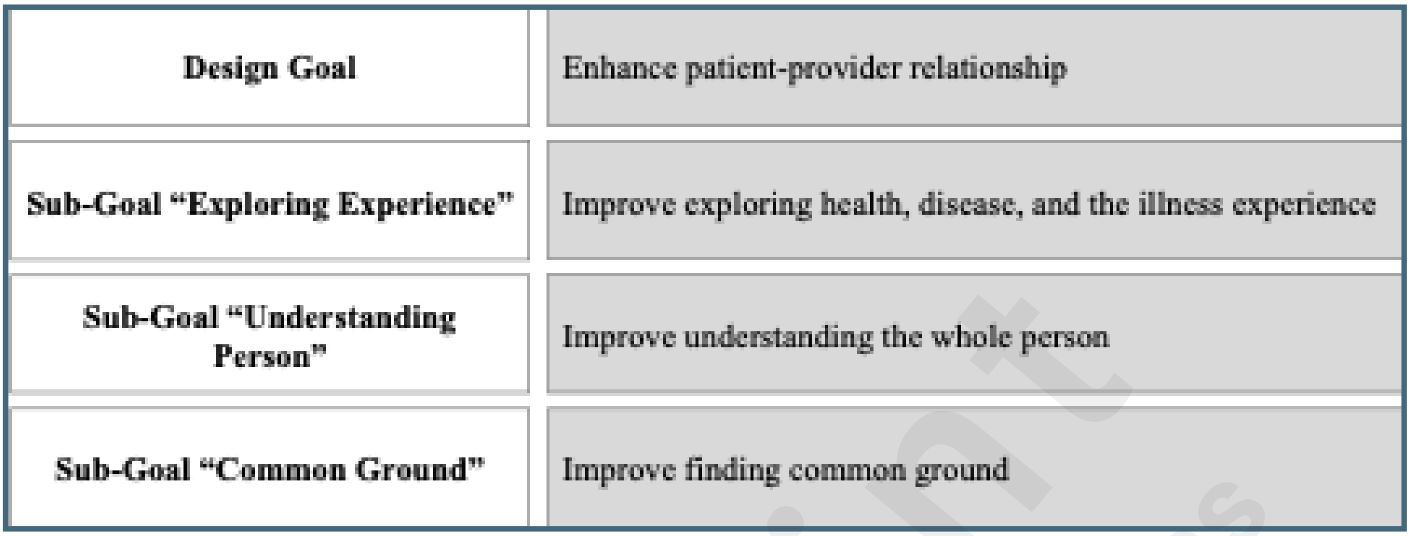
Figures

Patient-centered Care Framework by Stewart et al. [4].



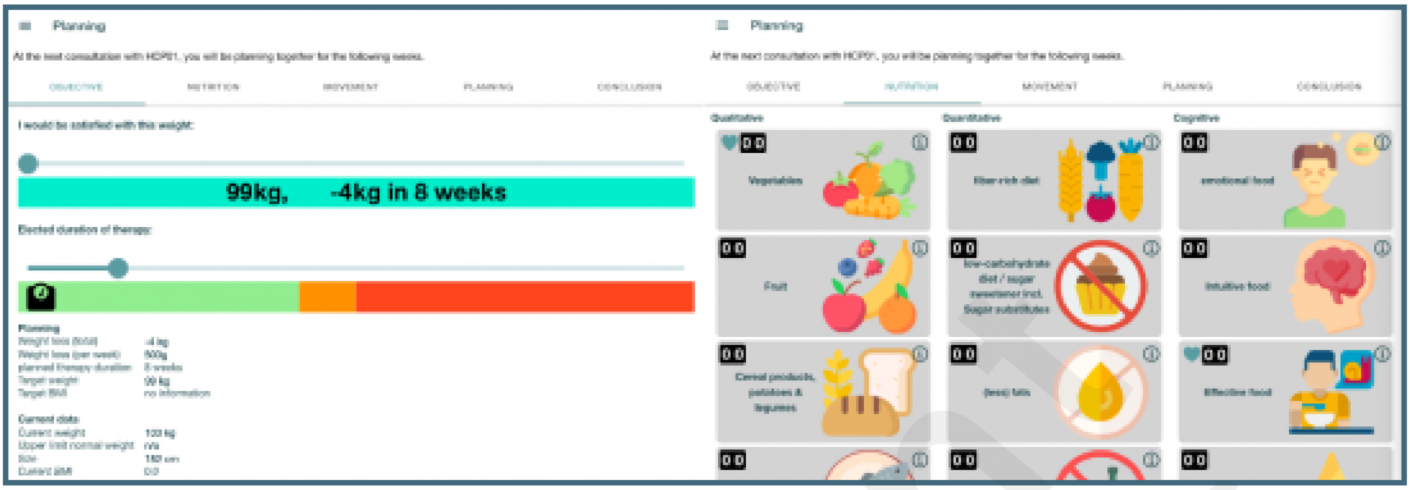
The process of patient-provider communication as a black box.

