Reimagining Medical Self-Report

Using Interaction Design to Enhance Respondent Experience

Rosaline Danielle Erica Barendregt

Thesis for the degree of Philosophiae Doctor (PhD)
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Scientific environment

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Ik heb vandaag een berg beklommen, En de top bereikt, Dat komt door jou

Abstract

In healthcare there is a growing emphasis on patient-centric approaches that actively involve patients in their own treatment. Self-reporting plays a crucial role in this shift, gathering essential personal and subjective information from patients, such as experiences of pain, stress, or fatigue, that sensors or monitors cannot capture. Its efficacy, however, depends on the patient's willingness and ability to provide information, a process often perceived as burdensome or tedious. This perceived respondent burden can lead to decreased adherence, lower response rates, and ultimately, reduced quality of data that is crucial for treatment outcomes.

While technology often facilitates self-reporting in healthcare, the challenge of respondent burden persists, impacting the reliability of data integral to treatment decisions. To counteract this, self-report methods must evolve to actively engage patients and enhance the inherent value of self-reports. This shift involves leveraging design and technology to reduce burden and improve interaction, making patient self-reporting more meaningful and relevant in patient-centric healthcare.

The research presented in this dissertation addresses these challenges by exploring how interaction design can be a means to enhance respondent experiences in medical self-reporting. It emphasises the critical role of self-reporting in capturing patient experiences and guiding healthcare decisions. Employing Design Science Research, two artefacts were developed: NOW Interactions and the Respondent-centric Design (RxD) Framework for Medical Self-report. In addition to these innovative artefacts, the research has resulted into four papers, each addressing different aspects and applications of these innovations.

NOW Interactions, the first artefact, represents a practical approach to enhancing data collection in medical settings. It streamlines the communication process by combining a reminder, information request, and response into a single seamless interaction. This reduces patient effort and enables more immediate and accurate responses, as supported by its application in a headache diary prototype.

The RxD Framework, the second artefact, redefines the approach to self-report design in

healthcare by extending user-centred design theory to meet the unique needs of medical self-reporting. Moving beyond the mere application of design principles to existing self-reports, it envisions an integrated design approach that combines information- and interaction design. This approach emphasises patient-centric care principles and ensures self-reports are both clinically relevant as well as aligned with patients' experiences and needs, thus bridging the gap between medical necessities and patient-centric care. Furthermore, it empowers patients to be active participants in their own care.

Ultimately, the work presented here demonstrates the transformative potential of interaction design in enhancing medical self-reporting, marking a significant step forward in the integration of patient-centric approaches in digital healthcare.

Sammendrag

Helsevesenet er i stadig utvikling, med økende vektlegging på pasientorienterte tilnærminger som aktivt involverer pasienter i deres egen behandling. Selvrapportering spiller en avgjørende rolle i denne endringen ved å samle inn essensiell personlig og subjektiv informasjon fra pasienter, som opplevelser av smerte, stress eller tretthet, informasjon som sensorer eller monitorer ikke kan fange opp. Effektiviteten avhenger imidlertid av pasientens vilje og evne til å gi informasjon, en prosess som ofte oppfattes som belastende eller kjedelig. Denne opplevde respondentbyrden kan føre til redusert deltagelse, lavere svarfrekvenser og til slutt, redusert kvalitet på data som er avgjørende for behandlingsresultatene.

Selv om teknologi ofte letter selvrapportering i helseomsorgen, er det fortsatt en utfordring med respondentbyrde, dette påvirker påliteligheten av data som brukes i behandlingsbeslutninger. For å motvirke dette, må selvrapporteringsmetoder utvikles for å aktivt engasjere pasienter og øke den potensielle verdien av selvrapporter. Bruk av design og teknologi som reduserer byrden og forbedrer brukeropplevelsen vil gjøre pasient-selvrapportering mer meningsfull og relevant i en pasientorientert helseomsorg.

Denne avhandlingen presenterer forskning som adresserer disse utfordringene ved å utforske hvordan interaksjonsdesign kan brukes for å forbedre respondentopplevelser i medisinsk selvrapportering. Det beskrives hvilken kritisk rolle selvrapportering har for å fange opp pasientopplevelser og veilede helsebeslutninger. Ved å anvende Design Science Research ble to artefakter utviklet: NOW Interactions og Respondent-sentrert Design (RxD) Rammeverk for Medisinsk Selvrapportering. I tillegg til disse nyskapende artefaktene har forskningen resultert i fire artikler som hver adresserer forskjellige aspekter og anvendelser av disse innovasjonene.

NOW Interactions, det første artefaktet, representerer en praktisk tilnærming til å forbedre innsamling av pasientrapporterte data. Det forenkler kommunikasjonsprosessen ved å kombinere en påminnelse, informasjonsforespørsel og respons i en enkelt sømløs interaksjon. Dette reduserer pasientens innsats og muliggjør mer umiddelbare og nøyaktige svar,

noe som støttes av dets anvendelse i en prototype for en hodepine-dagbok.

RxD Rammeverket, det andre artefaktet, omdefinerer tilnærmingen til selvrapporteringsdesign i helseomsorgen ved å tilpasse brukersentrert designteori for å møte de unike behovene til medisinsk selvrapportering. Ved å gå utover den rene anvendelsen av designprinsipper til eksisterende selvrapporter, beskrives en integrert designtilnærming som kombinerer elementer fra informasjons- og interaksjonsdesign. Denne tilnærmingen vektlegger prinsipper for pasientorientert omsorg og sikrer at selvrapporter er klinisk relevante, samt i samsvar med pasientenes opplevelser og behov. Den bygger dermed en bro som fyller gapet mellom medisinske nødvendigheter og pasientsentrert omsorg. Videre gir det pasienter muligheten til å være aktive deltakere i egen omsorg.

Det presenterte arbeidet demonstrerer det transformative potensialet av interaksjonsdesign til å forbedre medisinsk selvrapportering og markerer et betydelig skritt fremover i integreringen av pasientorienterte tilnærminger i digital helseomsorg.

List of publications

Paper 1:
Rosaline Barendregt & Barbara Wasson (2022) *Persuasive Mobile NOW Interactions*, In: Kurosu, M. (eds) Human-Computer Interaction. User Experience and Behavior. HCII 2022. Lecture Notes in Computer Science, vol 13304. Springer, Cham.

Paper 2:
Rosaline Barendregt & Barbara Wasson (Submitted) *RxD: Respondent-centric Design, a Framework for Reducing Respondent Burden in Medical Self-report.*

Paper 3:
Rosaline Barendregt, Yngve Lamo, & Barbara Wasson (2024) *Improving Self-report Diaries: a Respondent-centric Design Approach*, In: Proceedings of the 17th International Joint Conference on Biomedical Engineering Systems and Technologies - HEALTHINF. SciTePress.

Paper 4:
Rosaline Barendregt, Barbara Wasson, & Martin Heitmann (In Press) *Usability Evaluation of NOW Interactions.* Mobile and Ubiquitous Systems: Computing, Networking and Services. MobiQuitous 2023. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering. Springer, Cham.

Contents

List of Figures

List of Tables

List of abbreviations

DSR	Design Science Research
ESM	Experience Sampling Methods
HCI	Human Computer Interaction
IDTP	Internet Delivered Psychological Treatment
IT	Information Technology
IxD	Interaction Design
RCT	Randomised Clinical Trails
RxD	Respondent-centric Design
UI	User Interface
UX	User Experience

Part I

The extended abstract

Chapter 1

Introduction

In this digital age where our daily experiences are deeply intertwined with technology, the quality of our interactions with digital tools has become increasingly important. Every interaction with technology, from browsing social media to setting mobile alarms, is shaped by design choices. Interaction design (IxD) stands at the centre of user-technology interactions (Preece, Sharp, & Rogers, 2015). By placing the user at the heart of the design process and understanding their context, needs, and goals, interaction designers tailor both the design and its accompanying interactions to meet these specific requirements. By shaping the moments when we engage with technology and focusing on intuitive and user-friendly interactions, IxD enhances the user experience (UX) and facilitates smooth communication (Lowgren, 2019).

Healthcare stands out as a domain where such design choices hold substantial significance, especially in fostering effective communication between care providers and patients. Effective collaboration and communication, encompassing both verbal and non-verbal communication, has been shown to elevate patient's health outcomes (Martin, Williams, Haskard, & DiMatteo, 2005). When technology mediates communication it is important that user interfaces (UIs) and interactions are carefully designed, with the care and precision as a physician would approach face-to-face interactions. Treatment decisions frequently rely on self-reported patient data, such as individual feelings and experiences of pain. The quality and effectiveness of such data depend heavily on the willingness, ability, and motivation of those providing it, particularly when respondents perceive self-reporting[1] as burdensome or stressful, which can diminish the consistency and quality of the data provided (Bradburn, 1978). Here, integrating IxD holds the potential to craft engaging and user-friendly tools, optimising the respondent's perspective of self-reporting and thereby enhancing the reliability of the collected data.

Beyond mere convenience, enhancing self-reporting can benefit the evolution of patient-centric care where patients are transitioned from passive recipients to active contributors to their health journeys (Robbins, Curro, & Fox, 2013; Yeoman et al., 2017). This shift recognises and values the patient's needs, personal preferences, and experiences, and sees patients as important, active participants in their own healthcare (Bui, Oberschmidt, & Grün-

[1] In this dissertation, 'self-reporting' refers to the activity or process of providing data, while 'self-report' is used to refer to the instrument or tool used in that process.

loh, 2023; Dekkers & Hertroijs, 2018; Doyle, Lennox, & Bell, 2013; McCarthy et al., 2016; Van der Wilt, Reuzel, & Grin, 2015). Central to this shift is the potential of digital tools to empower patients by equipping them with knowledge and understanding of their health. Well-designed tools can help foster patients' motivation and engagement, encouraging them to actively contribute and maintain accurate, meaningful data about their health. As patients gain a deeper understanding of their own health situation, they increase their competence to contribute to decision-making processes in their own treatment.

Despite the significance of self-reporting there often seems to be a mismatch between the current setup of these self-report tools and the realities of patients' daily life, potentially leading to compromised data quality or non-compliance. A key issue is the prevailing information-centric[2] design of these tools, highlighting the need for design approaches such as IxD to align these tools with patients' needs and wishes.

To optimise patient care and outcomes it is crucial to align self-report tools with the specific needs of patients (Bui et al., 2023). The research presented in this dissertation addresses this challenge through two main contributions: the introduction of a novel, practical design solution called ***NOW Interactions***, and the development of the ***Respondent-centric Design (RxD) framework for Medical Self-report***. NOW Interactions is designed to establish meaningful communication by focusing on the context of respondents, thereby bridging the gap between self-reports and genuine patient experiences. It integrates established design principles to ensure that the interaction is as intuitive and effective as possible. The RxD framework serves as a guide for self-report designers. It emphasises the importance of understanding and addressing respondent needs, connecting these needs to specific design attributes, and highlighting the inherent value of the self-reporting process. This approach has the potential to enhance the usability of self-report tools and to empower individuals in their health journeys while fostering more effective communication between patients and healthcare providers.

1.1 Motivation

My journey towards realising the significance of interaction design in medical self-reporting began during my involvement in a project on the redesign of an internet-delivered psychological treatment (IDPT). During this project, adherence was consistently highlighted as a primary indicator of success in IDPTs. A correlation that seems simple: when individuals actively engage in an intervention, there is a significantly higher chance of a positive outcome.

During the project I gained a unique insight into the lives of those using the intervention. I realised the depths of struggles associated with mental health challenges. While the project focus was on improving the user interface of the platform, I soon understood that just tweaking the UI was not the complete answer. For many, daily struggles start with basic tasks, such as getting out of bed. If getting up is already a monumental task, the benefits

[2] In this dissertation, the term 'data' refers to the unprocessed responses provided through self-reporting. While 'information', refers to the processed, or interpreted data that clinicians aim to obtain from self-reports to support medical decision making.

of interface tweaks may seem marginal. At this point I realised there is more to do than just tweak tools: there is a need to actively draw users into a healing journey. This involves reaching out proactively, creating engagement that resonates with their daily realities and encourages them to participate. It is about connecting solutions with their everyday experiences, ensuring they can actively engage in tools meant for their recovery.

My expertise in interaction design made it clear that the right design choices could possibly make a difference for many people. Is it possible to craft design solutions that facilitate adherence, but also empower users to feel accomplished, thereby serving as a subtle motivational boost in their recovery journey?

Given the fundamental role self-reporting plays not just in mental health, but across the broader healthcare spectrum, I decided to focus on this area. Improvements to self-report could resonate across various uses and therapeutic interventions, widening the scope and significance of potential contributions. By integrating IxD into self-reporting, we could potentially improve the daily experiences of countless people.

Moreover, while impactful design contributions are essential, I wanted to understand how we can ensure such solutions are both sustainable and reusable. This led me to adopt a meta-perspective, aiming to identify important elements underpinning effective self-report design and contextualise it within the broader realm of self-report design. This approach, balancing hands-on application with a deeper understanding of the underlying principles, laid the groundwork for this dissertation.

1.2 Research Questions

The main goal of the research presented in this dissertation is to investigate *how interaction design can be a means to enhance respondent experience in medical self-reporting.*

In addressing this goal my approach was twofold. Initially, my focus was on creating an immediate, practical solution for enhancing the self-reporting experience in medical contexts. This effort resulted in the design and development of NOW Interactions, a communication technique aimed to simplify and encourage patient adherence to self-report inquiries, making the overall process more engaging and less burdensome.

Following the development of NOW Interactions, my attention shifted towards a broader perspective. I focussed on how IxD can overall improve self-reporting. This involved understanding the problems people face with current self-reporting methods, as well as current approaches in self-report design and analysing which factors impact how respondents perceive self-reporting. From this deeper exploration, I developed the Respondent-centric Design (RxD) Framework for Medical Self-report. This framework integrates the needs of respondents in the self-report design process, thus helping designers focus on respondent needs, connecting these needs to design attributes, and instilling inherent value in self-reporting.

The following research questions were developed to guide this process:

RQ1 How can interactions for self-report be shaped to establish a low-threshold communication? *(Addressed in Paper 1, Barendregt & Wasson, 2022)*

RQ2 How can the respondent perspective be incorporated into the self-report design process? *(Addressed in Paper 2, Barendregt & Wasson, submitted)*

RQ3 How can the proposed solutions be applied in a practical use case to enhance the real-world respondent experience in self-reporting? *(Addressed in Paper 3, Barendregt, Lamo, & Wasson, 2024)*

RQ4 Can NOW Interactions impact respondent adherence in medical self-reporting? *(Addressed in Paper 4, Barendregt, Wasson, & Heitmann, in press)*

1.3 Results and Contributions

The research undertaken in this dissertation resulted in two artefacts: NOW Interactions and the Respondent-centric Design (RxD) Framework for Medical Self-report, each addressing distinct aspects of using IxD to improve self-reporting in medical contexts. Additionally, the research process has resulted into four papers, exploring various dimensions and applications of these innovations.

Artefacts:

1. **NOW Interactions**
   A tangible communication technique, designed to simplify and encourage patient adherence to self-report inquiries.
   NOW Interactions combines a reminder, a request for information, and a response into one seamless interaction, simplifying the data collection process from the respondent's perspective in healthcare settings. This approach reduces the effort required by patients, making it less burdensome and facilitating more immediate and accurate responses. Demonstrating its versatility and practicality, NOW Interactions has been specifically applied to a prototype in the context of a headache diary, showcasing its utility in a real-world healthcare scenario. It exemplifies how innovative design can significantly enhance respondent experience and efficiency in healthcare contexts.

2. **Respondent-centric Design Framework**
   A framework designed to alleviate respondent burden by aligning clinical needs and patient perspective in the self-report design process.
   The RxD Framework transforms healthcare self-reporting by integrating patient perspectives and patient-centric care principles. This approach shifts patients from passive data providers to empowered participants, reducing respondent burden and enhancing the meaningfulness and accuracy of self-reporting. Central strategies in the framework include tailoring data provision to patient needs and employing an iterative design and evaluation process to refine the self-report experience. Implementing the RxD Framework contributes to improved data quality, increased patient empowerment, and the development of more effective and sustainable healthcare communication, all while addressing and alleviating respondent burden.

Papers:

Paper 1 ***Persuasive Mobile NOW Interactions*** (Barendregt & Wasson, 2022)
This paper provides a comprehensive introduction to NOW Interactions, exploring the potential of its design and functionality. It discusses how this technique can facilitate user responses to self-report inquiries in a more efficient and timely manner. The paper also presents findings from a feasibility study that explored the practicality and potential effectiveness of NOW Interactions in enhancing user engagement and response accuracy. The study involved a series of user tests, which demonstrated the techniques potential in improving the user experience and data quality in self-reporting contexts.

Paper 2 ***RxD: Respondent-centric Design, a Framework for Reducing Respondent Burden in Medical Self-report*** (Barendregt & Wasson, submitted)
This paper addresses the crucial role of self-report in healthcare, analysing how its effectiveness hinges on choices around the design of the data collection tools and the attributes of the self-reporting process. It highlights interconnected challenges affecting data quality, such as respondent burden, recall bias, and design-influenced factors, and discusses how IxD can be used to address these issues to improve the self-reporting experience. The paper introduces the RxD Framework as a solution to enhance self-reported data quality by incorporating the patient perspective throughout the design process, aiming to reduce respondent burden. By applying this framework, the study demonstrates how thoughtful design can lead to more accurate and meaningful data collection in healthcare settings.

Paper 3 ***Improving Self-report Diaries: a Respondent-centric Design Approach*** (Barendregt et al., 2024)
This paper focuses on the redesign of a headache diary using the RxD Framework. The paper explores how the RxD framework can effectively bridge clinical needs and patients' needs within the self-report design process in a real-world scenario. A comparative analysis identified a need for timely and accurate data logging and easier methods of data entry, which became the focus of the redesign process. The application of the RxD framework, combined with the integration of NOW Interactions, led to a significant redesign of aspects of the headache diary. An objective evaluation of respondent burden post-redesign indicated a reduction in burden. The redesigned headache diary received positive feedback from both users and experts.

Paper 4 ***Usability Evaluation of NOW Interactions*** (Barendregt et al., in press)
This paper outlines two user studies designed to assess the efficacy of NOW Interactions, with a focus on testing adherence, user experience, and user acceptance. The studies aimed to provide a comprehensive evaluation of user interactions and responses to NOW Interactions in practical scenarios. Methodologies included quantitative usability studies for data-driven insights, supplemented by semi-structured interviews and engagement evaluations. The results from these studies underscore the efficacy of NOW Interactions as a low threshold communication technique in engaging users. This is evidenced by notable adherence rates and positive feedback regarding user experience and acceptance, demonstrating the technique's appeal and practicality in healthcare scenarios.

Figure 1.1 illustrates the contribution of each paper to the goal . It highlights the progression from exploring IxD for low-threshold communication in self-reporting, through the development of a respondent-centric design framework that integrates the respondent's perspective into the self-report design process, to the evaluation of practical applications and their impact on respondent adherence and experience.

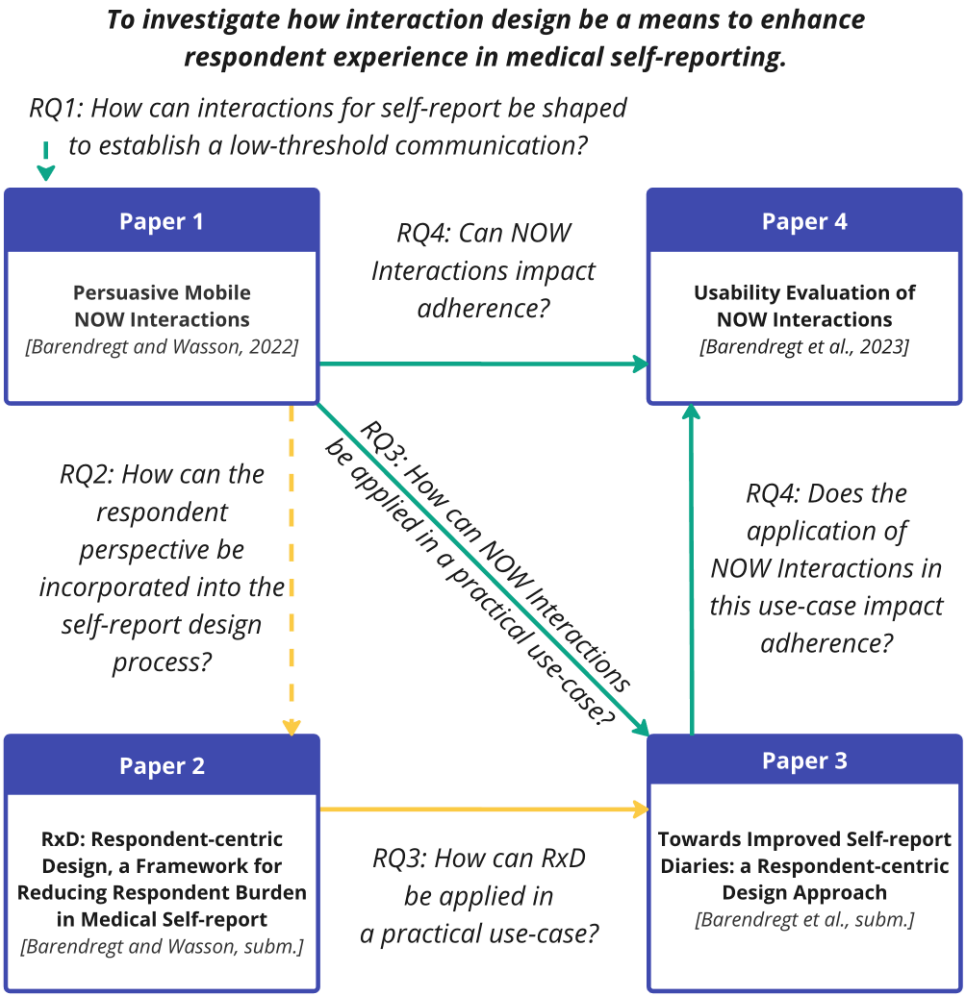


Figure 1.1: The interplay of research questions and associated papers in this dissertation

1.4 Organisation of this Dissertation

The doctoral dissertation is divided into two key sections: the Extended Abstract (Part I) and the Articles (Part II). The extended abstract provides information about the process and decision-making in this research. Furthermore, it connects the individual studies to

the overarching research question, thereby offering a holistic perspective of the research findings and their scholarly contributions. The articles provide detailed descriptions of the activities and results summarised in Part I.