Design goal and sub-goals based on the patient-centered care framework [4].



Design Goal	Enhance patient-provider relationship
Sub-Goal “Exploring Experience”	Improve exploring health, disease, and the illness experience
Sub-Goal “Understanding Person”	Improve understanding the whole person
Sub-Goal “Common Ground”	Improve finding common ground

Goal Setting (left) and Dietary Interventions (right).



At the next consultation with HCP01, you will be planning together for the following weeks.

I would be satisfied with this weight:

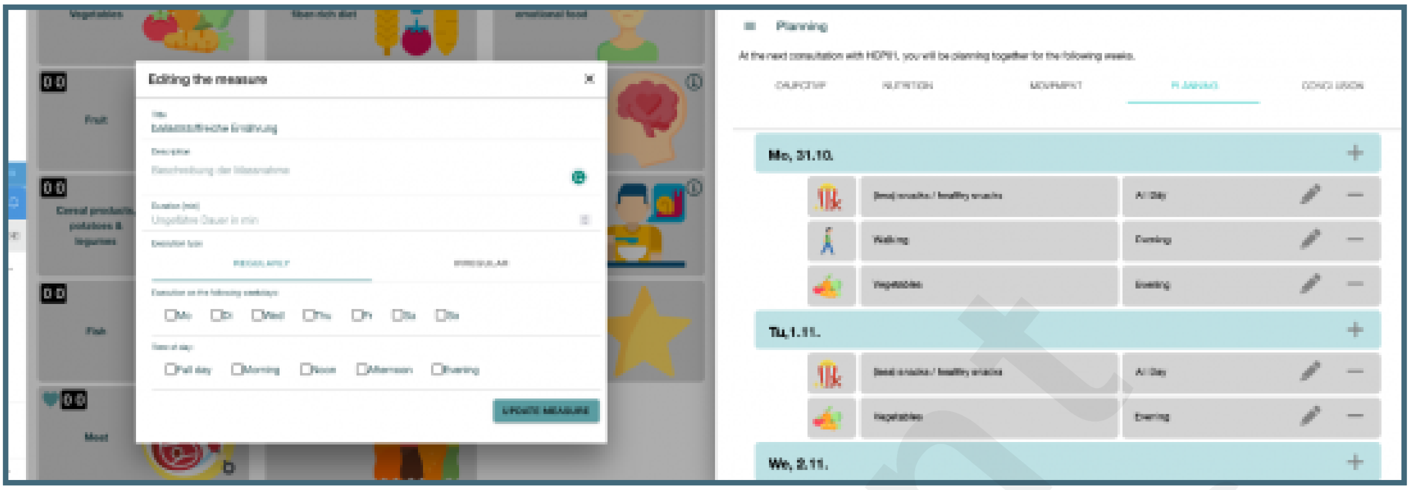
99kg, -4kg in 8 weeks

Elected duration of therapy:

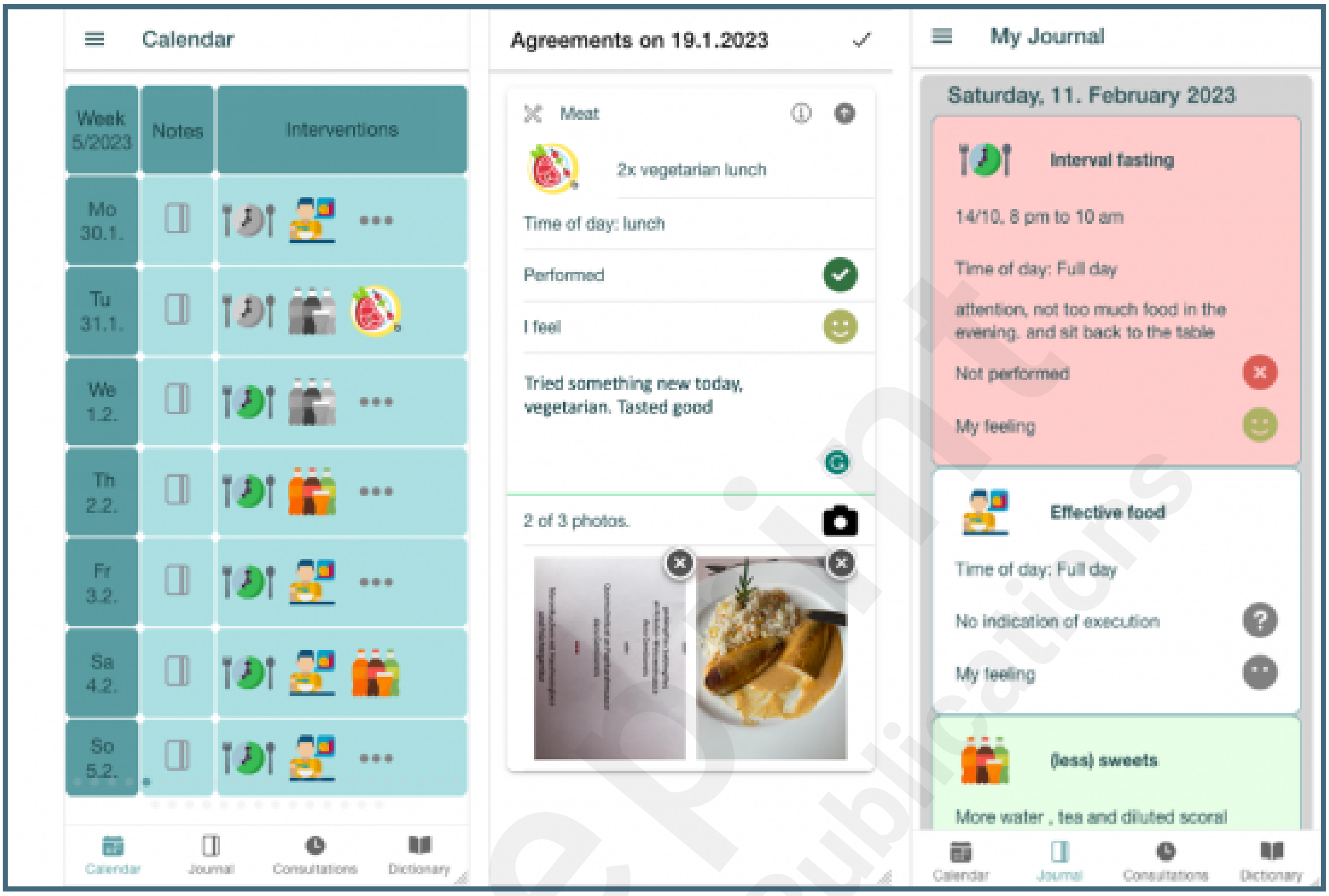
Planning
Weight loss (total) -4 kg
Weight loss (per week) 500g
planned therapy duration 8 weeks
Target weight 99 kg
Target BMI no information

Current data
Current weight 103 kg
Upper limit normal weight n/a
Size 180 cm
Current BMI [illegible]

Measure Specification (left) and Planning (right).