Part I of this disseration consists of seven chapters, including this introduction.

Chapter 2 Background identifies and discusses open problems in medical self-reporting from an IxD perspective. This chapter lays the foundation for the research by exploring open problems in the field.

Chapter 3 Methods the research methods used throughout the study is introduced in this chapter. It discusses the research process and details the methods and techniques employed in the development and evaluation of the artefacts.

Chapter 4 NOW Interactions presents NOW Interactions, one of the key artefacts of this research, discussing the results and implications of this artifact in the context of medical self-reporting.

Chapter 5 RxD Framework presents the second artefact, the RxD Framework, along with contributions this artefact provided to the research, practical applications, along with the evaluation results and their significance.

Chapter 6 Discussion synthesises the findings from the previous chapters, reflecting on their implications for the field of medical self-reporting and IxD. It also addresses limitations.

Chapter 7 Conclusion suggests avenues for future research, and concludes the dissertation by summarising key contributions and insights.

Part II compromises the four papers included in this dissertation (Paper 1, Barendregt & Wasson, 2022; Paper 2, Barendregt & Wasson, submitted; Paper 3, Barendregt et al., 2024; and Barendregt et al., in press). All papers included in this work were the result of a collaborative effort, with my substantial contributions meriting first author.

Over the span of my doctoral research, I have participated in the creation of seven academic publications. Among these, the aforementioned papers were selected for inclusion within this dissertation. The remainder of the papers, referenced as Barendregt & Wasson, 2016, Lamo, Rabbi, & Barendregt, 2016, and Barendregt, Lamo, & Rabbi, 2016, while valuable contributions, have been excluded due to their differing thematic focus.

Chapter 2

Background

Technology plays a transformative role in shaping the landscape of modern healthcare, offering innovative solutions for improving patient outcomes, enhancing efficiency, and enabling more personalised and accessible health care (Lamo et al., 2016; Torous, Nicholas, Larsen, Firth, & Christensen, 2018). This transformation makes healthcare more sustainable and supports the transition to a more patient-centric healthcare system, which has been recognised for its positive impact on patient recovery and emotional health (Oates, Weston, Jordan, et al., 2000).

In this context digital self-reports emerge as a key tools for facilitating the transfer of patient data to care providers. However, the design of self-report tools often fail to adequately consider user perspectives, overlooking how patients perceive, experience, and wish to engage with self-reporting in digital environments. This leads to an increased burden for patients required to provide data through these self-reports. Consequently, this also potentially impacts the quality and reliability of the data collected.

The upcoming sections begin with a discussion of the concept of self-report, highlighting key challenges such as respondent burden and adherence. Then the intersection of Interaction Design (IxD) with self-report and the self-reporting process are discussed. Finally, the focus shifts to identifying existing gaps within medical self-reporting, emphasising how IxD can be used to enhance patient experience and improve healthcare outcomes.

2.1 Self-report in Medical Settings

Self-report is historically seen as a communication process between the respondent (typically a patient) and the initiator (or the *designer* in this dissertation's context) (Foddy & Foddy, 1994; Hunt, Sparkman Jr, & Wilcox, 1982) that allows respondents to report on their own behaviour, experiences, feelings, or intentions without external interference (Lavrakas, 2008). While self-report finds its application in diverse fields such as public opinion measurement, research studies, behavioural studies, and Experience Sampling Methodology, its role in healthcare is particularly important.

2.1.1 Value of self-report in healthcare

The unique value of self-report in healthcare lies in its ability to capture the patient's personal insights into their health journey, which provides healthcare providers with crucial subjective data that usually cannot be obtained through other measures. This data includes personal accounts of symptoms, experienced pain levels (e.g., Hadjistavropoulos et al., 2011; Horgas & Elliott, 2021; Schiavenato & Craig, 2010), and emotional states (e.g., Masood, Ahmed, Choi, & Gutierrez-Osuna, 2012), which are essential for accurate diagnosis and effective treatment planning. Such data is often collected through standardised questionnaires, medical diaries, or interviews. As technology becomes integral to health settings, self-reports are increasingly collected through digital chanels, including mobile platforms (Felderer, Herzing, Bruch, Krieger, & Blom, 2021).

The data collected through self-report can be subject to various inaccuracies stemming from the subjective nature of self-reporting, where patients' accounts are accepted at face-value without the possibility of external verification (Demetriou, Ozer, & Essau, 2015). To ensure the highest possible quality of data, it is critical to identify and mitigate the factors that influence the reliability of self-reporting. Some of these factors are inherent to the design of the self-report tool, such as the duration of the questionnaire and the subject of the self-report (Bradburn, 1978). Others are rooted in the respondents' context, including their motivation, honesty, stress levels, and current health conditions (Araújo, Barbosa, Lemos, Domingues, & Teixeira, 2012; Salters-Pedneault, 2022; Yan, Fricker, & Tsai, 2020).

2.1.2 Challenges in self-report

Respondent burden is a crucial factor in self-reporting that directly impacts both data quality and adherence (Bradburn, 1978; Graf, 2008; Short, Smit, & Crutzen, 2022). This burden reflects the degree to which individuals *perceive* self-reporting as time-consuming, difficult, or stressful (Graf, 2008; Lavrakas, 2008; Short et al., 2022). Key factors contributing to this burden include the length and frequency of contact, the effort required from respondents, and the stress involved in the process (Bradburn, 1978), a low respondent burden implicates a smooth self-report process. Additionally, retrospective questions can increase respondent burden due to their high cognitive demand. This challenge to accurately recall past details, due to health conditions, memory issues, and cognitive factors such as motivation and mood, often leads to measurement errors (Araújo et al., 2012; Barsky, 2002; Coughlin, 1990; Himmelweit, Biberian, & Stockdale, 1978; Solga, 2001). These errors not only compromise the reliability of the collected data, but also affect overall data quality (Barsky, 2002).

When self-reporting is perceived as burdensome, it negatively influences respondent behaviour (Graf, 2008), which in turn affects *adherence*. Adherence is particularly crucial, as it relates to how consistently and accurately patients engage in self-reporting. Without adequate patient response and engagement, the entire process of self-reporting in healthcare is compromised, leaving healthcare providers without the vital information needed for effective clinical decision-making and patient care. Adherence issues usually arise from a mismatch between what is expected in the self-report and what patients are willing or able to provide (Fogg, 2009; Graf, 2008). A decline in adherence can manifest as patients rush-

ing through surveys, giving less thoughtful responses, dropping out, or completely avoiding participation. This results in incomplete data, gaps in data, and lower response rates, reducing both data quality and quantity that can have significant implications for clinical decision-making. Addressing these adherence issues is crucial for the reliability of self-report in healthcare (Van Berkel, Ferreira, & Kostakos, 2017).

The perception of respondent burden is influenced by a combination of personal attributes, including respondents' attitudes and life circumstances, and the structural aspects of the self-report tool itself, like its length, the nature of its content, and collection methods. The interplay between these factors ultimately shapes how respondents experience self-reporting.

Figure 2.1 (from Paper 2, Barendregt & Wasson, submitted) illustrates how various factors interconnect and influence both respondent burden and data quality. By addressing these factors in the design and implementation of self-report, it is possible to enhance the patient experience and the utility of self-reported data in healthcare settings. However, traditional self-report design processes have often overlooked these critical factors, focusing more on data collection objectives rather than the user experience.

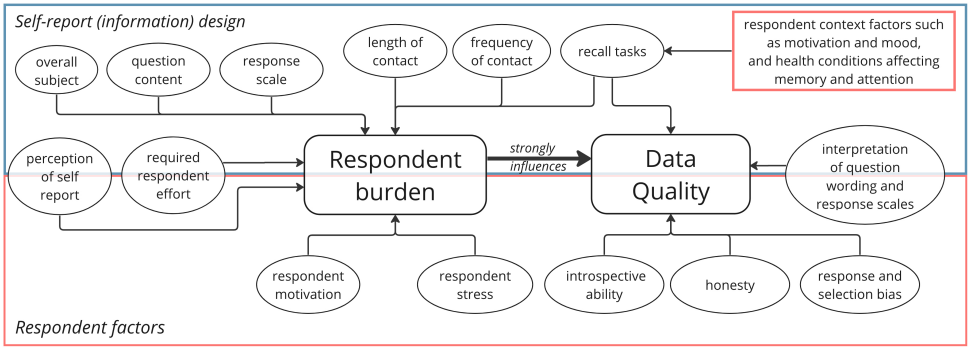


Figure 2.1: Illustration of influencing factors on data quality and respondent burden (Barendregt & Wasson, submitted)

2.1.3 Traditional self-report design

Traditional self-report design processes (such as described in Bradburn, Sudman, & Wansink, 2004; Crawford, 1997; Demetriou et al., 2015; Magee, Rickards, A. Byars, & Artino Jr, 2013) primarily focus on designing questions to collect certain information from respondents, with the questionnaire or survey format often predetermined. While some researchers recommend starting the design process by questioning whether a survey is an appropriate tool in a given situation (e.g., Magee et al., 2013), the decision of suitability is related to the type of data they aim to collect, rather than the needs or context of the respondent. Various sources (e.g., Bradburn et al., 2004; Crawford, 1997; Demetriou et al., 2015; Magee et al., 2013) outline common steps in traditional self-report design processes (see Figure 2.2). However, variations may exist depending on the particular self-report design process being employed.

By insufficiently considering the respondents and their context during the self-report design process (as illustrated in Figure 2.2), opportunities to enhance the respondents experience, reduce respondent burden, and ultimately improve data quality are missed. Utilising the affordances of technology that respondents already use in their everyday life, such as mobile phones and smart watches, and recognising and addressing the context of respondents how they would like to interact, and their context specific needs and preferences has the potential to inform the development of more effective and patient-centric self-reports.

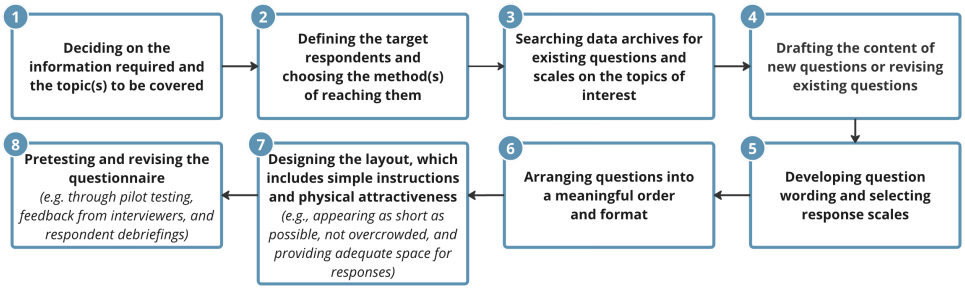


Figure 2.2: Common steps in self-report design (based on Bradburn et al., 2004; Crawford, 1997; Demetriou et al., 2015; Magee et al., 2013) (from Barendregt & Wasson, submitted)

2.2 Interaction Design

The significance of Interaction Design (IxD) in the realm of self-reporting stems from its focus on how users interact with and experience technology. IxD is centred on designing interactive tools that facilitate smooth interactions and minimise complexity, thereby enhancing the overall intuitiveness and user-friendliness of digital interfaces (Nielsen, 2009). Given the heavy reliance of self-report quality on respondent-provided data, adopting an approach that considers how respondents prefer to interact with self-report tools is necessary to make sure that self-report tools align with the needs of respondents. Based on the established benefits of user-centred approaches for usability and ease-of-use (Preece et al., 2015), it is likely that a similar approach in healthcare could significantly improve engagement to self-reporting processes.

2.2.1 Interaction design process

The IxD process is inherently iterative and user-centric, focussing on integrating the user perspective consistently throughout the design process (Preece et al., 2015). This approach, involving cycles of prototyping, feedback, and usability testing, is key in ensuring that the final tool or product aligns with the needs and expectations of its intended users, thereby preventing extensive and costly adjustments later on (Garret, 2011).

In a typical IxD process, designers engage in a series of iterative phases (e.g., Garret, 2011; Preece et al., 2015). The major phases of this process typically include:

1. *explore* the problem domain and identify main stakeholders, and their needs and wants
2. *analyse* the problem domain and identify the impact of stakeholder needs and wants on the situation
3. *design* potential solutions that address these needs and wants
4. *evaluate* prototypes and potential solutions against the needs and wants of the stakeholders through techniques such as expert reviews, usability testing, observations, interviews, and literature studies.

Additionally, depending on the project's specific requirements, there may be variations to this process.

This process is dynamic, with each phase building upon the insights gathered from the previous one. Designers use methods such as observations and interviews to form a foundation for how user interfaces should appear and function, ensuring they facilitate user needs effectively. Continual refinement and improvement of designs and interactions based on feedback and testing are integral, significantly increasing the likelihood of achieving a positive user experience and meeting user expectations (Garret, 2011; Preece et al., 2015; Soegaard & Dam, 2014).

2.2.2 Optimising interactions

IxD enhances the user experience by shaping how users interact with technology, focusing on intuitive and user-friendly interactions (Lowgren, 2019). Good design prioritises smooth interactions, is easy to use, and gives meaning and value to users, increasing the likelihood that prospective users will have a positive interaction with the product, known as *user experience* (UX) (Garret, 2011; Preece et al., 2015). Techniques such as minimising complexity, providing clear feedback, and implementing a suitable user interface design can be used to achieve this (Nielsen, 2009).

Effective IxD includes facilitating smooth communication between users and the product, ultimately leading to a positive UX. The goal is to design experiences that enable users to effortlessly complete tasks and goals (Soegaard & Dam, 2014). This involves designing user interfaces that support seamless interaction, minimise complexity, remove unnecessary hindrances that might appear during use, and keep interactions intuitive, short, and instantaneous. These elements contribute to a sense of control and ease for the user, significantly enhancing the overall interaction with the system or tool (Nielsen, 2009).

When users need or are asked to carry out tasks in digital environments that they are not intrinsicly motivated for *persuasive design*, grounded in behaviour theory, can be beneficial. This design approach uses design techniques to subtly guide behaviour towards specific objectives. It is based on the understanding that an action typically requires a combination of motivation, ability, and appropriate triggers; if one of these is missing, the action will likely not be performed (Fogg, 2009). Actions rely on the interplay between motivation and ability; the more challenging the task, the greater the motivation required for its completion. Conversly, tasks that are less demanding are more likely to be completed. This aligns

with *equity theory*, suggesting that people are more inclined to perform tasks when they perceive a favourable or fair balance between the effort required and the benefits gained (Adams, 1963).

Streamlining, optimising, and simplifying user interfaces and interactions to reduce the effort needed for tasks makes the process less daunting and more appealing and also increases the probability of task completion (Fogg, 2009).

2.2.3 Interaction design and self-report

Self-report design involves a blend of information design and UX design, each playing a pivotal role in its effectiveness. Information design involves content-related decisions such as question content, response formats, and frequency of contact. On the other hand, UX focuses on how respondents perceive interacting with the self-report, encompassing the technological medium, interactions, attention triggers, layout, presentation of response options, and feedback mechanisms.

In the context of digital self-report design, IxD and related design techniques have most notably been used to optimise mobile questionnaire layouts for self-reporting, resulting in the development of smartphone-optimised designs and effective design heuristics (Antoun, Katz, Argueta, & Wang, 2018). These advancements include the acknowledgement of needing features such as screen size adaptation, larger text and buttons, and minimising scrolling, all aimed at enhancing the user experience for self-reporting on mobile platforms (Antoun, Couper, & Conrad, 2017).

Likewise, questions design for mobile devices has been a focal area of study. The unique context of mobile usage, with its smaller screens and anywhere, anytime nature, necessitates a re-evaluation of how questions are structured and presented. Research has indicated that mobile users tend to find long, complex questions challenging (e.g., Delgado, Vargas, Ackerman, & Salmerón, 2018), leading to a need for concise and straightforward queries that can be easily understood and answered on smaller devices. Research has also examined the impact of various response formats in mobile self-report tools, recognising that the way responses are captured can significantly influence user experience and data quality. For instance, smiley scales have been shown to be effective for certain demographics, like children, providing an intuitive and engaging way to capture their responses (e.g., Hall, Hume, & Tazzyman, 2016). On the other hand, slider scales, often used in mobile surveys, tend to be less suitable in general due to their association with higher drop-out rates and increased response times (e.g., Funke, 2016; Funke, Reips, & Thomas, 2011).

While existing research mainly focuses on refining current methods and warning against bad practices, there is a call to explore how creative input methods and interactions on mobile devices can benefit self-reporting (Van Berkel et al., 2017). Innovative solutions are emerging, employing modern technology and user interactions to facilitate data provision and integrate self-reporting into daily routines.

2.3 Self-reporting Process

Self-reporting in healthcare involves the duality of data collection and provision. On one hand, there are self-report initiators who need answers to their questions; on the other hand, there are respondents who must take time and use effort to provide this data.

The process respondents go through when digitally self-reporting is a communciation process (Foddy & Foddy, 1994; Hunt et al., 1982) mediated by a digital interface. The use of modern technology offers great opportunities to enhance this communication, yet we must be aware of the pitfalls that busy daily lives filled with technology bring with.

Keeping the ongoing shift towards a patient-centric healthcare system in mind, this process is not just about collecting data, there is a potential to create an environment where self-reporting aids patients in feeling empowered and heard.

2.3.1 The role of user interfaces

In the context of healthcare communication, the nuances of verbal and non-verbal cues play a significant role in how patients perceive and respond to interactions (Marcinowicz, Konstantynowicz, & Godlewski, 2010). In face-to-face settings, elements such as a physician's tone of voice, eye contact, and body language can profoundly affect patient comfort and understanding (Mast, 2007; Mast, Hall, Klöckner, & Choi, 2008; Roter, Frankel, Hall, & Sluyter, 2006). These subtleties help convey empathy, reassurance, and clarity, contributing to effective therapeutic communication. These communication skills are deemed an essential component of good clinical practice (Marcinowicz et al., 2010).

When communication shifts to digital platforms through self-reporting, the direct, human elements of verbal and non-verbal communication are absent and are replaced by the user interface (UI) of the technology used. The UI takes on the role of facilitating communication, becoming the primary medium through which information and emotions are conveyed.

Thus, the UI design of self-report tools becomes a critical factor in influencing how patients perceive and engage with the self-report. The absence of direct human interaction means that designers should strive to create an environment that is intuitive, reassuring, and engaging for patients, ensuring that the tool facilitates the communication, and is not in the way.

2.3.2 Communication process

While self-reporting is historically framed as a communication process akin to interviews, involving exchanges between the respondent and the initiator (Foddy & Foddy, 1994; Hunt et al., 1982), paper-based self-reports typically have a more linear and one-sided structure, resembling a list of questions such as questionnaires. The respondents role is more passive in this format, primarily providing data rather than engaging in a mutual exchange of in-

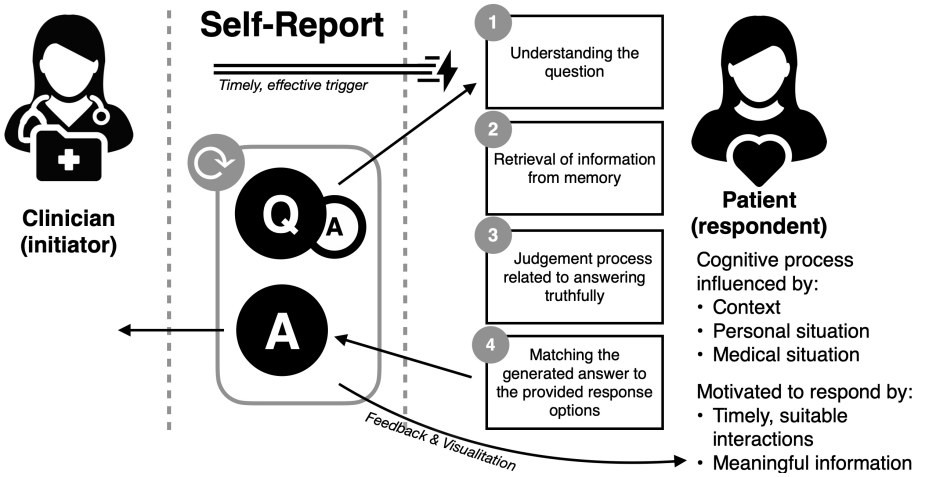


Figure 2.3: Illustration of the cognitive process respondents go through when self-reporting (Barendregt & Wasson, submitted)

formation. When transitioning to digital platforms, these paper-based formats were often replicated digitally, maintaining their reliable format that functions offline, yet continuing the trend of using respondents as passive data providers.