Calendar (left), Journal Entry (middle), and Journal Overview (right).



Agreements on 19.1.2023

Meat

2x vegetarian lunch

Time of day: lunch

Performed ✓

I feel

Tried something new today, vegetarian. Tasted good

2 of 3 photos.

My Journal

Saturday, 11. February 2023

Interval fasting

14/10, 8 pm to 10 am

Time of day: Full day

attention, not too much food in the evening, and sit back to the table

Not performed

My feeling

Effective food

Time of day: Full day

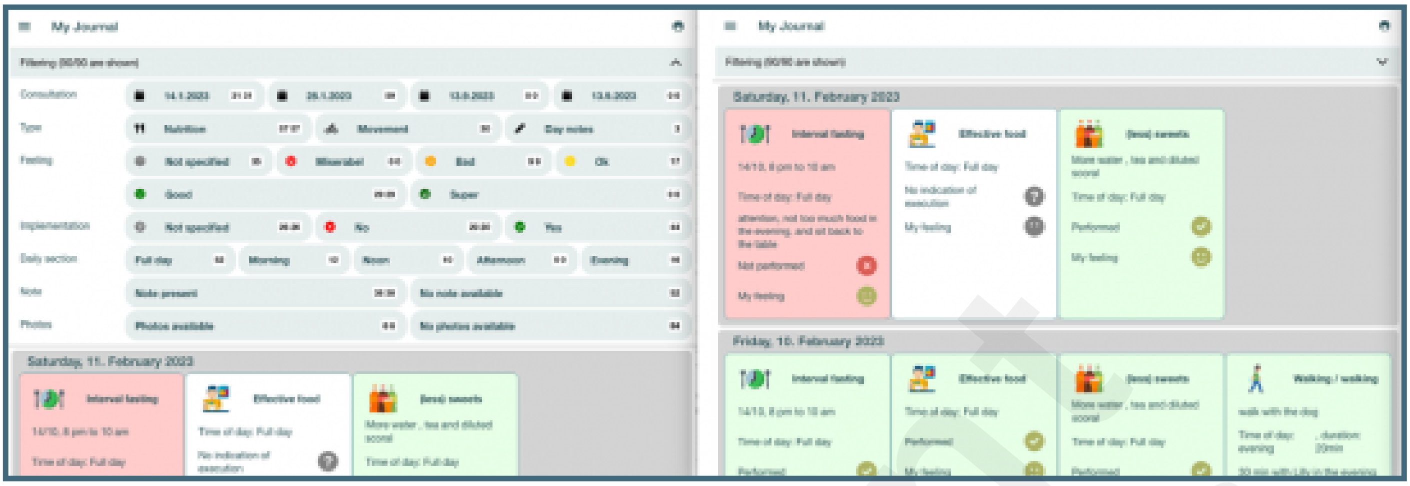
No indication of execution ?