Responding to a self-report typically begins with a trigger to make the respondent aware of the need to self-report and involves iterations of several steps of complex information processing for each question. As Figure 2.3 illustrates, these steps include 1) understanding the question, 2) retrieving information from memory, 3) a judgement process related to wanting to answer truthful or not, and 3) matching the fabricated answer to the provided response options (Aday & Cornelius, 2006; Lietz, 2010; Tourangeau, Rips, & Rasinski, 2000). Each step is vulnerable to various disruptions. Respondents might disengage or stop answering, influenced by factors such such as their personal context, their medical condition, or the clarity and perceived complexity of the questions asked. Being mindful of these factors is crucial in shaping the format and design of self-reports to ensure effective communication and engagement, and by doing so securing responses.

2.3.3 Timing of self-report

Today's advancements in technology offer unique opportunities to transcend beyond traditional, linear formats of self-report. The pervasiveness of mobile technology facilitates real-time engagement and allows for potentially dynamic and interactive self-reporting.

Mobile reminders and push notifications have emerged as powerful alert features for capturing peoples' attention (Pielot, Church, & De Oliveira, 2014). Within the health domain they are often used to encourage people to independently perform health related activities. For instance, reminders can assist people in adhering to medication schedules (Fenerty, West, Davis, Kaplan, & Feldman, 2012; Vervloet et al., 2012), and can enhance participa-

tion by reminding people to complete questionnaires or make diary entries (Koitsalu, Eklund, Adolfsson, Grönberg, & Brandberg, 2018). Such interactions are usually carried-out by opening an app to perform the action.

Typically, the respondent receives a notification on their phone with a request to answer the questionnaire or register a diary entry; the respondent taps the notification, which opens the self-report questionnaire in a browser window or an app where the respondent should answer the questions and hopefully fulfils the whole request.

People nowadays, however, are constantly navigating a competition for their attention, arising from both real-world distractions as well as from a multitude of messages and notifications on personal devices. The frequent demands on a person's attention and the need to process numerous notifications can lead to cognitive overload, which makes it challenging for important requests, such as those from medical self-report diaries, to stand out and not be overlooked or prematurely dismissed (Garlan, Siewiorek, Smailagic, & Steenkiste, 2002; Okoshi et al., 2016, 2015).

Poorly timed or designed notifications disrupt and lead to negative user experiences, even causing users to disable these important alerts (Hansson, Ljungstrand, & Redström, 2001). Failure to answer notifications in a healthcare context can have significant consequences for patient health and well-being. To effectively utilise the potential of technology in self-report, we must leverage technological capabilities while ensuring alignment with the contexts in which patients are self-reporting. This is in order to grab and keep attention.

The integration of wearables and smartphones into self-reporting strategies represents a significant advancement in healthcare technology. Researchers are exploring the use of sensor data from wearables and smartphones to identify optimal moments for patients to provide their data and to initiate collection at those moments (Struminskaya, Lugtig, Keusch, & Höhne, 2020). Such smart timing shows potential to improve the accuracy of self-reported data by capturing data at relevant moments and facilitates the triangulation of data, placing self-reports within a contextual perspective and enhancing the overall utility of the data collected (Struminskaya et al., 2020).

2.3.4 Self-report in patient-centric care

Beyond merely facilitating data collection, designing self-report tools that resonate with patients aligns with the needs of the shift of healthcare towards patient-centric care, which emphasises actively involving patients in their own treatment and ensuring that they are informed participants in all decisions concerning their health (Bui et al., 2023; Dekkers & Hertroijs, 2018; Doyle et al., 2013; McCarthy et al., 2016; Van der Wilt et al., 2015). Patient-centric care focuses on ensuring that all aspects of care, including self-reporting, are not only clinically relevant but also personally meaningful and valuable to the patients (Porter et al., 2010).

The degree to which patients feel in control of their situation significantly impacts their care outcomes (Wallace, Mullarkey, & Hevner, 2023). Even patients with identical health conditions and treatment plans can have varying outcomes based on how in control they

feel about their health and treatment process (Wallace et al., 2023).

Technology holds significant potential in the evolution towards patient-centric care, providing a means to empower patients to actively express their health experiences and control and influence their own care. By leveraging technology, healthcare can facilitate knowledge exchange and engage patients in maintaining accurate, meaningful health data (Robbins et al., 2013; Yeoman et al., 2017).

Ultimately, when patients feel their input as valued and impactful, their engagement and adherence to treatment protocols are likely to improve as they are more willing to accept higher levels of respondent burden (Yan & Tourangeau, 2008). This emphasises the potential of designing self-report with patients needs and preferences to align with patient-centric care values, to lower respondent burden, increase adherence, collect quality data, and better treatment outcomes.

2.4 Open Challenges in Medical Self-reporting

As healthcare continues to evolve towards a patient-centric system, digital self-reporting stands at the forefront, bridging the gap between patient experiences and clinical data and facilitating a digital communication between physicians and patients. In this digital era, the transformation of self-reporting from a traditional, linear task to a dynamic, interactive process is not just a possibility, but a necessity. We face two significant challenges: 1) reducing the respondent burden inherent in self-reporting and 2) fitting self-report to contribute to a patient-centric communication process.

2.4.1 Reducing respondent burden

Even though the concept of respondent burden has been known and acknowledged for decades, it continues to pose a significant challenge in self-reporting (Short et al., 2022). The transition from paper-based to digital platforms has not alleviated the issue, instead, it continues to impact the reliability and quality of self-reported data, marking respondent burden as a critical challenge that continues needing addressing (Short et al., 2022). This enduring issue highlights the need for innovative solutions to ensure data quality and address respondent adherence (Van Berkel et al., 2017), and approaches that take into account the changing context in which self-report is being collected and used.

Reducing respondent burden not only has the potential to enhance data quality but also plays a significant role in empowering patients. When patients find the self-reporting process manageable and see their input as valued and impactful, it can foster a sense of control over their health condition and treatment. This sense of control is linked to better health outcomes and patient satisfaction (Wallace et al., 2023).

2.4.2 Fitting self-report into patient-centric care

Even though self-report is historically seen as a communication process (Foddy & Foddy, 1994; Hunt et al., 1982), in practice, contemporary self-reports often do not seem to fully adopt this function. Rather than fostering a mutual exchange, many use a format predominantly driven by the initiator. This often results in a one-sided flow of information, where the respondent is more a passive provider of data than an active participant in a dialogue.

To lift self-report to address the needs of patient-centric healthcare, its design should take into account how self-reporting can contribute to empowering patients to be active participants in their healthcare, however, the availablity of digital solutions does not automatically ensure their effective integration into self-reporting. Current design approaches to self-report often limit opportunities for format innovation and interactive engagement (see Figure 2.2). To truly optimise patient care and outcomes, it is imperative that self-report tools are designed in alignment with the specific needs of patients (Bui et al., 2023). This extends beyond just looking how to optimise user interfaces and interactions, to finding ways to make self-reporting an inherently meaningful activity.

2.4.3 Addressing these challenges

The research presented in this dissertation explores the role of IxD in enhancing the self-reporting experience within healthcare. It addresses the direct need of reducing respondent burden through innovative solutions (Van Berkel et al., 2017) by looking into how self-report interactions can be shaped to establish low threshold communication. Through simplifying and optimising data provision and emphasising intuitive and less demanding interaction techniques, the approach seeks to minimise distractions and cognitive load. Furthermore, the research aims to reshape the self-report design process by integrating information and interaction design and embedding the respondent's perspective throughout. This approach aims to set the stage to develop sustainable self-report solutions that align with user needs and contribute to improved healthcare experiences.

Chapter 3

Methods

The research presented in this dissertation makes use of Design Science Research (DSR). Interaction Design (IxD) and User Experience (UX) methods to address the practical aspects of design.

The choice of DSR stems from its strong alignment with the goal of tackling real-world issues through the creation and evaluation of practical solutions. On the other hand, the inclusion of IxD and UX methods is not only a methodological choice, but also a direct reflection of the research focus and reflects the user-centric nature of the research problem. This combination is crucial for exploring and addressing the core research problem of how interaction design can be of use to enhance respondent experience in medical self-report while making sure it is well grounded and connected to the knowledge base.

This chapter outlines the structure of DSR, how it is applied in this research, and describes IxD and UX methods employed.

3.1 Design Science Research

Design involves crafting strategies to transform current scenarios into more desired ones. It focuses on envisioning how things ideally should be while creating tools or artefacts to achieve those visions (Simon, 1988). Moving from mere problem-solving, when design processes are structured and informed by empirical evidence and theoretical frameworks, they transcend into the realm of research.

Design science research (DSR) aims to address complex real-world problems through design, simultaneously constructing new knowledge related to both the problem and solution (Hevner, March, Park, & Ram, 2004). This ensures that outcomes are both theoretically grounded and practically relevant.

In DSR, the process of practical problem solving is deeply connected with the existing knowledge base, aiming at knowledge development through the design of artefacts. A problem within an application domain is addressed by drawing upon experiences and knowl-

edge of the problem area by iteratively designing an artefact, and in turn contributing back to the knowledge base (Hevner et al., 2004). Results from DSR are channelled both towards practice (through designed artefacts as solutions to stated problems) and towards enriching the knowledge base as contributions (Hevner, 2007), see Figure 3.1.

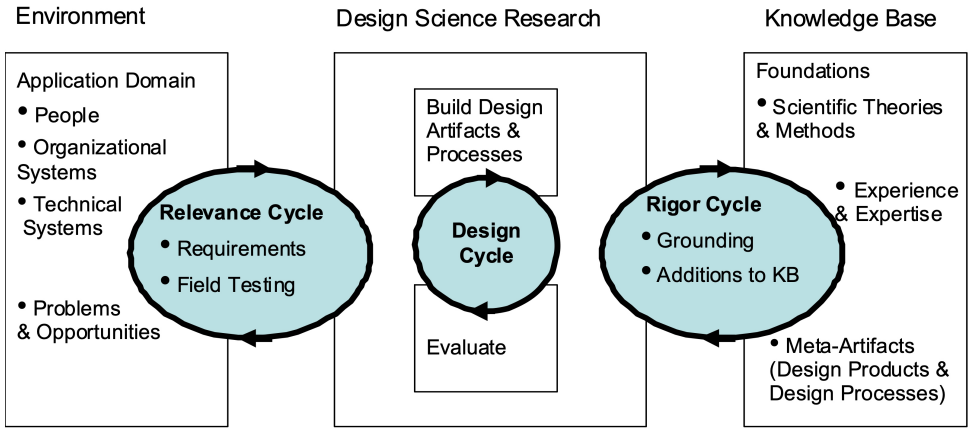


Figure 3.1: Design Science Research Cycles (Hevner, 2007, p. 88)

Traditionally, an artefact in DSR refers to an information technology (IT) solution crafted to address a specific problem in a particular domain (Hevner et al., 2004). Such IT artefacts can range from tangible or intangible, encompassing "constructs (vocabulary and symbols), models (abstractions and representations), methods (algorithms and practices), or instances (implemented and prototype systems)" (Hevner et al., 2004, p. 77). The process of designing artefacts is characterised by iterative cycles of building and evaluating (Hevner, 2007; Hevner et al., 2004). These iterative cycles align with the perception of design as a process of discovery through which deeper insights into the problem domain, innovation opportunities, and potential solutions are continually uncovered (Gregor & Hevner, 2013).

DSR unfolds as a two-layered process with alternating between concrete design work and abstract design-theorising: the 'design practice' layer focuses on situational design knowledge and concrete artefacts, while the 'meta-design' layer endeavours to abstract design knowledge (Goldkuhl & Lind, 2010; Gregor & Hevner, 2013). The latter often involves activities that transcend the traditional design realm, including data analysis, evaluation, and theorising, forming a bridge between practical design work and abstract design theorising. This duality in activities leads to contributions from a DSR that can range from case-specific to more abstract knowledge. Contributions made at the artefact level provide immediate solutions to identified problems, while contributions at the abstract level foster a deeper understanding and advancement of a problem (Gregor & Hevner, 2013), see Table 3.1.

Hence, both case-specific and more abstract knowledge contributions are integral to fulfilling the overarching aim of DSR, which is to provide effective means to tackle real-world problems while concurrently enriching the theoretical knowledge base (see Figure 3.2).

Table 3.1: Design science research contribution types (Gregor & Hevner, 2013, p. 342)

	Contribution Types	Example Artifacts
More abstract, complete, and mature knowledge	Level 3. Well-developed design theory about embedded phenomena	Design theories (mid-range and grand theories)
↕ ↕ ↕ ↕	Level 2. Nascent design theory—knowledge as operational principles/architecture	Constructs, methods, models, design principles, technological rules.
More specific, limited, and less mature knowledge	Level 1. Situated implementation of artifact	Instantiations (software products or implemented processes)

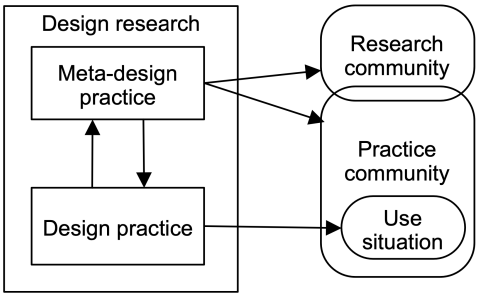


Figure 3.2: Design research as meta-design and design practice serving communities and situations (Goldkuhl & Lind, 2010, p. 49)

3.2 Interaction Design and User Experience

Central to DSR is the design process, emphasising an iterative journey that includes problem identification, solution creation, and evaluation. Having outlined how the framework of DSR relates to both the problem domain and the knowledge base, the focus now shifts to the practical aspects of the research, primarily explored through the lens of IxD.

IxD is primarily concerned with the optimisation of interactions within a system to enhance its usability and functionality. A typical IxD process has an early focus on users and their tasks and iterates through exploring and analysing the problem domain, designing potential solutions, and evaluating them against stakeholders' needs and wants through various methods such as usability testing, heuristic evaluations, and expert reviews (Lowgren, 2019; Preece et al., 2015). This iterative and user-centred focus aligns well with DSR, enhancing the exploration of practical design solutions.

The success of a design is heavily influenced by the experience it offers to its users. This is where UX comes into play. While IxD focuses on optimising individual interactions for usability and ease of use, UX encompasses the overall satisfaction and experience of the user when interacting with a system (Hassenzahl, 2013). The methods within these fields are instrumental in refining interactive systems, ensuring they are intuitive, user-friendly, and effectively fulfill their intended purposes and contribute to a positive experience.

Methods used in IxD and UX have a formative role in design, providing insights that help refine interactive systems (Budiu, 2017). By employing a range of qualitative and quantitative methods, utilising either attitudinal or behavioural approaches (Rohrer, 2022), practi-

tioners can delve into understanding user behaviours, needs, and preferences. Attitudinal methods aim to understand what people think and feel (e.g., through interviews or surveys), while behavioural methods focus on observing and analysing what people do (e.g., by collecting usage metrics or conducting usability testing). This understanding informs the design and crafting of solutions that are not only functional but better suited to the user's needs, aiming for enjoyable and effective user interactions. Moreover, IxD and UX are instrumental in addressing various problems including, but not limited to, enhancing usability, improving user engagement, and reducing user errors, ultimately enhancing the overall success and efficacy of the design.

In the context of DSR, integrating methods used in IxD and UX provides a proactive step towards connecting practical solutions with the knowledge base. By employing a mix of qualitative and quantitative methods such as user interviews, surveys, quantitative usability testing, and heuristic evaluation, it is possible to garner invaluable insights into the user's interactions and experiences with the system. These insights, in turn, inform the iterative design process, facilitating the refinement of design artefacts to better meet the users' needs and expectations.

3.3 Design Science Research in This Dissertation

The research presented in this dissertation addresses real-world challenges in medical self-reporting. Through DSR two innovative artefacts have been developed: the NOW Interactions communication technique, and the Respondent-centric Design (RxD) framework. The process and findings from the creation and evaluation of these artefacts are documented across four academic papers. A summary of the two artefacts, including the issues they address and their contributions to the application domain and the knowledge base, is provided in Table 3.2.

Table 3.2: Summary of artefacts developed in this dissertation

Artefact	Real-world Problem	Contribution to Application domain	Artefact description	Contribution to Knowledgebase
NOW Interactions	Inconsistent adherence to medical self-report protocols due to user engagement challenges.	A tangible, low-threshold mobile communication technique, simplifying the self-reporting process for patients, leading to higher adherence and more consistent data collection.	A push notification based technique that integrates reminders, requests, and responses to facilitate immediate and effortless interaction from resondents.	Insights into how interaction complexity can be reduced, improving adherence to inquiries, through streamlined communication design.
RxD Framework	Disconnect between medical self-report design and the needs of respondents.	A structured approach for incorporating respondent perspective effectively into self-report design process, enhancing the relevance and ease-of-use of self-reporting. leading to reduced user burden and higher quality data.	A methodological framework guiding medical self-report designers to include focus on user experience and respondent needs.	Extends user-centered design theory by contextualising its principles within the specific challenges of medical self-reporting, offering a comprehensive framework that aligns self-report design and respondent experience.

Both NOW Interactions and the RxD framework underwent an iterative design, development, and evaluation process, central to DSR. This process was characterised by interconnected phases, which included:

1. *Problem awareness and suggestion*, where the initial observations and identification of issues within the domain of medical self-reporting were made.

2. *Artefact design and development*, where potential solutions were conceptualised and prototypical implementations were created.

3. *Artefact refinement*, which involved iterative cycles of testing and feedback to refine the artefacts.

4. *Evaluation and reflection*, where the effectiveness of the artefacts was assessed and the overall research findings were synthesised.

Figure 3.3 shows how this iterative process manifested within DSR, highlighting the interplay between this design research and the practice community,the research community, and knowledge base. The figure illustrates the bidirectional flow of insights and contributions, showing how practical insights inform research, which in turn generates additions to the knowledge base and can be applied in practice.

These developed artefacts exemplify the sprectrum of contributions in DSR as illustrated in Table 3.1. The RxD Framework can be positioned at Level 3, representing an abstract contribution. NOW Interactions bridges the gap between theory and practice, offering a more concrete versitile approach, situated at Level 2. The prototype of NOW Interactions can be categorised as a Level 1 contribution as it serves a tangible, case specific solution addressing immediate practical needs.

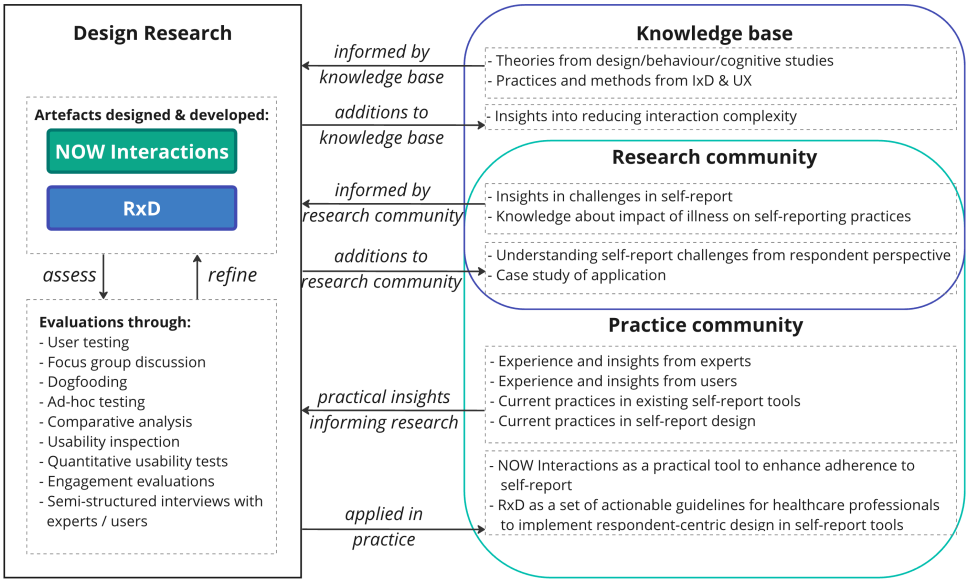


Figure 3.3: Design science research in this dissertation

3.4 Evaluation & Feedback Methods

Throughout this research, the iterative assessment and refinement of artefacts was guided by feedback and evaluation from both users and experts, obtained through a combination of informal methods and structured data collection methods. These include:

- **Informal feedback**: gathered at impromptu.
  - *Ad-hoc user feedback*: Casual feedback from users while interacting with the artefacts.
  - *Informal expert advice*: Insights gained from impromptu discussions with experts that helped shape the development process.

- **Structured data collection**: gathered at predetermined points during the feasibility study, usability studies, and expert interviews, including:
  - *Semi-structured interviews*: Interviews using a mix of open-ended and specific questions, allowing the exploration of set topics while capturing unique participant experiences and perspectives (Oates, Griffiths, & McLean, 2022).
  - *Engagement evaluations*: using TWEETS (Kelders & Kip, 2019), a tailored measure of engagement among users of eHealth technologies defines engagement as a combination of behaviour, cognition, and affect, using nine items. Responses are collected on a 5-point Likert scale, ranging from strong disagreement to strong agreement.
  - *Quantitative usability evaluation*: Objective assessment of user behaviour by collecting specific performance metrics as users engage with the technology (Budiu, 2017).

3.4.1 NOW Interactions feasibility study

The feasibility study was aimed at uncovering challenges and complications that might be associated with the overarching concept of NOW Interactions and the NOW Interactions prototype. It sought to validate the practicality and effectiveness of the proposed design of interactions in a real-world setting. A detailed breakdown of the study's components, the data collected, the methods used, and the participant engagement can be found in Table 3.3, and each are described thereafter. Insights from these evaluations are discussed in Paper 1 (Barendregt & Wasson, 2022).

Workshop with Students
The study began with a workshop involving high school students as participants. The participants were engaged in a series of activities, starting with an icon design session where they were asked to suggest icons and share their opinions on the use of icons within the NOW Interactions context. Participants were provided with a worksheet to guide their icon design process, as detailed in Appendix A.1.
Following the icon design activity, the participants engaged in a user test with a paper prototype of NOW Interactions. This exercise involved peer interviews where they collected feedback on the prototypes usability and the intuitiveness of the interface. The user test guide, available in Appendix A.2, facilitated this process by providing a structured series of

Table 3.3: Feasibility study: methods and participants

Method	Data collected	Collected through	Participants
Workshop: Icon design	Suggestions for icons, opinion about icon use	Paper worksheets	21 students
Workshop: User test with paper prototype	Judgements about icons, opinions on NOW Interactions, mobile use suitability, ease of use	Paper worksheets	21 students
Quantitative usability study	User metrics including timestamps	NOW Interactions prototype	3 students
Semi-structured interviews	Opinions on NOW Interactions, technical issues feedback, use-case suggestions, time usage, icon feedback, two-question sequence opinions, interruptibility	Note taking	3 students
App usability comparison	Responses to comparison questions on: ease of use, long-term usability, overall feeling, and perceived accuracy of tracking.	Paper-based 6-item questionnaire	3 students
Engagement evaluations (TWEETS)	Engagement with NOW Interactions	9-item Likert scale questionnaire, paper worksheet	3 students

tasks and questions for the participants to follow, ensuring consistency and thoroughness in the feedback process.

Quantitative Usability Study
Subsequent to the workshop, a focused hands-on testing phase was conducted with a select group of three participants. Over a three-day period, these students interacted with the NOW Interactions prototype, allowing for the collection of user metrics, including interaction timestamps, to quantitatively evaluate the usability of the prototype. The data collected served a dual purpose: firstly, to verify whether participants responded, and secondly, to identify any technical issues that might hinder user interaction.

App Usability Comparison
Participants from the hands-on testing phase were also engaged with an alternative app for tracking similar data. They compared both apps by completing a paper-based 6-item questionnaire that addressed ease of use, estimated long-term usability, and other relevant factors. This comparison provided insights into user preferences and their perceptions of the NOW Interactions prototype. The questionnaire used for this comparison is detailed in Appendix A.3.

Engagement Evaluations (TWEETS)
Following the app comparison, participants' engagement with the NOW Interactions prototype was assessed using the TWEETS method. Participants responded to a 9-item Likert scale questionnaire, measuring various facets of user engagement, which had been translated into Norwegian to ensure comprehension and accuracy in responses. The details of the TWEETS questionnaire, including its scale and items are available in Appendix A.3.

Semi-structured Interviews
The final stage of feedback collection involved semi-structured interviews with the three participants. These interviews were designed to explore the participants' experiences with the prototype in an open-ended manner, allowing for a broader discussion of NOW Interactions, any technical issues, potential use cases, and the overall impressions of NOW Interactions. The interview guide for these discussions is provided in Appendix A.4.

3.4.2 Usability studies (students & teachers)

The usability studies were designed to assess the effectiveness of the NOW Interactions prototype focusing on adherence, user experience, and acceptance within simulated real-world scenarios. Employing a triangulated approach, the studies integrated quantitative and qualitative research methods, engaging both students and teachers as participants. The methodologies used and the participant engagement details are summarised in Table 3.4. Findings derived from the usability studies form the core discussions in Paper 4 (Barendregt et al., in press). Additionally, selected insights are also referenced in Paper 2 (Barendregt & Wasson, submitted) and Paper 3 (Barendregt et al., 2024).

Table 3.4: Usability studies: methods and participants

Method	Data collected	Collected through	Participants
Quantitative usability study	User metrics including responses with timestamps, interaction frequency, total logs, drop-outs	NOW Interactions prototype	11 students 6 teachers
Semi-structured interviews	Perceptions and insights on user commitment, interaction, usage lapses, feedback on notifications, preferences, challenges, satisfaction	Transcribed audio recordings	8 students 1 teacher
Engagement evaluations (TWEETS)	Perceptions of NOW Interactions, ease of use, satisfaction, future use through	9-item Likert scale questionnaire, through NOW Interactions prototype	8 students 5 teachers

Quantitative Usability Study
The quantitative usability study involved 11 students and 6 teachers, focusing on collecting objective metrics such as interaction frequency and response times. This method allowed for a data-driven evaluation of the NOW Interactions prototype's usability, offering insights into how often and effectively users engaged with the prototype, and pinpointing drop-out cases. The collected data and subsequent analysis are discussed in Paper 4 (Barendregt et al., in press).

Engagement Evaluations (TWEETS)
Following the quantitative usability study, engagement evaluations using the TWEETS method were conducted with 8 students and 5 teachers. These evaluations aimed to understand the participants' perceptions of their interactions with NOW Interactions and its potential for future use. The TWEETS items were translated into Norwegian and adapted to align with the study's focus on adherence, user experience, and user acceptance. While a

summary of these evaluations is included in Paper 4 (Barendregt et al., in press), the complete set of adapted TWEETS items, average responses, and their relation to the evaluation criteria are detailed in Appendix B.1.

Semi-Structured Interviews
In-depth qualitative insights were obtained through semi-structured interviews with 8 students and 1 teacher. These discussions allowed participants to elaborate on their experiences with the prototype, providing a richer context for understanding the quantitative findings. The guide to these semi-structured interviews is provided in Appendix B.2.

3.4.3 Expert interviews

The expert interviews conducted as part of this research aimed to harness in-depth, practical knowledge from professionals and an end user with extensive self-reporting experience. The following healthcare professionals across various specialties were interviewed:

1. A neurologist specialising in self-reports for mobile headache diaries.
2. An Ear-Nose-Throat specialist with expertise in digital pain maps.
3. A psychologist with a background in Internet Delivered Psychological Treatment and standardised questionnaires.
4. A statistician skilled in healthcare research and the analysis of self-report data.
5. A biological and medical psychologist specialising in stress monitoring in sports.
6. A sleep researcher and neuro-physiologist focused on digital tools and self-reporting for sleep quality assessment.

Additionally, an end user who regularly uses self-reporting tools to manage and document chronic headaches was also interviewed to provide a user's perspective.

The interviews were structured into two parts. Initially, the objective was to understand the experts' views on self-reporting tools and practices. Subsequently, the experts were introduced to NOW Interactions. All interviews were recorded, transcribed verbatim, and subjected to thematic analysis to identify common topics and insights. These interviews served to pinpoint challenges, illustrate examples of self-reporting in practice, and evaluate the utility of NOW Interactions within a use case scenario. The interview guides used for these sessions are included in Appendix C.

While some of the findings from the neurologist and the expert user are detailed in Paper 3 (Barendregt et al., 2024), a publication detailing all expert interviews is forthcoming. For a

Table 3.5: Expert interviews: method and participants

Method	Data collected	Collected through	Participants
Semi-structured interviews with demo	Expert experiences with self-report tools, adherence/compliance discussions, feedback on NOW Interactions, potential use-cases	Transcribed audio recordings	6 medical experts 1 expert user

concise overview of the methods and participants involved in these expert interviews, see Table 3.5.

3.4.4 Other evaluation methods

In addition to the participant-based evaluation methods, this research also employed a set of non-participant methods to further assess the developed prototypes. These methods provided additional insights into the design and usability of the artefacts, contributing to a more comprehensive evaluation. These non-participant evaluation methods played an important role in refining the prototypes, mainly used in Paper 3 (Barendregt et al., 2024). These complemented the participant-based methods by providing a different perspective on the artefacts usability and impact.

Dogfooding
This approach involved the designers and developers using their own prototypes in real-life scenarios. By using the artefacts ourselves, first-hand experience of the user journey was gained, which enabled them to identify unforeseen issues and areas for improvement.

Comparative Analysis
A comparative examination of the NOW Interactions and RxD artefacts was conducted alongside existing solutions. This comparison helped to highlight design features associated with user satisfaction and revealed opportunities for innovative design interventions.

Usability Inspection
Alongside the comparative analysis, usability inspections were conducted to estimate the number of interactions and the time spent on specific tasks within the prototypes. The aim was to measure potential reductions in respondent burden and assess the systems' efficacy.

3.5 Data Analysis

The analysis processes used in this research were multifaceted, targeting both qualitative and quantitative data to uncover user behaviour patterns, assess engagement levels, and extract thematic insights from expert contributions.

Semi-structured interviews
The semi-structured interviews from both the expert interviews and the usability studies were subjected to thematic analysis (Bryman, 2016; Clarke & Braun, 2017). This analysis followed a deductive approach as there was some expectation of what themes would emerge, based on the semi-structured nature of the interviews. The thematic analysis proceeded as follows:

1. Multiple readings of the transcripts to familiarise with the data.
2. Identification of preliminary themes based on the research objectives and interview questions.

3. Coding of the data, where extracts of the text were tagged with codes representing the identified themes.
4. Organisation of these codes into the potential themes and subthemes, ensuring they are supported by the data.
5. Refinement of themes, defining and naming them clearly.
6. Final analysis to ascertain the essence of what each theme represented about the data as a whole.

This process was facilitated by the use of a spreadsheet, where coded data could be efficiently organised and compared.

Quantitative usability study
The analysis of usage metrics included evaluating interaction frequency, noting signs of user dropouts, and assessing engagement consistency. The time intervals between sequential interactions were also examined. This analysis was crucial for understanding how users interacted with NOW Interactions in real-time and for comparing user engagement across the two studies.

Engagement evaluations
The analysis of the engagement evaluations centred on calculating the mean response for each item in the TWEETS questionnaire, serving as a quantitative measure of participant consensus and user experience. In addition to the mean response, attention was given to the range and distribution of responses to pinpoint any outliers or instances of significantly low satisfaction. This step helped with the understanding of both the collective experience and the individual user perspectives, and highlight potential extreme positive or negative experiences with the prototype.

In conclusion, the data analysis in this research combined quantitative and qualitative methods, with attitudinal and behavioural approaches. This strategy provided a comprehensive understanding of user behaviour, engagement, and experiences. Notably, during the usability studies, both usage metrics and engagement evaluations were collected through the same prototype. This approach enabled an anonymous comparison of these data sets, facilitating the correlation of behavioural data with self-reported engagement levels.

3.6 Research Ethics

During the feasibility study and usability studies, participants provided written, informed consent, permitting the use of their data for testing and improving the NOW Interactions prototype. The research obtained approval from University of Bergens system for risk and compliance for processing of personal data in research [1].

Additionally, for the semi-structured interviews, the audio recordings were made with the consent of the participants, ensuring that ethical protocols were followed. Audio recordings were deleted after transcription.

[1] RETTE: https://rette.app.uib.no

3.7 Overview of the Papers

The research presented in this dissertation has been documented across four academic papers, each addressing different aspects of the main goal of this research of finding out how interaction design can be a means to enhance respondent experience in medical self-reporting.

Table 3.6 provides an overview of the papers, outlining the specific research question tackled, the methods applied, and the participants involved. Complementing this, Figure 1.1 illustrates the interplay between the research questions and the corresponding papers.

Table 3.6: Overview of the papers

How can interaction design be a means to enhance respondent experience in medical self-reporting?				
	Paper 1	*Paper 2*	*Paper 3*	*Paper 4*
Title	Persuasive Mobile NOW Interactions	RxD: Respondent-centric Design, a Framework for Reducing Respondent Burden in Medical Self-report	Towards Improved Self-report Diaries: a Respondent-centric Design Approach	Usability Evaluation of NOW Interactions
Research question	How can interactions for self-report be shaped to establish a low-threshold communication?	How can the respondent perspective be incorporated into the self-report design process?	How can the proposed solutions be applied in a practical use-case to enhance the real-world respondent experience in self-reporting?	Can NOW Interactions impact respondent adherence in medical self-reporting?
Methods	Interaction design approach (+ methods from feasibility study)	A multi-phase research design (integrating narrative literature review and feature modelling for domain analysis, comparative analysis of self-report design methodologies, and application of framework to use case)	RxD Framework, (including comparative analysis, dogfooding, user feed-back, and usability tests)	Quantitative usability evaluation, engagement evaluations, semi-structured interviews
Participants	Students from feasibility study	Experts and expert user from expert interviews	Teachers from usability studies Expert and expert user from expert interviews	Teachers and students from usability studies

Chapter 4

NOW Interactions

This chapter presents the results associated with NOW Interactions, a tangible, mobile-based artefact designed to facilitate communication. Its primary aim is to enhance patient adherence and data accuracy in self-reporting activities, which are crucial in healthcare.

Self-reporting, despite its importance to healthcare, often faces obstacles such as busy schedules and illness-related symptoms, leading to inconsistent adherence, suggesting that there is a too high respondent burden (Short et al., 2022). This is further underlined by the challenges faced in current self-reporting practices, as captured in discussions with healthcare professionals across various specialties (see Table 4.1). These experts highlight concerns such as the difficulty of engaging patients in self-reporting due to illness symptoms and the risk of dropout when patients are faced with complex questionnaires.

NOW Interactions was ideated in response to these challenges, identified through a mental health interventions project. Collaborative discussions with psychologists and patients revealed a significant need for means to engage those struggling with participation. The design of NOW Interactions aimed to addresses this critical challenge of respondent burden by establishing a low-threshold communication channel leveraging technology. This approach is a response to the growing demand for innovative solutions in self-report data collection (Van Berkel et al., 2017).

During the research presented in this dissertation, the NOW Interactions prototype has been described and feasibility tested (Paper 1, Barendregt & Wasson, 2022), applied to the practical use case of redesigning a headache diary (Paper 3, Barendregt et al., 2024), and been subject to usability studies (Paper 4, Barendregt et al., in press). The next sections describe the NOW Interactions prototype, and present results relating to the studies.

4.1 Responding to NOW Interactions

The design of NOW Interactions prioritises immediacy and clarity. Each interaction is encapsulated within a single push notification that appears in the phone's notification centre. The notification is crafted to show the full message at a glance, without requiring the user

Table 4.1: Quotes from experts on challenges relating to self-report

Expertise	Quotes
Neurologist (Headache Diaries)	"Maybe the biggest challenge is to target the questionnaires or the application towards what you want to see" "There are different demands in the research field, and clinical field, and for patients" "Doctors want really short, clinical summarised information that they can take immediately into decision making." "If you're going to record something over years, then you need to make sure that patients do not get tired, you need to secure compliance over time." "Some patients are so burdened by their headache, that they do not have the capacity to write a lot of details when they do have the headaches."
ENT Specialist (Digital Pain Maps)	"When people are very sick, the threshold to use digital tools may be higher. It is a barrier for many to do things digitally, as it becomes too complex." "We use many questionnaires in clincal practice, and they are exclusively on paper." "In my practice, we typically use 4 or 5 forms that are all validated in Norwegian. However, one of the forms is so complex that many people have difficulty completing it. Other forms are very simple, but still, even though patients receive them by mail before their doctor's appointment, they either don't fill them out or don't bring them along." "There are many patients that do not undertand why they need to fill in these questionnaires, or they find the questions weird."
Psychologist (Internet Delivered Psychological Treatment)	"We include several questionnaires before, during, and after the intervention." "We are concerned all the time that we are burdening patients with too many questionnaires." "We have seen that people are not completing all interventions, and all modules. We do not know if it is the text, the content, or the questionnaires themselves, but we know it stops." "We are concerned all the time that we are burdening patients with too many questionnaires. But we have no data on which part makes it too much." "Maybe the reason we don't investigate non-responses more is because the mental health research community relies on certain gold standard questionnaires. To ensure our results are acknowledged by this community, we use these established questionnaires. Which is also why we are hesitant to modify them." "It is sad to say, but a lot of the things we have been doing is very much putting electricity on paper. We haven't taken new media fully into account." "I'm sure we can, as health personnel, be challenged to not always need 5 different parameters on every single thing. Maybe the most important thing is did you sleep okay or not?"
Statistician (Healthcare Research)	"People decide themselves if they want to participate or not, which makes the association of what you're looking for or are estimating biased." "When people start to fill out a survey, but suddenly drop-out because they don't want to do it or have no time, then you have missing data on lots of questions." "Questionnaires do not need to be validated. You collect the data that you're interested in." "What should you do with people that drop-out?" "I think people with some kind of disease or a condition, are more willing to comply with questionnaires."
Biological and Medical Psychologist (Stress Monitoring)	"When you use digital, you can't force people to answer. The risk is that they may drop-out of complete questionnaires if you force them to answer every question." "Compliance rate is areally big challenge, it takes quite an effort to get good data." "50% response-rate is considered fairly good in larger ecological studies, but in in smaller, more experimental studies, you want answers from everyone." "When you target a large population, where people just get a text message or an email with a link to a questionnaire, the compliance is generally really low. Within clinical trials, or experimental studies, the compliance is much better, because people have signed up."
Sleep Researcher and Neuro-Physiologist (Digital Sleep Tools)	"Why will people answer to self-report?" "We use mostly sensor data, not use much self-report questionnaires." "We help people understand their own sleep, their daily rythms, so we can teach them about how to sleep better." "We once attempted to use the Karolinska sleepiness scale, a validated questionnaire meant to measure various degrees of sleepiness. But the scale that people are supposed to use is something like a little sleepy, or somewhat sleepy, or quite sleepy, and then like 10 variations of this. This did not give any usable insights." "To use wearables in clinical settings, it is necessary to have a communication between the device and the study subjects"

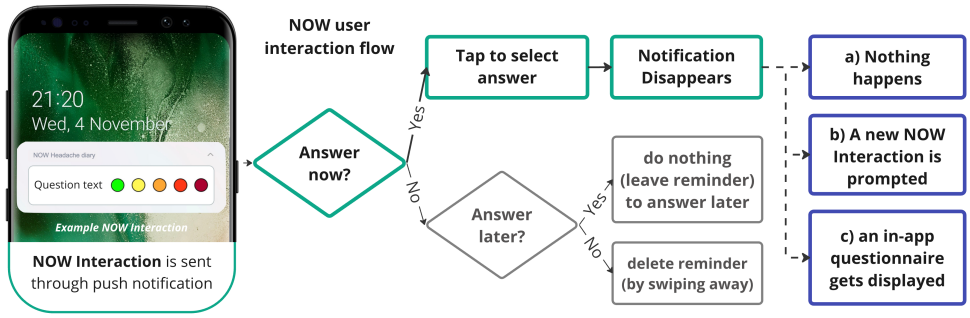


Figure 4.1: Reacting to NOW Interactions from a user perspective (Barendregt et al., in press)

to expand it to view the entire content. It succinctly poses a question and provides up to five answer options, displayed as icons (see screenshot in Figure 4.1).

A simple tap on one of the icons records the response and dismisses the notification. Then, depending on which answer was selected, the respondent goes on with their day, or a new NOW Interaction is displayed, or they could be sent to an inn-app location to, for example, provide more data. See Figure 4.1 for an overview of this process.

The NOW Interactions process is more straightforward than traditional methods that often require navigating to an app or browser to complete a questionnaire. The NOW user interaction model combines the inquiry and response into one swift interaction, significantly cutting down the user's time and effort. This model contrasts with traditional methods, where users must take several steps before able to register answers.

NOW Interactions facilitates a communication that benefits both respondents and initiators. The user interface of NOW Interactions is designed to persuade people to provide bits of information in a moment, at the right time, with minimal interruption of their current activity. This makes it easier for users to respond than to dismiss an information request, without even needing to open an application. The overarching idea is to maximise the amount of data collected, while having as few and as small interactions as possible; thus taking as little as possible energy and time from respondents.

4.2 Design Foundation

To establish a low-threshold communication, NOW Interactions condenses essential elements of self-reporting (the trigger, the question, and the response options) into a cohesive interaction. This enables a streamlined communication flow, allowing the user to immediately respond within the phone's notification centre. See Figure 4.2 for a comparison of NOW Interactions with traditional way. The fewer obstructions present during this process of answering to questions (read, comprehend, retrieve from memory, judge, and then match their answer to available options (Aday & Cornelius, 2006; Tourangeau et al., 2000)), the higher the chance of accurate and genuine reporting.

NOW Interactions leverages behaviour theory (Fogg, 2009), which suggests that tasks are

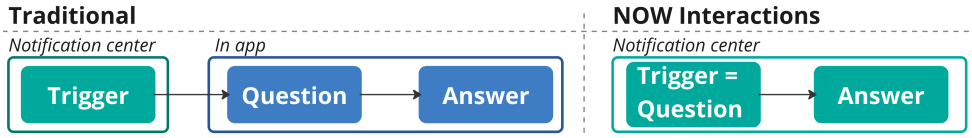


Figure 4.2: Comparison of traditional & NOW Interactions flow (Barendregt et al., in press)

most likely to be performed when motivation, ability, and trigger converge. The design emphasises ease of response, using the user interface to facilitate motivation and cater to the respondent's ability. This includes that responding to a request is made more convenient than dismissing the request, effectively making the act of participation the path of least resistance for the user (responding would be one direct tap, dismissing usually a swipe. By concentrating on the moment a respondent decides to act on a inquiry, NOW Interactions simplifies the decision-making process. Incorporating response options directly within the notification allows data to be provided at the same time as the trigger has drawn the user's attention. This approach transforms the push notification from merely being a reminder into a direct, actionable request, encouraging swift responses, without the complexity of navigating through in-app interfaces. This also increases the chance that the users flow of thought remains uninterrupted. Studies have shown that if the response time of a UI remains under 0.1 seconds, a person's flow of thought remains uninterrupted (Nielsen, 1994b, 2009). Eliminating the delay of opening an app, the user's focus is kept at the same place, minimising the chance of them altering their initial response or abandoning the task altogether.