My feeling

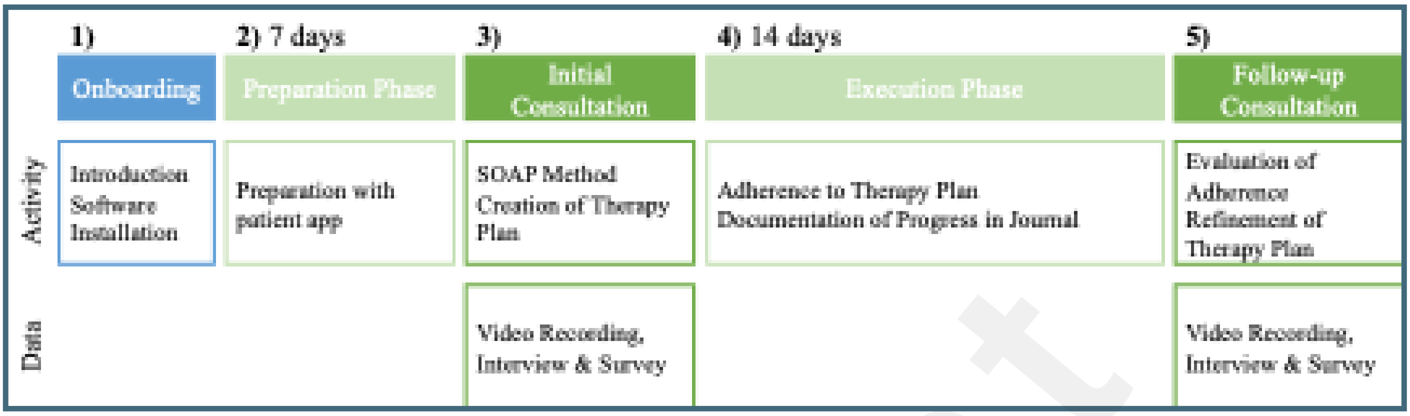
(less) sweets

More water , tea and diluted scoral

Filter Options (left) and Journal Overview (right).

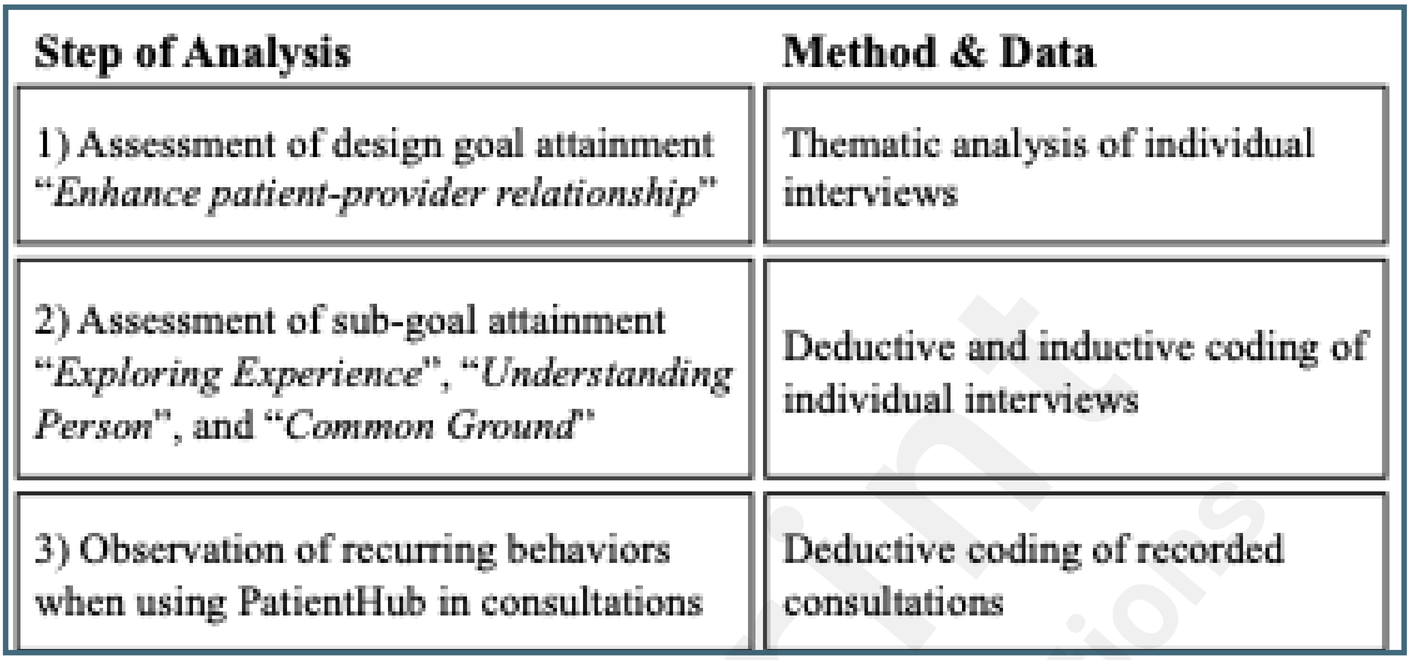


Field Study Design.