NOW Interactions adopts a user-friendly approach by presenting a single inquiry at a time, breaking down the task of responding to multiple questions into more manageable segments. This aligns with the principles of *microinteractions* (Saffer, 2013), which advocate for simplifying complex tasks into smaller, less daunting ones. This segmentation ensures that even if a user is interrupted, the task remains approachable and less overwhelming. Additionally, if an interruption does occur, the notification remains visible in the phones notification center, ready to re-engage the user.

By integrating these design principles, NOW Interactions significantly reduces the time and effort required for people to respond to self-report requests, thereby enhancing the likelihood of task completion (Adams, 1963). This user-centric approach not only facilitates the collection of essential health data, but also aligns with the core objectives of interaction design (Preece et al., 2015). Ultimately, NOW Interactions is crafted to assist individuals in fulfilling their health reporting goals efficiently and effortlessly, embodying the essence of user-friendly design in healthcare communication.

4.3 The Prototype

The development of the NOW Interactions prototype was a collaborative effort with a software engineer at SLATE. It represents the culmination of a journey from initial concept sketches to a fully functional tool, reflecting both design and technical evolution.

Figure 4.3: One of the earlier designs for NOW Interactions (Barendregt & Wasson, 2022)

The initial paper prototypes and non-functional digital mock-ups served as the first tangible representation of the NOW Interactions concept. Discussing these designs, such as the one in Figure 4.3, with psychologists and patients allowed for gathering initial feedback on the concept and identifying potential challenges.

After establishing the potential of the NOW Interactions concept, the project progressed to developing the first functional version. This prototype, which was a significant step forward from the conceptual models, underwent feasibility testing as detailed in Paper 1 (Barendregt & Wasson, 2022). While this version already encapsulated the core user experience of receiving and responding to NOW Interactions, the later versions focused more on technical and administrative enhancements, including an in-app calendar giving users insight into their response patterns over time.

Transitioning from the early development stages to the present, the latest iteration of the NOW Interactions prototype is the embodiment of our initial concept, refined through on-

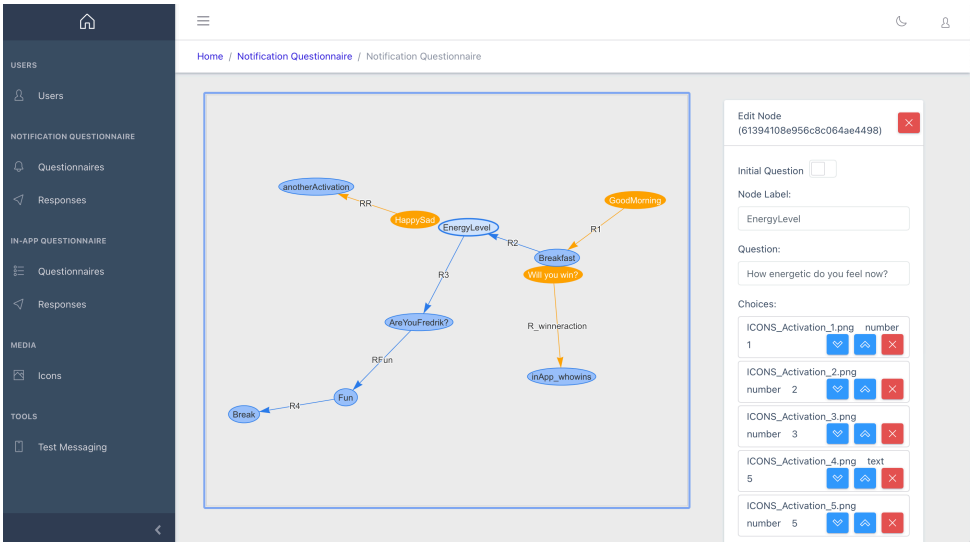


Figure 4.4: Administrative dashboard illustrating a dynamic questionnaire setup used in internal functionality testing

going feedback. This version, which was instrumental in the usability studies detailed in Paper 4 (Barendregt et al., in press), and integral to the development of a headache diary in Paper 3 (Barendregt et al., 2024), represents a refined culmination of our design and development efforts.

The core of the prototype is the ability to send interactive notifications, with responses recorded and saved seamlessly. These notifications, appearing in the device's notification centre, allow users to respond directly from the notification, bypassing the need to open the accompanying app. The latest prototype comprises three primary elements: an administrative dashboard, a back-end integrated with a database, and a native Android app.

- *Administrative dashboard*: The dashboard allows for customisation of notifications to align with unique requirements of different studies. It enables the precise scheduling of notifications, tailoring of questions, selection of response option icons, and the configuration of question logic. This functionality ensures that notifications can be specifically designed to meet the varied requirements of different studies, making it a versatile tool capable of adapting to diverse (research) scenarios. Figure 4.4 displays the administrative dashboard, showcasing a setup used in one of our internal tests.
- *Backend and database*: The backend and integrated database provide the infrastructure to manage user interactions, store response data, and facilitate communication between the Android app and the administrative dashboard.
- *Android app*: The native Android app serves as the means to deliver the NOW Interactions to users' notification centre. The app itself features a simple interface that includes a diary view of all answered questions and provided answers. This diary view provides users with a comprehensive overview of their interactions, allowing them to track their responses over time. Additionally, for research purposes, the app incorporates an in-app survey feature. This feature effectively links the data collected from NOW Interactions with additional survey data, making it a practical tool for both users and researchers.

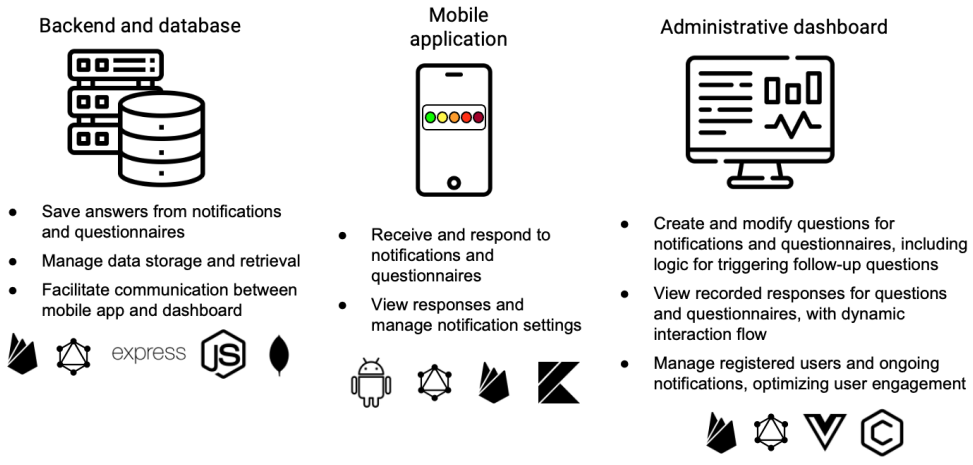


Figure 4.5: Prototype functionality overview and used software stack

Figure 4.5 illustrates the components of the prototype and their functionalities. The way the prototype is designed allows for flexibility in data collecting, enabling the design of custom questions and response evaluation logic. This means that depending on participants' responses, specific follow-up questions or actions can be triggered, enhancing the dynamic nature of the interaction flow. This ensures that no unnecessary questions are asked to users, tailoring the interactions to the specific situation at hand. As a result, the information exchange becomes relevant and efficient, enhancing the overall user experience.

Designing the notifications for the NOW Interactions prototype presented unique challenges due to the limited space available on Android's notification platform. To address this, each application of the prototype required careful selection and development of questions and corresponding icons, ensuring both clarity and space efficiency. The necessity for conciseness resulted in a division of the space into space for a short question and up to five answer options, displayed as icons to save space. Figure 4.6 illustrates how the available space was effectively utilised for individual NOW Interactions, showcasing the approach to balancing functionality with design constraints.

Figure 4.6: The design space for Android notifications & how it was utilised for NOW Interactions (Barendregt & Wasson, 2022)

4.4 Results from User Testing Feasibility Study

Paper 1 (Barendregt & Wasson, 2022) presents the concept of NOW Interactions as a communication technique to increase engagement to healthcare apps. The paper reports on a study aimed to assess the feasibility of using NOW Interactions for self-report data collection and to gauge user acceptance. It mainly focused on identifying potential technical challenges or complications with the prototype, especially in terms of interaction within a notification without the necessity of opening an app.

Following the outlined objectives (see Paper 1 Barendregt & Wasson, 2022) to explore the feasibility and user acceptance of NOW Interactions, the study adopted a practical approach. It involved engaging 24 high school students in a workshop for icon design and testing a low fidelity, paper version of the prototype. This was followed by hands-on testing phase with three participants over three days, complemented by semi-structured interviews, an app usability comparison, and engagement evaluations. The study faced logistical challenges, notably the limited availability of Android devices and restrictions due to the Covid-19 pandemic, which affected participant availability and the extent of hands-on testing.

The hands-on phase of the study utilised a specific application of the NOW Interactions prototype, focusing on the measurement of core affect, a key psychological construct reflecting people's feelings (Västfjäll, Friman, Gärling, & Kleiner, 2002; Västfjäll & Gärling, 2007). The prototype was set up to send a sequence of two NOW Interactions three times a

Figure 4.7: An example of NOW Interactions in the context of core affect, in Norwegian (Barendregt & Wasson, 2022)

day, each targeting either valence or activation. This setup was designed to test the prototype's effectiveness in a practical environment and its proficiency in collecting psychological data in an engaging manner. Figure 4.7 shows two of the NOW Interactions that were used during the study. For an in-depth explanation of how this measure was adapted and integrated into the NOW Interactions prototype for this user test, please refer to Paper 1 (Barendregt & Wasson, 2022).

A key result of this feasibility study was that the prototype successfully functioned for collecting data, and no major technical challenges were revealed. However, due to the low number of participants in the hands-on user test, an additional, informal, test with five participants was set up during an academic workshop. This supplementary test also confirmed the absence of significant issues, strengthening confidence in the technical feasibility of NOW Interactions.

In addition to the absence of significant technical issues, based on the interviews, engagement evaluations, and user test observations were carried out and key findings relating to the user acceptance of interaction through NOW Interactions were identified:

- *Direct engagement*: Participants valued the ability to engage directly via notifications, without the need to open an app.
- *Non-disruptive sequence*: The sequence of two questions was not perceived disruptive to participants.
- *Response time*: A reduction in response time was observed after the first set of questions. Follow-up interviews clarified that participants did not fully realise the variation in the question sets, instead, they focused on the icons.

4.5 Results Application to Use Case

In Paper 3 (Barendregt et al., 2024), NOW Interactions was applied during the redesign process of a headache dairy. In this use case, the redesigned prototype facilitated the registration of headache intensity and medication intake, providing users with a streamlined diary overview, as illustrated in Figure 4.8.

(a) Registering headache intensity

(b) Registering medicine intake

(c) Diary overview

Figure 4.8: NOW Interactions headache diary (Barendregt et al., 2024)

During the redesign process described in Paper 3 (Barendregt et al., 2024), the NOW Interactions prototype was subject to usability inspections and compared to the original, to be redesigned app Brain Twin and other headache diaries available on Google Play (See Table 1 in Barendregt et al., 2024). These inspections revealed a substantial reduction in the number of user interactions and the time required to report a headache. The prototype was further evaluated by a neurology professor and an experienced headache diary user.

The NOW Interactions prototype enables users to record headache intensity and medication intake through two consecutive interactive push notifications, requiring no more effort than two screen taps without the need to open an app. Figure 4.9 compares this process with Brain Twin, where logging similar data involved multiple steps. An estimation of the time taken for these steps in Brain Twin was around 15 seconds, which is threefold the time required by NOW Interactions. The comparative analysis indicated that alternative apps necessitate between 5 to 19 interactions for equivalent data entries.

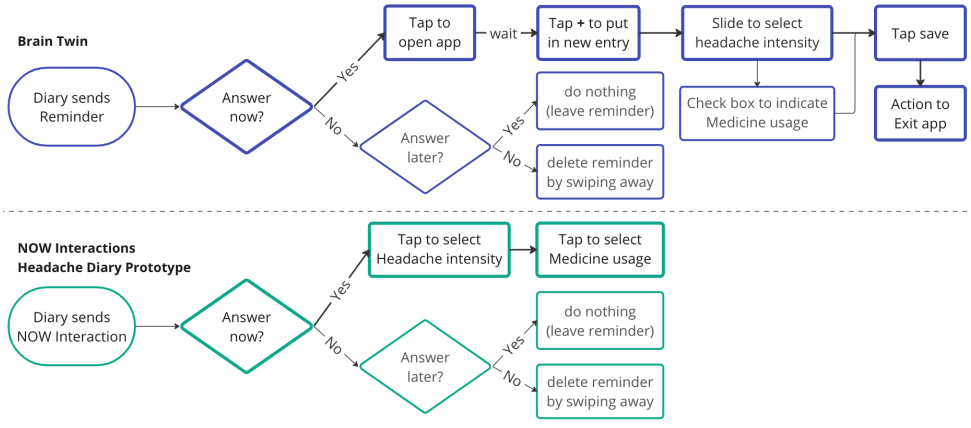


Figure 4.9: Comparison of processes to register a diary entry (Barendregt et al., 2024)

Expert evaluations provided external validation of the prototype's design. An experienced headache diary user praised the simplified interaction process, particularly the elimination of the need to navigate to, and open, an app for each data entry. Additionally, a neurology professor endorsed the prototype as particularly beneficial for chronic pain patients, who often require simplified methods for tracking health information. The professor emphasised the potential of NOW Interactions to facilitate brief, non-intrusive interactions that align with the needs of chronic pain management.

Further insights and detailed results from the usability tests conducted on this application of the prototype are presented in Paper 4 (Barendregt et al., in press) and are discussed in the next section.

Table 4.2: Overview of the usability studies (Barendregt et al., in press)

	Students	**Teachers**
Duration	1 week	2 weeks
Scenario	Group-defined scenario focusing on post-school sleep and energy levels.	Headache diary, tracking occurrences, severity, and whether medicine was taken.
Participants & Method	38 high school students in IT and media were introduced to NOW Interactions during a workshop. 11 students qualified for the digital user test, receiving 14-22 tailored inquiries throughout the week.	During an interaction design workshop, 13 teachers were introduced to NOW Interactions. 6 qualified for the user test, receiving 41-82 inquiries over two weeks.
TWEETS + interview	8 students answered to TWEETS, 6 participated in semi-structured interview	5 teachers answered to TWEETS, 1 participated in semi-structured interview

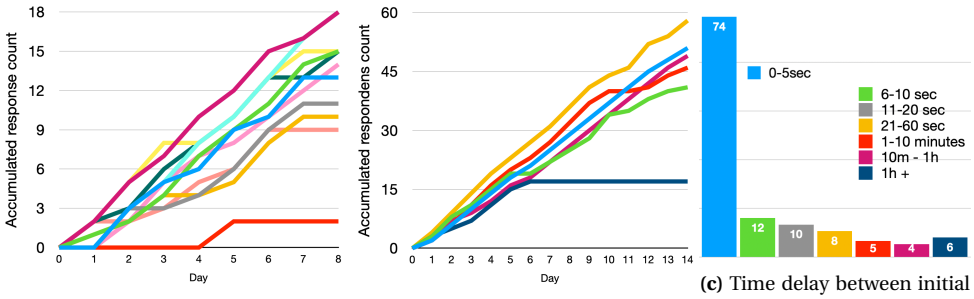
4.6 Results from Usability Study

Paper 4 (Barendregt et al., in press) presents the findings from two user studies evaluating the integration potential of NOW Interactions into medical diaries and health apps. These studies aimed to measure user adherence, experience, and acceptance through a multi-faceted approach incorporating quantitative usability tests, interviews, and TWEETS (Kelders & Kip, 2019) engagement evaluations.

The first study focused on a scenario relevant to high school students' post-school activities, examining their sleep and energy levels. The second study engaged teachers in a headache diary context. Both studies involved a predetermined number of initial NOW Interactions, which could lead to a secondary interaction based on the user's response. An overview of the study designs is summarised in Table 4.2.

Table 4.3: Overview of NOW notifications sent and answered (Barendregt et al., in press)

	Initial NOW notification			Secondary NOW notification			Total		
	sent	answered	%	sent	answered	%	sent	answered	%
Teachers (6)	246	181	74 %	84	81	96 %	330	262	78 %
Students (11)	154	102	66 %	38	38	100 %	192	140	72 %
Total	**400**	**283**	**71 %**	**122**	**119**	**98 %**	**522**	**402**	**77 %**



(a) Student responses **(b)** Teacher responses **(c)** Time delay between initial and 2ndary NOW

Figure 4.10: User response frequency and time delays for secondary NOW Interactions (Barendregt et al., in press)

Quantitative data from the usability tests showed a 77% response rate across 522 sent NOW Interactions. A deeper look into this data, as shown in Table 4.3, reveals a 98% response rate to secondary NOW Interactions out of 122 sent. Additionally, response time analysis showed that the majority of the secondary NOW Interactions was responded to within 5 seconds, see Figure 4.10c. There was consistency in use throughout the study duration, evidenced by the accumulated responses visualised in Figures 4.10b and 4.10a. Here, each line traces the response patterns of individual participants, showcasing the sustained engagement over time.

Semi-structured interviews and engagement evaluations provided qualitative insights into user perceptions, revealing a positive reception of the system's design regarding efficiency and simplicity. Participants across both studies rated the system highly for ease of use and indicated a strong likelihood of integrating it into their daily routines when envisioned in medical or health contexts.

Technical aspects surfaced as areas for further refinement. Participants reported occasional delays or missed notifications, which they attributed to their phones being in power-saving mode.

The *design of questions* and interactions received praise, particularly for the intuitive icons and manageable sequence of prompts. Icons used in the study are shown in Figure 4.11.

The *flow of secondary interactions* was commended for its efficiency. This aligns with the high response rate to these follow-ups and the quick turnaround time, often within 5 seconds. Most participants estimated that managing up to 3 to 5 consecutive interactions would be feasible.

Participants also reported *minimal disruption* and appreciation of the non-intrusive na-

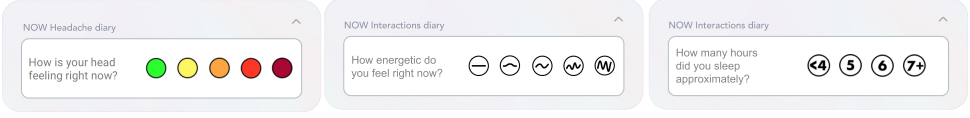


Figure 4.11: Different type of icons used in NOW Interactions (Barendregt et al., in press)

ture of NOW Interactions. The ease of responding without opening an app was frequently mentioned as a significant advantage over traditional methods.

4.7 Expert Feedback on NOW Interactions

Expert interviews conducted throughout this research have provided invaluable perspectives on the potential impact of NOW Interactions in the realm of medical self-reporting. each providing insights based on their specialised fields of expertise. The following is a summary of the expert opinions on NOW Interactions, with detailed quotes available in Tables 4.4 and 4.5.

- *Neurology Professor - Self-Reports for Mobile Headache Diaries*: The neurologist underscored the suitability of NOW Interactions for patients with chronic pain and headache disorders, noting the system's capacity for brief and non-intrusive data collection. The idea of a gatekeeper question to filter the necessity for further data was particularly well-received, as it aligns with the need for efficient patient screening in large-scale population studies.
- *Statistics Professor - Analysis of Self-Report Data*: The Statistics Professor praised the 'one question at a time' model for its potential to simplify a survey process and improve adherence, particularly when collecting data from respondents with medical conditions. They also acknowledged the need to test this interaction independently of its future applications, emphasising the importance of keeping in mind the ultimate needs of researchers and doctors when designing such tools.
- *Psychology Professor - Internet Delivered Psychological Treatment*: The psychology professor appreciated the design of NOW Interactions for its motivation and inviting approach, which could potentially improve patient compliance in psychological self-reporting. They stressed the importance of self-reporting without the need to log into an app and how personalised feedback could be used to motivate patients effectively.
- *Biological and Medical Psychologist - Stress Monitoring*: This expert saw NOW Interactions as a valuable supplement, especially for short questions such as 'How is your stress level?' and sees potential to combined with exercises for relaxation. She worries about using it for longer questionnares, but valued the NOW Interactions' ability to obtain data more often with timestamps.
- *Ear-Nose-Throat Specialist - Digital Pain Maps*: The ENT specialist recognised the potential of NOW Interactions to simplify the self-reporting process, which can often be a challenge for patients dealing with pain. She strssed that NOW Interactions will not be compatible with conditions like cancer or fibromyalgia, where constant awareness of pain can be negative. The specialist was optimistic about the potential benefits of NOW Interactions for postoperative recovery monitoring, such as after a tonsillectomy or hip replacement surgery. In these cases, NOW Interactions could serve as a valuable tool for patients and healthcare providers to monitor pain levels and adjust medication or interventions accordingly.
- *Sleep Researcher / Neuro-physiologist - Self-Reporting for Sleep Quality*: The sleep researcher emphasised the need for communication between wearables and users in

clinical settings, suggesting that NOW Interactions could facilitate this. They proposed exploring NOW Interactions for sleep guides and linking subjective perceptions of stress with physiological data, such as pulse or heart rate. The expert was eager to experience NOW Interactions first-hand and proposed a small trial just for her. Despite initial concerns about potential annoyance from frequent notifications, she found the daily responses over a week to be unintrusive and easy to manage.

The experts' feedback has been instrumental in refining NOW Interactions to better serve the needs of both healthcare providers and patients.

Table 4.4: Quotes from experts relating to NOW Interactions - part 1 (part 2 on next page)

Expertise	Quotes
Neurologist (Headache Diaries)	"First of all, I think that you are addressing a very important thing, and that is compliance." "Particularly patients with chronic conditions need to have sort of easy ways of registering. So I think that this is very good"
	"The idea of being able to interact very briefly, without requiring to sort of go into the application itself sounds very interesting."
	"I'm definitely sure that we can test this out on a headache patient population. I think it actually would be quite ideal for this patient population, either in clinics or in research, because in research, we might also need solutions, short interaction questions, to make it as easy as possible."
	"I think in most cases, it could be very good to have a gatekeeper question."
	"Let's say that you only want to get more information from patients that give red responses, then you haven't really wasted the time of the patients that do not have the red ones."
ENT Specialist (Digital Pain Maps)	"You could connect this with sensor data, to get the right timing."
	"Or use it for diaries for different conditions, like sleep or headache diaries."
	"For many questionnaires, the questions are built on top of each other. So if you have one question, then you have to follow with the rest. If you if you respond to one question in the morning, and one in the afternoon, it might not be as relevant."
	"When we ask patients to fill out sleep diaries about when they went to bed and when they got up, they ususly fill in the forms right before they go to the doctor. This could be a better way to fill in a diary, but you depend on knowing when they go to bed."
	"But still, if you if you get the question the next morning, 'when did you get up?' and 'when did you go to bed last night?' It's likely to be more accurate than if you filled in everything after a week."
	"Cancer patients have to be monitored several times a day… But you don't want them to focus more on their pain than they have to. So you don't want to promt them too much."
	"It might be a good idea for pain assessment for revalidating, because you might get a better profile over the day, how the patient is feeling. You want them to be able to move around, but you have to make sure the pain level is not too high."
	"After surgery on otherwise healthy people like tonsillectomy, where the goal is to have sufficient pain relief, so the patient is able to eat and drink, which greatly improves recovery time."
	"Also, if you are asked a couple of times, every day, during a week or so, the patient will be able to see the progress. 'Yes. See that? Things are getting better.'"
	"If the pain is too high over too long time, then you can show it to your doctor and say, 'Well, I am not getting enough pain relief', or 'I'm not healing the way I'm supposed to'."
Psychologist (Internet Delivered Psychological Treatment)	"Your diary thing is like instead of measuring the effect of the pill. That is the pill. I think is a very good idea."
	"I tried different kinds of apps, to try to run more, drink more water, relax more, etc., and I personally feel that reminders often remind me about what I haven't done…"
	"How we can we use these reminders in a motivating an inviting way."
	"I think there are many relevant use cases, it could help with motivation for exposure"
	"I think it would be very interesting for us when we start to develop the eating disorder app, on which we are working now."

Table 4.5: Quotes from experts relating to NOW Interactions - part 2

Expertise	Quotes
Statistician (Healthcare Research)	"You want to have the smallest possible interaction with them to comply with the information given. So I think it's a brilliant idea. It's fantastic if you can design something like that." "You designed a method to improve data quality and that they are complying to the instrument so they do not withdraw from the study." "I think this is a very good idea, because it's easier to respond to one and one question throughout the week or the day, compared to sitting down with a questionnaire to fill out. And you see, it's very boring to fill out on a web application. It's better to have one on one question like this, I think it's a very good idea. And it's very easy."
Biological and Medical Psychologist (Stress Monitoring)	"What is really cool about it, I think, is that you get more data, you can get data more often, and you can get the timestamp. So it's instead of 'How did you feel last week or last month?' 'How do you feel now?'." "Combining this with sensor data could be really cool in experimental situations. And also, if you get more timely data." "It's a different ballpark people when people need to answer tons of questions, but for this, 'How is your stress level?' Or 'Do you have muscle pain?' For those things I think it is a really good idea." "You could combine this with posititve feedback like 'Thank you, your data is so valuable. We appreciate your response', you know, appreciate your response." "Can we use this to provide stress exercises?"
Sleep Researcher and Neuro-Physiologist (Digital Sleep Tools)	"People might get tired of this. If it's just like, three, four things, that they can do, but if it's 10 things?" "It's really maybe exactly what the person needs, where you have your simple screen. But how long they will be willing to use this will depend on if it can help them improve something. You need to give personalised feedback, using their own data, to motivate them."

4.8 Chapter Summary: NOW Interactions

This chapter presented NOW Interactions, including its design foundations and the development of its prototype. It highlighted the application of NOW Interactions in a specific use case involving a headache diary and discussed the results from feasibility and usability studies.

Chapter 5

Respondent-Centric Design Framework for Medical Self-report

This chapter presents the Respondent-centric Design (RxD) Framework, designed to alleviate respondent burden by aligning clinical needs and patient perspectives during the self-report design process. The RxD Framework places the needs and perspectives of patients at the forefront, reshaping how healthcare data is collected and utilised.

The need for the RxD Framework arises from a significant disconnect between traditional medical self-report design practices and the actual needs and perspectives of respondents. The issues raised by healthcare professionals, as seen in Table 4.1, highlight this disconnect and the necessity of finding solutions for issues such as low compliance rates and complexity of self-report measures. While there has been plenty of information-centric approaches to self-report design, there is a notable absence of methods that adequately incorporate the respondent perspective. The RxD Framework addresses this gap by proposing an approach to the design of self-report to include unique contextual requirements and embracing the principles of patient-centric care.

During the research presented in this dissertation, the RxD framework has undergone several iterations during its development. It progressed from a simple setup applying an IxD process, to actively including patient-centric care principles. The RxD framework has been described and exemplified in Paper 2 (Barendregt & Wasson, submitted) and applied to the practical use case of redesigning a headache diary in Paper 3 (Barendregt et al., 2024). The next sections describe the RxD Framework, and the implications it had on the redesign of the headache diary.

5.1 Bridging Design, Self-Report, and Patient-Centric Care

The initial inspiration for the RxD Framework came from recognising the potential of new interaction technologies (e.g., mobile phones) and input methods such as NOW Interactions to transform self-reporting. However, during the exploration of how the effective use of such new technologies can be ensured, it was noticed that the traditional approach to

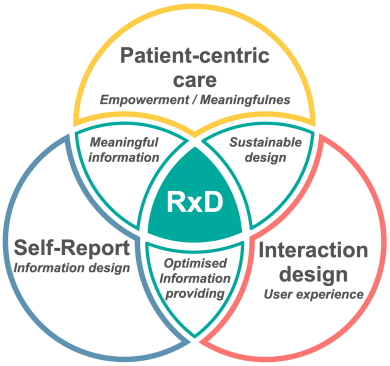


Figure 5.1: RxD, situated at the intersection of self-report, interaction design, and patient-centric care (Barendregt & Wasson, submitted)

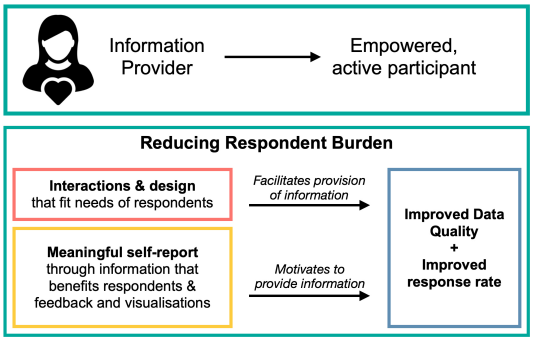


Figure 5.2: Conceptual model of reducing respondent burden through RxD (Barendregt & Wasson, submitted)

self-report design, primarily focused on information collection (e.g., question formulation and selecting response scales), was ill-suited for adopting these new interaction technologies and input methods.

It became increasingly clear during the research that conventional self-report design processes lacked sufficient focus on the respondent's perspective, a limitation highlighted in Figure 2.2. These traditional approaches, preoccupied with predetermined informational needs, limits the potential impact of IxD, as layout and user experience considerations are secondary to information demands.

Yet, while enhancing the self-report with improved interactions can lead to significant improvements for respondents, a greater opportunity lies in increasing the inherent value of the self-reporting activity. This transcends the mere provision of health data, aiming instead to enhance patient insight, understanding, and ultimately, empowerment, in line with patient-centric care (Bui et al., 2023; Doyle et al., 2013; McCarthy et al., 2016; Van der Wilt et al., 2015).

Acknowledging this potential, the RxD Framework emerged to be situated at the centre of self-report, interaction design, and patient-centric care domains. This placement, as visualised in Figure 5.1, reflects an all inclusive approach. In order to effectively integrate these elements into a cohesive self-report, the RxD Framework proposes that patient perspectives must be considered from the very beginning of the self-report design process. As illustrated by Figure 5.2, reducing respondent burden is addressed through implementing suitable interactions & design that fit the needs of respondents, which can support the facilitation of data provision, and increasing the meaningfulness of the self-reporting activity can inherently motivate respondents to actively participate. This approach, central to the RxD Framework, aims to transform patients from passive information providers to empowered, active participants.

The RxD Framework envisions self-reporting as a sustainable communication process that considers the needs of both clinicians (or researchers) and patients (see Figure 5.3). To facil-

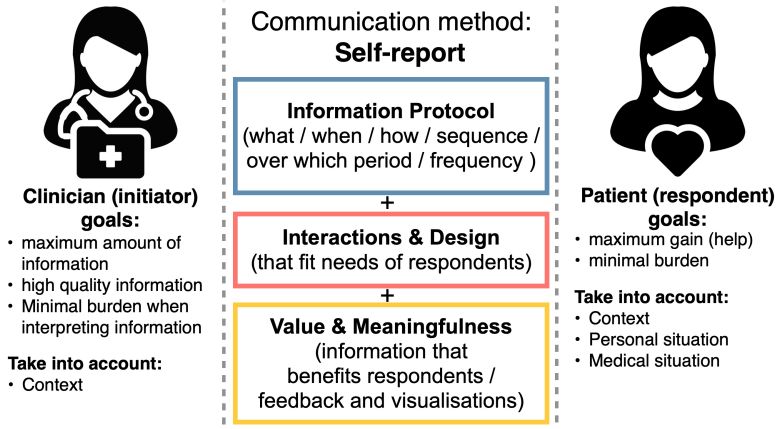


Figure 5.3: Self-report as a communication method situated between clinicians and patients (Barendregt & Wasson, submitted)

itate this communication, the framework employs strategies that 1) optimise information provision to meet respondent needs through tailored interactions and design, 2) empower respondents by increasing the meaningfulness of self-reporting through strategies for sustainability and timeliness, and 3) establish an appropriate information protocol.

This approach is driven by the idea that truly engaging patients in their healthcare extends beyond mere data collection. It involves understanding the context in which people provide data and providing them with insights and understanding. When self-reporting is meaningful and convenient to patients, they are more likely to provide data. This empowers patients, enabling patients to feel in control of their healthcare journey, which can significantly improve healthcare outcomes, making self-reporting a valuable tool in patient-centric care (Robbins et al., 2013; Wallace et al., 2023; Yeoman et al., 2017).

5.2 The Phases of RxD

The RxD framework is structured around a four-phased iterative process: Explore, Analyse, Align & Design, and Evaluate. Each phase, as represented in Figure 5.4, addresses different aspects related to information (info), interaction design (IxD), and patient-centric care (pcc). The phases assist self-report designers[1] in considering aspects of the respondents that can influence the properties the self-report should possess.

The overarching concept of the RxD Framework in designing self-report centres on an interplay between clinical information needs and design choices, while incorporating patient-centric care considerations. By leveraging technology and interaction design the information needs are aligned with to bring together the needs of clinicians and the preferences

[1]The term 'self-report designers' refers to individuals or teams responsible for creating and developing self-reports. This group can include for example, researchers, psychologists, healthcare professionals, IxD and UX designers, and software developers.

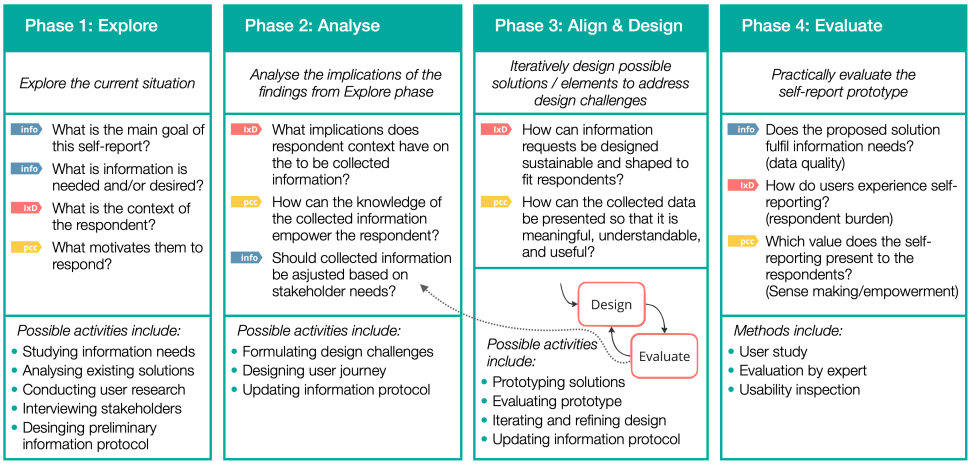


Figure 5.4: The four phases of the RxD framework (Barendregt & Wasson, submitted)

of respondents. The goal is to ensure that information requests are effectively transformed into actual provided data.

The first phase, Explore, delves into understanding the aspects about the current situation. This phase aims to address various overarching questions related to the purpose of the self-report, such as the main goal of the self-report, the desired information, the context of the respondents, and their motivation to respond.

The second phase, Analyse, focuses on evaluating the implications of the findings from the exploration phase. In this stage the goal is to assess the relationship between the respondent context and the information that needs to be collected. This phase addresses several critical questions, such as what implications the respondent context has on the to be collected information, how the knowledge of the collected information can empower the respondent, and whether the needs for the collected information should be adjusted based on stakeholder needs. During this phase, the primary activities are designing a respondent journey and formulating design challenges.

The third phase, Align and Design, entails the iterative design of potential solutions and elements, that best meet the needs and wants of clinicians and patients. This phase focuses on several key questions: how can information requests be designed and shaped to fit the respondents' needs, how can the collected data be presented in a way that is understandable and usable, and whether the needs and wants need to be adjusted or compromised. This phase includes an iterative process of design and evaluation, which may even revisit questions from previous phases, such as whether the collected information should be adjusted or compromised. This process involves prototyping, evaluating through dogfooding (using one's own product), gathering user feedback, conducting usability tests, and consulting domain experts. Iterating and refining designs based on evaluations gives a higher chance that the chosen solution will indeed meet both the clinical needs and the needs of respondents.

The fourth and final phase, Evaluate, involves testing the prototype to ensure it meets both clinical and patient needs. The following questions are answered: does the proposed solution fulfil the information needs in terms of data quality, how do users experience self-reporting in relation to respondent burden, and what value does the self-report present to the respondents in terms of sense-making. To answer these questions, various methods can be employed, such as interviewing users and experts, conducting user studies, and performing usability inspections. If necessary, the prototype can be further refined.

5.3 Results: Application in Use Case

To demonstrate the practical application of the RxD Framework, it was used to guide the redesign of the headache-diary Brain Twin, which is recommended by the Norwegian Directorate of Health. This process, including the methodologies and evaluation techniques used, is detailed in Paper 3 (Barendregt et al., 2024). And a summary of this process is also included in Paper 2 (Barendregt & Wasson, submitted).

The redesign process targeted specific areas of the headache diary where interaction design could substantially improve user experience and efficiency. The RxD framework was used to identify user needs, define design challenges, and conceptualise innovative solutions such as NOW Interactions, which directly addressed these challenges. Thus, it demonstrated the practical impact of the RxD Framework in a real-world healthcare application.

Phase 1: Explore
This phase involved a study of headache literature to understand the user context, followed by identifying main information needs through analysing of existing headache diary apps. It also included interviews with a neurologist and an experienced diary user, ultimately leading to the design of a preliminary information protocol.

The research revealed that headaches can impact cognitive functions, particularly when recalling past events. A comparative analysis of various apps, including Brain Twin, showed a common focus on logging headache intensity and medication intake (see Table 5.1. Feedback from both users and experts underlined the difficulties encountered in consistent diary entries and emphasised the importance of these features for clinical relevance.

Summary of the results from this phase:

- *Goal of Self-Report*: To collect information about headaches for diagnosis
- *Needed Information*: Occurrence, intensity, date, and medication use
- *Desired Information*: Duration, location, time, menstruation, additional details
- *Respondent Context*: Patients suffering from headaches; typically use diaries between general practitioner referral and neurologist consultation; use the diary during normal daily activities; use mobile phones for logging
- *Motivation for Response*: Desire to understand the causes of their headaches and potential influences

Table 5.1: Summary of comparative analysis of existing headache diary apps (Barendregt et al., 2024)

app + downloads *data as of 20th Dec 2023*	**rating + reviews**	**information**	**interactions: type + min amount to log intensity (incl open /exit app)**	
Brain Twin 10K+ d/l	2.9 (52 reviews)	- 10 intensities + no headache - medication intake / note menstruation / length / location	- reminder 1x a day - adjustable time - in-app registration	#5
Hodepinedagboken 10K+ d/l	4.2 (118 reviews)	- 3 intensities + no headache - medication intake / note - length / menstruation	- reminder 1x a day - adjustable time - in-app registration	#9
Migraine Log 10K+ d/l	4.3 (511 reviews)	- 3 intensities + aura only - medication intake / note	- no reminder - in-app registration	#5
Migraine Buddy 1M+ d/l	4.6 (55.6K reviews)	- 10 intensities + no pain - medication intake - still occurring + very many var	- reminder 1x a day - adjustable time - in-app registration	#19
*Headache Log** 100K+ d/l	4.4 (1040 reviews)	- 10 intensities - medication intake / note - duration / location + many var	- in-app registration * we could not download app	# ≈ 5
Manage my Pain 100K+ d/l	4.4 (3.73K reviews)	- 10 intensities + no pain - note + many var	- as many as desired - adjustable time - in-app registration	#5
NOW	N/A	- 4 intensities + no headache - medication intake	- 3x initiate interactions per day	#2

Phase 2: Analyse

This phase built on the previous phase by focusing on understanding respondent contexts and how these affect their ability to self-report effectively. It also explored the empowering potential of the collected information for respondents, and the need for adjusting information based on stakeholder needs. Key activities included designing a user journey, formulating design challenges, and updating the information protocol.

The analysis uncovered that existing registration processes were inconvenient, particularly for individuals experiencing cognitive difficulties due to headaches. This insight led to the identification of two key design challenges: 1) to ensure that the logging process is both timely and accurate, and 2) to simplify the logging process for enhanced ease of use.

Summary of the results from this phase:

- *Respondent Context Implications*: Challenges in self-reporting due to pain, attention, memory issues
- *Empowerment through Collected Information*: Ability to be able to self-report even while in pain, and precise insights into headache patterns for better condition management
- *Adjustment of Information Based on Stakeholder Needs*: Need differentiation between absence of headache and not registering

Phase 3: Align & Design

This phase focused on designing solutions that align information needs with patient preferences. It involved an iterative process of design and evaluation. The emphasis was on sustainable information requests and designing interactions that fit the needs of respondents. Strategies included optimising interactions, adjusting the information load to reduce respondent burden, and making sure the feedback visualisations provided accurate information. Iteratively prototyping and evaluating designs were key activities in this phase.

In response to the identified design challenges, the redesign incorporated NOW Interac-

tions, streamlining the process of diary entries to enhance efficiency and user engagement. This integration facilitated immediate headache or absence of headache logging, significantly reducing the likelihood of retrospective inaccuracies and improving the overall user experience with the diary.

Summary of the results from this phase:

- *Alignment of Needs and Preferences*: Focusing on most important needed information for short logging; allowing for in the moment logging.
- *Presenting Information in a meaningful way*: During data collection distinguishing between collecing of absence of headaches and non-reporting of headaches, and the diary visualisation reflecting this information
- *Prototype Features*: Simplified question formats, NOW Interactions for easy logging, focus on headache occurrence and intensity, correct visualisations of entries

Phase 4: Evaluation
This phase involved evaluating the redesigned headache diary in practice. Key activities included user studies, expert evaluations, and usability inspection. The focus was on data quality, respondent burden, and added value of the self-reporting process.

During the user test, participants used the redesigned headache diary over two weeks, responding to 78% of 330 inquiries. The redesigned process, requiring minimal effort with only two taps and no app opening, facilitated swift and straightforward logging. This method enhanced data quality by prioritising immediate reporting over retrospective reporting. The participants' feedback indicated a positive reception towards the simplicity and efficiency of the redesign.

Summary of the results from this phase:

- *Effectiveness of Solution*: Usability inspections revealed improved data quality due to the frequency of capturing data, along with more precise data through differentiating between the absence of headaches and non-registration. The prototype received endorsement from a neurologist during expert evaluation.
- *User Experience*: User studies, which included engagement evaluations and interviews, indicated a reduction in objective respondent burden due to fewer interactions and less time required than the original diary. There was also a reduction in subjective respondent burden, evidenced by positive feedback on the streamlined data entry process.
- *Value of Self-Reporting*: Although not the primary focus of the redesign, the correct diary overview enhanced the meaningfulness of the data, improving understanding and management of the condition, as indicated by the expert headache diary user.

More details about the usability of this headache diary prototype are detailed in Paper 4 (Barendregt et al., in press); the details have also previously been discussed in Section 4.5.

5.4 Chapter Summary: RxD Framework

This chapter presented the RxD Framework, situated at the intersection of interaction design, self-report, and patient-centric care. The practical application of the RxD Framework to the redesign of a headache diary, exemplifies its practicality, showcasing its ability to gain actionable insights to improve headache tracking.

Chapter 6

Discussion

The main goal of the research presented in this dissertation was to investigate how interaction design can be a means to enhance respondent experience in medical self-reporting. This challenge was addressed through four guiding research questions, which were answered through the development and evaluation of two artefacts: NOW Interactions and the RxD Framework. The results relating to these artefact have been presented in the previous chapters. In this chapter, the essence of these results is discussed and related to the research questions.