	1) Onboarding	2) 7 days Preparation Phase	3) Initial Consultation	4) 14 days Execution Phase	5) Follow-up Consultation
Activity	Introduction Software Installation	Preparation with patient app	SOAP Method Creation of Therapy Plan	Adherence to Therapy Plan Documentation of Progress in Journal	Evaluation of Adherence Refinement of Therapy Plan
Data			Video Recording, Interview & Survey		Video Recording, Interview & Survey

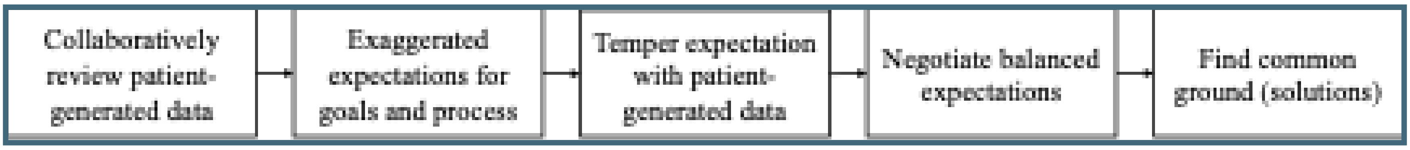
Data analysis approach.



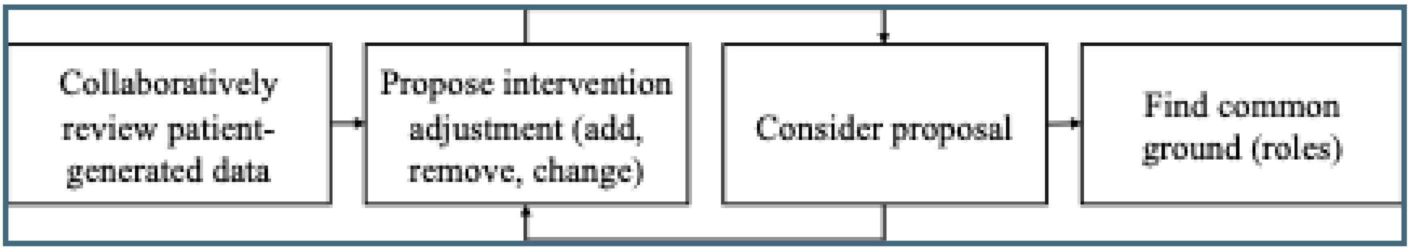
Step of Analysis	**Method & Data**
1) Assessment of design goal attainment "*Enhance patient-provider relationship*"	Thematic analysis of individual interviews
2) Assessment of sub-goal attainment "*Exploring Experience*", "*Understanding Person*", and "*Common Ground*"	Deductive and inductive coding of individual interviews
3) Observation of recurring behaviors when using PatientHub in consultations	Deductive coding of recorded consultations

Sequential view of the Emotion Labeling behavior.

Sequential view of the Expectation Decelerating behavior.



Sequential view of the Decision Ping Pong behavior.



Multimedia Appendixes

Authors' positionality statement.
URL: http://asset.jmir.pub/assets/e00f565303210ca554a4e087e446d3a7.docx

Interview guide physicians initial consultation (English translation from German).
URL: http://asset.jmir.pub/assets/fa6268a22217e09921d70b372f770fb0.docx

Interview guide patients initial consultation (English translation from German).
URL: http://asset.jmir.pub/assets/12b5eefebffa4e7f5827826ed729824d.docx

Interview guide physicians follow-up consultation (English translation from German).
URL: http://asset.jmir.pub/assets/cf3ad95ddae48174515e46b465f30a1b.docx

Interview guide patients follow-up consultation (English translation from German).
URL: http://asset.jmir.pub/assets/a5fed00ee6a8e76e708a49dd1041bb3f.docx