6.1 NOW Interactions: Facilitating Low-Threshold Communication in Self-Reporting

RQ1: How can interactions for self-report be shaped to establish a low-threshold communication?

This research question was addressed through the conception of NOW Interactions. NOW Interactions simplifies the communication process between patients and healthcare professionals by leveraging interactive push notifications on mobile devices, allowing patients to report health data efficiently and intuitively through-out the day. The essence of NOW Interactions is grounded in the principle that the easier it is to respond to information requests, the more likely it is to receive responses. Thus, by reducing the effort required for patients to engage in self-reporting, the likelihood of receiving timely and accurate health data increases.

The feasibility study conducted to assess the effectiveness of NOW Interactions confirmed the technical feasibility of the approach and highlighted the participants positive reception of engaging directly within notifications without needing to open an app. Furthermore, the study indicated the potential for sequencing NOW Interactions without causing disruption, as consecutive questions were not perceived as intrusive by participants. This demonstrates the practicality and user-friendliness of NOW Interactions and the potential for facilitating healthcare communication.

Later, these results were strengthened by the results from the usability studies. Participants were positive to using NOW Interactions to provide data, which was evidenced by the continued engagement over the study's timeframe by most participants. A quote from a participant in one of the usability studies:

> *"I liked the concept. It makes it easier to respond! I didn't need to respond, and if it was a day I didn't want to answer, I could just ignore the notification until tomorrow."*

6.1.1 Comparing NOW Interactions

While existing research mainly focuses on refining current methods and warning against bad practices, the call to explore how creative input methods and interactions on mobile platforms can benefit self-reporting (Van Berkel et al., 2017) has not gone unnoticed. Innovative solutions that explore how unique interactions on mobile platforms can enhance self-reporting are emerging. Notable among these are:

- *Unlock journaling*: Zhang, Pina, and Fogarty (2016) innovatively used the smartphone's unlocking mechanism for collecting user responses to brief queries. This approach cleverly transforms a routine action into a convenient opportunity for data collection.
- *Audio and Voice Input*: (Lenzner & Höhne, 2022) explored the growing trend of audio and voice input via smartphones. They identified this as a potential engaging format for mobile surveys, particularly resonating with younger demographics and experienced smartphone users.
- *Digital Manikins for Pain Mapping*: Ali, Lau, McBeth, Dixon, and van der Veer (2021) reviewed research using body maps as an interactive tool for localising pain. This method represents an innovative approach in pain assessment and reporting.

NOW Interactions shares similarities with Unlock journaling in its capability for frequent, non-disruptive inquiries throughout the day. However, by presenting requests through push notifications, NOW Interactions takes this a step forward and gives users the freedom to engage at their convenience.

Traditional methods such as SMS or standard push notifications often serve as mere reminders, posing the risk that respondents acknowledge the notification but still fail to complete the information request. NOW Interactions innovates this process by eliminating the intermediate step of acknowledging a reminder separately from providing a response. With NOW Interactions, if a notification is not immediately acknowledged, which is only possible by answering, it remains accessible in the notification centre, allowing respondents to provide an answer at a later time. This bridges the gap between reminder and action.

Unique characteristics of NOW Interactions include:

- *Flexibility*: NOW Interactions can be adapted for both single transactions and sequential questions, fitting various contexts and needs.
- *Immediate Engagement*: real-time data provision directly from notifications, without the need to open an app.

- *Inquiry Availability*: Unacknowledged notifications remain available, allowing later response without missing the opportunity.
- *Low Threshold*: Simplifies interaction, reduces effort, and increases likelihood of timely response.
- *Broad applicability*: Compatible with diverse tools and applications, enhancing its utility in different scenarios.

Through these features, NOW Interactions contributes by facilitating a communication that minimises respondent effort, thereby enhancing the ease and efficiency of self-reporting.

6.1.2 Design challenges

The design and implementation of NOW Interactions presented several challenges, primarily due to platform restrictions and inherent limitations in the design space for notifications. The Android platform was chosen in collaboration the software developer because of the greater potential for customisation compared to other operating systems, and more straightforward testing process. Androids push notification system, while capable of delivering interactive notifications, offers limited space. This constraint necessitates concise questions and answers, demanding a creative approach to both.

During the feasibility study (Paper 1, Barendregt & Wasson, 2022) traditional Likert scale questions were transformed into an icon-based format that fit within the restricted notification space; the activation icons shown in Figure 4.7 are an example. Results showed that participants understood these non-traditional icons without difficulty. Implementing other formats, such as sliders, was not possible, leading to the choice of icons. Regarding icon design, which was not the primary focus of our studies, the coulored icons depicted in Figure 4.8a were well-received by participants, even though they do not meet accessibility standards. Moving forward, icons need to be designed with accessibility guidelines in mind, incorporating distinct features to enhance clarity for all users.

Even though the maximum available space is used, the icons are slightly smaller than the recommended touch screen target area of $1cm^2$ (Parhi, Karlson, & Bederson, 2006). One participant commented on the icons being small, yet they also noted that using NOW Interactions is “better than other alternatives! It’s less stressful than having to open the app.” (Translated from Norwegian.)

The space limitation can also also pose challenges for question presentation. For complex questions, a possible strategy is to divide them into simpler, sequential inquiries. This adaptation maintains the straightforward nature of NOW Interactions while capturing the depth of information required. This can also address known difficulties in digital text comprehension (Delgado et al., 2018).

For instance the Insomnia Severity Index (ISI) questionnaire (Bastien, Vallières, & Morin, 2001) item: “How NOTICEABLE to others do you think your sleep problem is in terms of impairing the quality of your life?” can be split into two question for clarity and simplicity: “Do you feel your sleep problem impairs the quality of your life?” immediately followed by “How noticeable to others do you think this impairment is?”.

On the otherhand, to optimise interactions during the redesign of the headache diary (Paper 3, Barendregt et al., 2024), the question "How is your head feeling right now?" posed with five answer options. This approach allowed the differentiation between no headache and four levels of headache severity, capturing both headache occurrence and intensity in a single question.

In summary, the design of questions and response options for NOW Interactions required careful consideration of the platform's capabilities and limitations, emphasising the need for short questions and creative use of icons to fit within the constrained space of mobile push notifications.

6.1.3 Expert insights and feedback

The expert insights collectively suggest that NOW Interactions could be a transformative approach in medical self-reporting. Their feedback reflects a wish and a need for solutions that simplify responding to self-report inquiries, making the process more patient-centric and efficient, benefitting both clinical practice and research studies. One expert notably commended the concept:

> *"You want to have the smallest possible interaction with them to comply with the information given. So I think it's a brilliant idea. It's fantastic if you can design something like that."*

6.1.4 Summary

NOW Interactions represents a significant step in low-threshold communication for self-reporting. Despite design challenges, creative solutions were implemented to optimise user interaction. Positive feedback from experts and users underscores that NOW Interactions is seen and perceived as low-threshold and seen favourable over traditional approaches. One study participant noted: "Simple and straightforward. No need to open an app or remember a password. Just click, and you're done with that part." The insights and feedback gathered point towards exciting possibilities for future research and applications in healthcare.

6.2 RxD Framework: Incorporating Respondent Perspective

RQ2: How can the respondent perspective be incorporated into the self-report design process?

This research question was addressed with the development of the RxD Framework (Paper 2, Barendregt & Wasson, submitted), recognising the limitations of traditional self-report design processes that primary focus on the to information to be collected. The RxD Framework introduces a shift in approach by integrating the respondent perspective, considering their preferences for interaction with self-reports and enhancing the meaningfulness of the self-reporting activity.

By doing so, the RxD Framework aims to create self-reports tailored to patient needs, leading to benefits for both patients and healthcare professionals. Patients experience less burden in providing data and gain more control over their healthcare process through insightful self-reporting. This in return leads to more volume and accuracy in the provided data, which can be used to aid clinicians in making informed treatment decisions.

By proposing a design process that serves as a guide for self-report designers, the RxD Framework provides a tool that integrates the respondent perspective into every phase of development, leading to self-reports that better address the needs of both respondents and clinicians.

6.2.1 Interplay between information, respondent burden, and design

The RxD Framework capitalises on the interplay between information collection, design, and respondent burden by illustrating that improved design can lead to reduced respondent burden, and consequently, more effective data collection. However, improving design might not only alleviate respondent burden but also create an opportunity for clinicians to request more information without overwhelming respondents.

Medical self-reporting is used both in practice and research settings (e.g., Demetriou et al., 2015). While collecting lots of data can give a more complete picture of the studied phenomena (Van Berkel et al., 2017).

Medical self-report presents a balance between the need for comprehensive data and the burden this places on patients. When self-report is used for research purposes, researchers often would like to gather as much information as possible, in order to get a deeper understanding of the studied phenomena (Van Berkel et al., 2017). This may not always be feasible as the respondent burden that comes with a large information load may be too high for respondents to handle (Bradburn, 1978), resulting for example in non response or dropout, a concern reflected in the experiences shared by healthcare professionals in Table 4.1. The use of thoughtful design and interaction strategies can successfully be employed to lift burden from respondents, and may therefore allow for an increase in requested information load.

This perspective takes the position that the information load is a tangible element influenced by design and responsive to respondent needs. In some scenarios, the inclusion of specific information requests might even reduce respondent burden if it adds meaningfulness for patients, aligning with their interests or contributing to their understanding of their health condition.

Figure 6.1 conceptually represents this balance. It illustrates that with 'good design' such as lowering the threshold to respond, enhancing the respondent's experience, and increasing the meaningfulness of the task, more data can be collected while remaining an acceptable level of respondent burden compared to an 'average design'.

This suggests that investing in design quality can pay off in terms of the volume and quality of data that can be requested. The model challenges traditional approaches by emphasising the need for thoughtful design that respects the patient's capacity to provide data, leading to a more engaging and less burdensome self-reporting process.

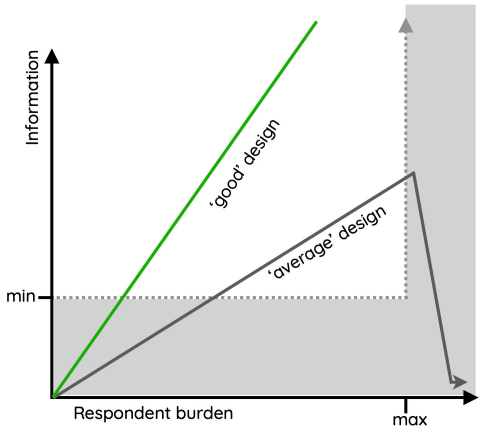


Figure 6.1: Representation of the interplay between information, respondent burden, and design (Barendregt & Wasson, submitted)

6.2.2 Comparing the RxD Framework

Traditional self-report design processes typically prioritise data collection objectives, often at the expense of user experience. This approach can lead to tools that seem efficient for researchers but still lead to challenges with adherence and compliance due to high respondent burden. In contrast, IxD in a broader context aims to enhance user interaction by focusing primarily on user experience and usability. The RxD Framework integrates principles of IxD processes into the specific context of healthcare self-reporting, and taking it a step further by aligning closely with patient-centric care principles.

This approach ensures that the design of self-reporting tools not only meets the data collection requirements of healthcare professionals, but also respects and addresses the needs and burdens of the patients.

In summary, characteristics of the RxD Framework include:

- *Focus on Respondent Perspective*: Unlike traditional self-report processes, which often prioritise data collection over user experience, the RxD Framework places the respondent's perspective and experience at the core of the design.
- *Focus on Patient-Centric Care*: The RxD Framework integrates patient-centric care principles deeply into the design process. This includes enhancing the meaningfulness of the self-reporting experience making the process empowering, helping patients to feel in control.
- *Balancing Information Needs with Respondent Burden*: The RxD Framework specifically targets the balance between information needs and respondent burden, ensuring the design process is both effective for data collection and considerate of the respondent's experience.
- *Adaptation to Healthcare Contexts*: The RxD Framework's approach to self-report design directly addresses the unique dynamics of healthcare reporting, emphasising that effective self-reporting benefits both patients and healthcare profession-

als. It addresses user experience holistically, considering the perspectives of respondents (patients) and the practical needs of healthcare professionals who use the collected information. This dual-focus ensures that self-reporting tools are not only user-friendly and meaningful for patients but also effective and reliable for medical decision-making.

Through these distinctive features the RxD Framework incorporates the respondent's perspective into the self-report design process. This contributes to the development of self-reporting tools that are not only efficient in data collection but are also considerate of the needs and experiences of patients.

6.2.3 Summary

The RxD Framework advocates for a fundamental shift in the self-report design process, steering away from an information-centric approach to an approach that prioritises respondent experience. By recognising the link between the quality of design and respondent burden, the framework suggests that a thoughtful and respondent-centric design can effectively lower the barriers to data provision. Switching from 'what information do we want?' to 'what data is feasible to collect, through which methods, and how can we make the process meaningful?' respects the respondent's capacity to engage in self-reporting and opens the door to richer data collection by making the process more valuable (Barendregt & Wasson, submitted).

6.3 Application to Practical Use Case

RQ3: How can the proposed solutions be applied in a practical use case to enhance the real-world respondent experience in self-reporting?

This research question was addressed through the practical application of both the RxD Framework and NOW Interactions in the redesign of a headache diary (Paper 3, Barendregt et al., 2024). By applying the RxD framework, actionable insights were gained to improve headache reporting, while the application of NOW Interactions in a real-world context illustrated its potential for integration into current healthcare practices.

Due to the research focus on enhancing the respondent experience, and considering the limited resources available for a full redesign, our efforts during this redesign process were concentrated on specific areas where interaction design could notably improve user experience and efficiency. The four phases of the RxD Framework, Explore, Analyse, Align & Design, and Evaluate (see Figure 5.4), guided the redesign, emphasising patient needs and defining design challenges. The design challenges focused on timely and accuracy to minimise errors stemming from memory issues and a simplified logging process.

A key aspect of the redesigned diary that addressed the design challenges was the incorporation of NOW Interactions to allow for swift and efficient logging of headaches, cater-

ing specifically to the needs of individuals experiencing headaches. The design process involved adapting question formats to fit the NOW Interactions format and a simple redesign of the diary view to visualise a more meaningful overview of the logged data.

Collectively, the application of the solutions showed that it is possible to apply these artefacts in a real-world practical use case and thereby enhancing respondent experience in self-reporting.

6.3.1 The redesign process with the RxD Framework

The application of the RxD Framework in redesigning the headache diary was useful to explore how self-reporting can be a more effective and meaningful activity for individuals experiencing headaches.

This involved identifying and addressing specific challenges such as attention and memory issues resulting from pain, leading to the realisation that there is a need for a self-reporting process that is both timely and accurate. By examining existing diaries, the process identified key areas for improvement, such as simplifying the logging process and enabling the distinction between non-reporting and the absence of headache.

The study focused on redesigning Brain Twin, an existing app which was developed in a collaboration between headache specialists and recommended by the Norwegian Directorate of Health. This provided a time-efficient way to apply the RxD Framework, as it allowed for a quicker identification of improvement areas while ensuring clinical needs are met.

While the redesign focused specifically on interaction design issues, the process using the RxD Framework highlighted the potential of RxD to design a headache diary from scratch. One insight that emerged was that current interfaces tend to emphasise certain information due to their immediate visibility, potentially leading to missing other relevant data that could contextualise the headache. The RxD Framework can be used to address such design challenges. Specific information needs are aligned with improved design strategies, logical structure, and personalised features.

Related to this, the interview with the neurologist highlighted the necessity for diaries to provide concise overviews tailored to clinicians, implying the need for different interface views for clinicians and users. This approach would allow for a more focused summary for clinicians, while offering users a more detailed and personalised view of their data, improving both utility for clinicians and engagement for patients.

The results of the usability inspections (Paper 4, Barendregt et al., in press, and Section 4.6) and expert evaluations of NOW Interactions (see Section 4.7) suggest that the prototype offers a promising addition to traditional headache diaries, prioritising user convenience and streamlined data reporting.

6.3.2 Using NOW Interactions for headache diaries

Using NOW Interactions in the context of the headache diary revealed its potential as a valuable tool for enhancing the self-reporting experience in this context. Feedback from both the neurologist and expert headache diary users, as well as test participants, was positive.

The neurologist particularly appreciated the potential of NOW Interactions for gatekeeper questions, which could streamline the reporting process for patients. The ability to add logic to these questions was seen as a way to respect the patients' time.

One participant, after using the NOW Interactions prototype for two weeks, felt that while the prototype alone was not sufficient for her needs in logging headaches, she was enthusiastic about the possibility of integrating it into a comprehensive headache diary. She suggested customising the timing and frequency of questions to better suit individual patterns of headache occurrences, highlighting the potential for personalised healthcare.

The expert headache diary user's enthusiasm about the NOW Interactions and her immediate response to start imagining how she could customise such notifications for her own needs was inspiring.

This feedback, combined with the results from usability inspections showing a reduced number of necessary interactions, reinforces the potential of NOW Interactions in practical applications such as headache diaries.

6.3.3 Good headache diaries?

There are many headache diary apps available on mobiles for personal use. There is, however, a growing concern regarding their lack of proper involvement from healthcare professionals during the design process. For example, Lalloo, Jibb, Rivera, Agarwal, and Stinson (2015) emphasise the urgent need for developing evidence-based apps to support patients in pain care self-management and testing their effectiveness.

While Hundert, Huguet, McGrath, Stinson, and Wheaton (2014) have proposed a comprehensive set of criteria for headache diaries, including expert involvement and clinical testing, these criteria unfortunately overlook the significance of user involvement. Although usability is considered through usability inspections making use of Nielson's heuristics, these heuristics are meant as "broad rules of thumb" (Nielsen, 1994a) and are not case-specific. They may not highlight specific user interaction issues that could hinder user interaction. Modern usability guidelines, such as those suggested by (Pribeanu, 2017), offer an approach that considers aspects such as cognitive load and minimal user actions, which are more aligned with modern interaction patterns.

For the next step in self-report design, it should be explored how heuristics like those of Pribeanu (2017) and Nielsen and Molich (1990) can be reshaped specifically for self-report tools and used together with the RxD Framework, to create an even more well rounded approach.

6.3.4 Summary

The application of the RxD Framework and NOW Interactions in the redesign of the headache diary has demonstrated their practical utility in enhancing real-world respondent experience in self-reporting. This approach gave insights in how the framework can contribute to the design process and how NOW Interactions could contribute to make headache diaries more suited to the needs of patients.

6.4 Adherence

RQ4: Can NOW Interactions impact respondent adherence in medical self-reporting?

NOW Interactions addresses the challenge of respondent adherence in medical self-reporting by establishing a low-threshold communication (Paper 1, Barendregt & Wasson, 2022). The core idea is that by simplifying the self-reporting process and making it less burdensome for users, it will be easier for them to adhere to information inquiries.

The potential of NOW Interactions to improve adherence was explored through its application in self-report scenarios, and conducting usability studies, interviews, engagement evaluations, and expert feedback (Paper 4, Barendregt et al., in press). The positive outcomes from these studies indicate that NOW Interactions are a promising solution for increasing patient adherence in self-reporting.

6.4.1 Comparing adherence

The comparison of adherence rates between NOW Interactions and traditional self-report diaries is challenging due to differences in study setups and the frequency of inquiries.

The usability study presented in Paper 4 (Barendregt et al., in press) focused mainly on the adherence to NOW Interactions. The 77% response rate to all sent NOW Interactions including those sent to participants who dropped in or out in the middle of the study illustrates promise for this approach. Other studies (e.g., Krogh, Larsson, Salvesen, & Linde, 2016; Seng, Prieto, Boucher, & Vives-Mestres, 2018; Tassorelli et al., 2008) measure adherence by days that received an entry, while in our user studies, participants often responded multiple times a day. In addition, taking into account that respondent burden is directly influenced by frequency of contact (Bradburn, 1978), the frequent inquiries through NOW Interactions could potentially affect adherence negatively. However, the high response rates and the feedback on NOW Interactions suggest that frequency was not perceived as a problem.

During the expert interviews, the statistics professor suggested to compare NOW Interactions with a paper based format. This led to an attempt to engage students without Android devices during the usability study with high school students (presented in Paper 4, Barendregt et al., in press), to use a paper version of the diary. Despite efforts to make the paper diary appealing (imagine a tiny booklet at creditcard format with the same design as NOW

Interactions), not a single student was willing to participate. This left the paper diary with some disheartening statistics. Still, even if it would have been possible to test a paper version, the potential for backwards logging, as pointed out by Krogh et al. (2016), would have complicated the measuring of adherence.

Lastly, a technical issue pointed out by multiple participants was the non-delivery of notifications when their phones were in power-saving mode, as exemplified by the student that dropped-in for answering to two sequential NOW Interactions, see Figure 4.10a. This issue substantially reduced the number of notifications participants could respond to, thus addressing this could significantly improve adherence rates.

6.4.2 Adherence to secondary interactions

Examining the response-rates to NOW Interactions (Table 4.3), a significant difference is noticeable between initial and secondary interactions. While initial NOW Interactions received a 71% response rate, secondary interactions, triggered by response to an initial interaction, received a 98% response-rate. This indicates that once a user engages with the initial notification, they typically also engage with the subsequent notification. This pattern, combined with the quick response time (see Figure 4.10c), underscores the effectiveness of NOW Interactions in maintaining user engagement and attention throughout this short sequence of inquiries.

This observation was reinforced by the participant feedback where most participants indicated that they felt they could manage 3-5 sequential notifications, suggesting a high level of user acceptance for this engagement pattern. This opens up the possibility of using NOW Interactions for more extended sequences or even complete questionnaires, thereby expanding the scope of its application in self-reporting contexts.

6.4.3 Summary

The results of the usability studies of NOW Interactions illustrate the potential for positively impacting respondent adherence in medical self-report. Not only do participants mention how easy it was to respond to NOW Interactions, the response-rates, especially those to secondary NOW Interactions, indicate potential to keep engagement and attention, which will be explored further in future studies.

6.5 Usability Testing in Healthcare

Ensuring that healthcare tools are usable and effectively serve their intended purpose is very important, as their functionality can directly impact patient care and health outcomes. Early usability testing plays a critical role in this context as it can help identify and address potential issues already during the design phase, in a safe test setting, ultimately ensuring

that the final applications are both efficient and user-friendly for both professionals and patients (Cassano-Piché et al., 2015).

During the studies presented in this dissertation, patient feedback was taken into account during interviews and ad-hoc feedback moments, however, for the planned usability tests, non-patients were used as participants. This approach was mainly to avoid putting extra burden on people already dealing with health issues, a view strengthened by the psychology professor's concern about overloading patients with questionnaires. Using non-patients allows for effective evaluation without jeopardising patient care (Cassano-Piché et al., 2015; Moran, 2019) and can give valuable insights (Krug, 2000).

However, the scenarios used during these usability tests aimed to represent realistic activities that participants might actually perform in real life, as advised by Moran (2019). The students were involved in designing their own scenario and teachers were selected because of their stressful jobs that could potentially lead to headaches, enhancing the chance of getting relevant feedback, despite them not being patients. In the latter, this strategy resulted in five teachers who completed the full testing period and reported experiencing headaches, emphasising the relevance of their feedback. The teacher that dropped out mid-study had not reported any headaches, thus most likely dropped out as it was not relevant for him.

Using non-patients also facilitated obtaining ethical approval through the universitys system for risk and compliance[1] for processing of personal data in research, as the study did not involve patients directly. Using patients would have required a substantially longer, more complicated process to obtain approval from the regional committee for medical and health research ethics.

In usability studies, small sample sizes are often sufficient to reveal significant issues (e.g., Krug, 2000; Nielsen, 2012). Our studies used varied test groups, including students and teachers, to assess NOW Interactions from different perspectives. This strategy, coupled with additional feedback from interviews and ad-hoc feedback sessions, allowed for broad understanding of user experiences and contributed valuable insights for future refinements. A notable ad-hoc feedback moment occurred during one of the expert interviews, where the interviewee expressed a strong interest in trying out NOW Interactions firsthand, leading us to setup a tailored, week-long study where she would answer a sleep-related question each day.

In summary, the approach of refining and optimising interactions first with non-patients strategically postpones patient involvement, aiming to minimise imposed burden and increasing the significance of patient feedback during clinical viability assessment in subsequent stages. This approach aligns with the RxD framework's emphasis on iterative design and feedback, underscoring the importance of establishing a solid design foundation before setting up more resource intensive patient trials, and subsequently clinical trials. Thus, the studies presented in this dissertation, while not establishing clinical validity, represent a crucial step towards refining the user interface and interactions, before advancing to patient trials, thereby, enhancing future trial reliability and minimising patient inconvenience.

[1] RETTE: `https://rette.app.uib.no`

6.6 Limitations

While the research presented in this dissertation offers valuable insights into enhancing self-reporting in healthcare through interaction design, there are several limitations that need to be acknowledged.

NOW Interactions artefact: Building the NOW Interactions prototype as a native Android app restricted the potential participant pool for studies, as it excludes users of other operating systems. This was especially noticed during the feasibility study presented in Paper 1 (Barendregt & Wasson, 2022), where only 3 of 21 participants owned Android devices. This Android-specific design also closed the door for possibilities for larger patient trials in collaboration with headache specialists, as during discussions they mentioned that it is difficult to select participants based on mobile device. Additonally, the usability studies presented in Paper 4 (Barendregt et al., in press) revealed problems with notification delivery. Though this problem might have been caused by the Beta testing facilitation app down prioritising notifications, it still negatively influenced the study's results.

While data security was a priority during the studies including adherence to data protection guidelines, further measures will be necessary when dealing with real patient data that could influence treatment decisions. Also, the potential visibility of incoming notifications on phones can raise privacy concerns, which was not extensively investigated. A possible solution to address such concerns involves allowing users to customise the timing notifications, such as avoiding work hours, to enhance privacy and control about their health situation.

The RxD Framework: The framework requires further validation through practical application by self-report designers and teams. This would involve an examination of the framework's effectiveness throughout the entire design process to asses its utility and impact in real-world self-reporting scenarios. While the RxD Framework's approach to self-report design may seem resource extensive compared to traditional processes, it is neccesary to start taking into account respondent perspectives to raise the value and sustainability of self-report. To make the application of the RxD Framework more time-efficient could involve creating a comprehensive overview that that outlines the implications of self-reporting for patients with specific conditions. This would require outlining how design and context considerations vary across different health scenarios. Additionally, developing tools for orchestrating self-reports, moving beyond traditional questionnaire tools, could enhance the process as there will not be need to develop new tools. A dashboard similar to the one developed for administrating NOW Interactions could serve as a start, as it allows to manage questions, timing, and logic, and interactions.

A possible limitation standing in the way of enhancing self-report practices through the RxD Framework and technologies such as NOW Interactions, is hesitance in certain research communities to modify validated self-report questionnaires, one of the most used assessment tools in clinical psychology (Demetriou et al., 2015). As explained by the psychology professor (See Table 4.1, this hesitance originates from concerns that modifications could jeopardise the acknowledgement of results. Such concerns can limit the adoption and influence of new methodologies aimed at enhancing respondent experience and data accuracy. Yet, the insights from the professor also mention the potential risk of 'electric-

ity on paper' which she sees as an outdated approach to data collection that does not fully exploit the capabilities of digital media. There is even an argument to be made that *not* updating standardised self-reports to the needs and contexts of respondents could lead to invalidation. Is it ethical to present mobile users who are for example known to find long, complex questions challenging Delgado et al. (2018) complicated questionnaires without making adjustments for clarity and accessibility?

Participants: Although discussed in the previous section, the particpant demographic and the size of the studies are seen as limitations. Testing with real patients would have added an extra dimension to this research, however, for reasons mentioned above, it was deemed best for the majority of the research to not burden patients with usability issues. As evidenced during the usability studies, non-patient participants also provided relevant data. Unfortunately, the Covid-19 pandemic restrictions severely hindered the recruitment of participants. However, as students were at school, the tests involving high school students could still be carried out, and additional participants were also recruited despite these challenges.

Chapter 7

Conclusions and Future Work

The research presented in this dissertation has explored how interaction design can be a means to enhance respondent experience in medical self-report.

The artefacts NOW Interactions and the RxD Framework have been introduced to address two current, high stake challenges in the field of medical self-report: reducing respondent burden and enhancing patient-centric communication. NOW Interactions aims to reduce respondent burden by addressing adherence, it leverages interactive notifications to establish a low-threshold communication to increase adherence to self-report. The RxD Framework aims to alleviate respondent burden by updating the self-reporting design process to include the respondent perspective.

Both artefacts demonstrate significant potential in enhancing the medical self-reporting experience by addressing respondent burden and facilitating a patient-centric communication. To further improve and extend these artefacts, there are many things in future work.

7.1 Contributions & Future Work - NOW Interactions

The NOW Interactions artefact contributes to both the healthcare application domain and the broader knowledge base of interaction design and user engagement. By shifting the role of mobile notifications from their traditional use as reminders, to serving as the primary interaction point and paving the way for instant reactions, make them particularly suitable for in the moment self-reporting.

Within the healthcare application domain, NOW Interactions represent a tangible, low-threshold mobile communication technique aimed at simplifying the self-reporting process for patients. This innovation leads to higher adherence and more consistent data collection, making it a versatile approach to addressing immediate practical needs. Additionally, the practical implementation of NOW Interactions to the specific use case of the headache diary, offers a situated implementation to address immediate problems in this scenario.

Beyond the healthcare application domain, NOW Interactions contribute valuable insights into interaction complexity reduction, a key factor in improving adherence to inquiries. By demonstrating how communication can be streamlined to encourage user engagement, NOW Interactions enrich the knowledge base of interaction design and user-centred design.

NOW Interactions is not envisioned as a stand alone tool, rather, it could be used as a valuable feature that could be integrated into, for instance, health diaries or interventions. Some of the concrete applications for NOW Interactions could include:

- *Gatekeeper Questions*: NOW Interactions can serve as an initial filter to determine if further in-app information or follow-ups are necessary.
- *Pain/Symptom Monitoring*: As a low threshold technique, it can help to monitor symptoms or pain levels, helping patients receive the right care based on their immediate feedback, or to follow symptoms to diagnose over time.
- *Low Threshold Engagement*: For instance through integration into cognitive behaviour apps, NOW Interactions can gently engage users with subtle questions about their day. Such interactions have the potential to pave the way for increased interaction with the app's main content.

This potential of NOW Interactions could be further enhanced by linking them with sensor data and personal preferences, optimising both the timing of the notifications and the overall user experience. Intertwining NOW Interactions with attention aware systems, which are known to minimise attention overload (Künzler, Kramer, & Kowatsch, 2017; Okoshi et al., 2016), can further reduce frustration. The future work for NOW Interactions includes several key areas:

- *Addressing Technical Issues*: Ensuring reliable notification delivery and developing a compatible version for iOS.
- *Improved Logic*: Exploring how the logic between questions can be enhanced, including the use of delayed secondary interactions.
- *Sequential Interactions*: Assessing the feasibility and effectiveness of using NOW Interactions in longer sequences or complete questionnaires for various use cases.
- *Icon Design*: Creating multiple sets of icons that comply with accessibility standards, particularly for users with problems such as colour vision deficiencies.
- *Customisation of Notifications*: Investigating users' preferences for personalising notification content and scheduling to enhance the relevance and timeliness of NOW Interactions.
- *Interplay with Sensors*: Exploring the interplay between NOW Interactions and sensor data to see how enabling attention aware and physiologically informed prompts can make self-reporting more meaningful and effective.
- *Integration within a Full System*: Exploring the use and utility of integrating of NOW Interactions within comprehensive self-report apps, particularly in collaboration with healthcare professionals to align with medical protocols and ensure clinical relevance.
- *Patient Studies*: Carrying out field trials with actual patients to evaluate the practical use and impact of NOW Interactions in real-world healthcare settings.

7.2 Contributions & Future Work - RxD Framework

The RxD Framework contributes to the healthcare application domain by addressing the disconnect between medical self-report design and the needs of respondents. By proposing a structured approach to aid self-report designers in incorporating the respondent perspective effectively into the self-report design process and thereby enhancing the relevance and ease-of-use of self-reporting, it contributes to both reducing respondent burden and the collection of higher quality data.

The framework is an instrument that contextualises the principles of user-centred design theory by applying them within the specific challenges of medical self-reporting, offering a comprehensive framework that aligns self-report design and respondent experience, within the realm of patient-centric care.

Realising the potential of the RxD Framework could set new standards in self-report tools for patient-centric healthcare. However, its transformative effects must be demonstrated across diverse scenarios and subjects to illustrate its impact on reducing respondent burden and enhancing data quality.

A first step in this direction requires applying the RxD framework in a multidisciplinary team comprising medical experts, developers, patients, and designers to create a comprehensive self-report diary from scratch, and evaluate the solution to make sure it truly meets the needs of all stakeholders. To make sure the RxD Framework's approach to self-report design is practical and sustainable it should be paired with self-report specific design heuristics and tools that facilitate the orchestration of questions, timing, and interaction techniques such as NOW Interactions.

The future work relating to the RxD Framework includes:

- *External Validation*: Having other teams test and apply the RxD Framework in their self-report design projects to gather broader feedback and insights. This includes observing their efforts to see how the guidlines can be more effective in assisting the application of the RxD Framework.
- *Case Studies*: Conducting case studies across diverse healthcare scenarios to showcase the RxD Framework's adaptability and impact.
- *Comprehensive Application*: Applying the RxD Framework to the full design process of a specific case to evaluate its effectiveness and impact on user experience and data quality.
- *Self-report Design Heuristics*: Creating specific design heuristics tailored to self-report contexts to aid in designing and evaluating solutions.
- *Enhancing the NOW Interactions Dashboard*: Exploring how the NOW Interactions administrate dashboard can be used together with the RxD Framework to streamline the design and implementation of tailored self-report tools.
- *Evaluation the Impact on Standardised Questionnaires*: Exploring the possibility of balancing innovative design in self-reporting while maintaining the integrity and comparability of research data, which is crucial when altering standardised tools.

7.3 Concluding Notes

Reflecting on this research journey, it becomes clear that NOW Interactions and the RxD Framework have the potential to transform the landscape of medical self-reporting. These artefacts represent a solid design for self-report interactions which are ready for patient trials, and a novel approach that meaningfully incorporates patient perspectives into the design process, enhancing utility and relevance of self-reports.

The enthusiasm and interest of experts, patients, and participants in exploring and adopting NOW Interactions underscores its potential for widespread application and impact. This research paves the way for further exploration, not only within healthcare, but also in other domains, such as education, where NOW Interactions could offer a fresh approach.

The research presented here is just the beginning of an exploration of how these innovations can impact self-reporting in healthcare. The administrative dashboard developed alongside NOW Interactions, which facilitates the orchestration of questions, responses, timing, and interactions, represents an interesting direction for exploration. Already facilitating the delivery and integration of NOW Interactions and simple traditional questionnaire functionality, the dashboard represents an example of how self-reporting can be customised to specific needs and contexts. Its potential for further development makes it a promising asset to use together with the RxD Framework.

As we look to the future, the potential of NOW Interactions and the RxD Framework to set new standards in patient-centric healthcare tools is both exciting and inspiring. These innovations hold the potential to enhance the quality of healthcare and most important, make a significant difference in people's daily lives, potentially making their days a little brighter.

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Appendices

Appendix A

Materials Feasibility Study

A.1 Icon design worksheet

This worksheet was used during the icon design session in the workshop.

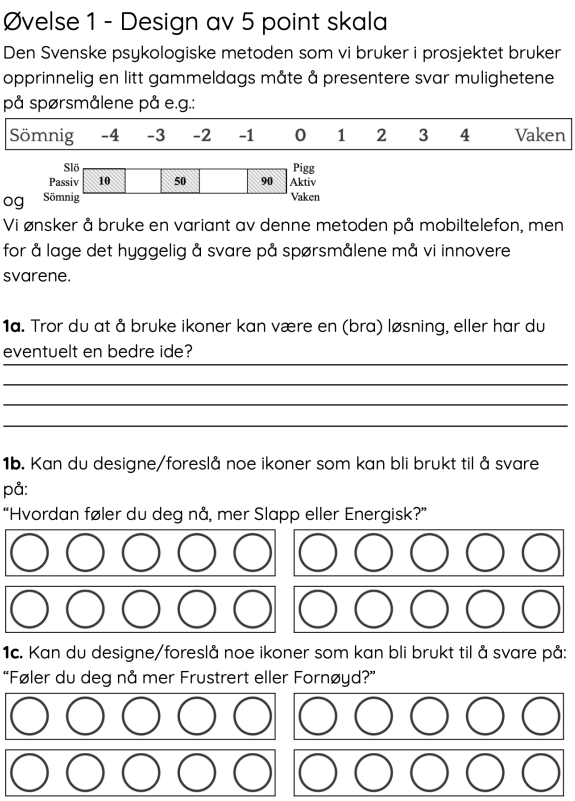

Figure A.1: Icon design worksheet

A.2 User test guide

This user test guide provided a structured approach for participants to interact with the paper prototype.

Brukertest Scenario og spørsmål / Åpen interview

Introduksjon
"Takk for at du vil vil være med i denne brukerundersøkelse!"
"Vi skal se på en funksjon av en app som er laget for folk som sliter litt og kanskje har vanskelige hverdager på grunn av stress eller psykiske problemer. Disse personer har behov for å følge med med hvordan de føler seg, og skal derfor tracke humøret sitt 3 ganger om dagen ved å svare på 2 spørsmål."

---- Vis appen i pop, eller vis **dine** screenshots på papir. Forklar hva skjer når de svarer.
(når de svarer på spørsmål 1, så får de et nytt spørsmål opp, og når de svarer på spørsmål 2, så forsvinner melding og kan de gå videre med dagen sin)

1. **Syns du at 'svar ikonene' passer til spørsmålet?**
   evt oppfølgingsspørsmål
   a. hva skjønte du ikke?
   b. hva hadde kanskje vært bedre?
   c. hvorfor syns du det var bra?

2. --- vis de forskjellige designs per spørsmål, evt på papir.
   Hvilke av ikonene likte du best og hvorfor? sammenlign de to designs

3. **Hva syns du om å svare på spørsmål på en slik måte?**
   a. **Syns du det var enkelt eller vanskelig å svare på denne måten?**
   b. **Hadde du likt bedre å bruke andre måter? fortel?**

4. **Hvis du hadde vært i en situasjon hvor det er viktig å svare på disse/slike spørsmål, tror du at slike interaktive meldinger kunne funke for deg?** hvorfor? hvorfor ikke?

Figure A.2: User test guide page 1

5. **Hva tror du krever mindre energi, å svare på en sånn melding eller å få en melding som åpner en app hvor du skal svare på disse spørsmål?**

6. **Hva tror du tar mindre tid, å fjerne den melding eller å svare på den?**

7. **Har du noe annet som du ønsker å si? eller har du noen spørsmål?**

Avslutning
"Takk for at du var med i brukerundersøkelse! Dine svar hjelper oss å komme videre i prosjektet, og etterhvert kanskje å gjør hverdagene til noen folk litt bedre!"

Til deg:
Hvilke ting la du merke til i testen? Hva er din konklusjon om testen, og app funksjonalitet? pga den brukertest, er det verdt å forske videre på muligheter her?
(tenk på utvikle funksjonalitet, eller andre områder?)

Figure A.3: User test guide page 2

A.3 App usability comparison & TWEETS sheet

Participants used this sheet to compare the usability of the NOW Interactions prototype with another app as well as the TWEETS answers.

Figure A.4: App usability comparison & TWEETS sheet

A.4 Semi-structured interview guide

This guide was used to conduct in-depth interviews with participants after they interacted with the NOW Interactions prototype.

Questions:

1. **Hva syns du om å bruke denne metoden for å svare på spørsmål?**
   a. hva likte du best med den?
   b. hva likte du minst med den?

2. **Opplevde du noe tekniske problemer med meldingene?**

3. **Spørsmålene du fikk var rettet mot folk som kanskje har vanskelige hverdager, kan du tenke på hvilke andre måter denne teknologien kunne bli brukt?**
   a. kanskje noen eksempler fra ditt eget liv?

4. **Hvor lang tid brukte du på å lese spørsmålene?**
   a. Hvorfor leste du ikke?
   b. Leste du spørsmålet eller så du bare på ikonene?

5. **Syns du at ikonene representerte hvordan du følte deg?**

6. **Var det greit for deg å svare på 2 spørsmål om gangen?**
   a. Synes du at det 2. spørsmålet kom kjapt nok?
   b. Tror du det kan være greit med flere spørsmål etter hverandre?
   c. Hvor mange spørsmål etter hverandre tror du kunne være max?

7. Synes du at denne måten å svare på spørsmål er for påtrengende?

8. Ved å svare på spørsmålene ble du forstyrret i de aktivitetene du gjorde?

Figure A.5: Semi-structured interview guide

Appendix B

Usability Studies

B.1 Adjusted Engagement Evaluations

Table B.1: Adjusted TWEETS Items, including average responses by the cohorts

Adapted TWEETS Items (translated from Norwegian)	**Relating to:**	**Students**	**Teachers**	**Combined**
If it was important for me to use a medical diary, this type of communication could become part of my daily routine	*Adherence + User acceptance*	4,63	4,60	4,62
This type of communication takes me little effort to use.	*UX*	4,25	4,80	4,46
It was easier to answer questions than to delete the notification.	*UX*	4,38	-	
I can use this type of communication to answer the questions.	*UX*	4,63	4,40	4,54
This type of communication made it easy for me to answer the questions	*UX*	4,50	4,80	4,62
If it was important for me to use a type of medical diary, I would enjoy using this type of communication.	*Adherence + User acceptance*	4,50	4,60	4,54
I like how easy it is to deal with the communication.	*UX*	4,25	4,60	4,38
This type of communication could fit me as a person.	*User acceptance*	4,25	4,20	4,23
Total:		**4,42**	**4,57**	**4,48**

B.2 Semi-Structured Interview Guides

Table B.2: Interview guide for participants of the usability studies

Section	Questions	Purpose
Introduction	Greet and thank the user for participating. Confirm consent to record the session.	Set welcoming tone and obtain consent for recording
General Feedback on NOW Interactions	What are your thoughts on using this method for answering questions? Which aspect of the method did you like the most? Which aspect did you like the least?	Gather overall impressions and likes/dislikes about NOW Interactions
Technical Aspects and Design	Did you encounter any technical problems with the messages? Were the visuals, including icons and text, clear and easy to understand?	Assess technical issues and evaluate visual clarity.
Interaction and Engagement	How long did it take for you to read the questions? If you skipped any questions, why did you choose to do so? Did you focus more on the question text or the icons? In your opinion, are the icons representative of the answer options provided?	Explore engagement, reading speed, and icon representation.
Frequency and Flow of Questions	Was it comfortable for you to answer two questions at a time? Did you feel the second question appeared promptly? Would you be comfortable with more consecutive questions? If so, what do you think would be the maximum number of consecutive questions?	Assess comfort with multiple questions and timing.
Disruption and Intrusiveness	Did you find this method of answering intrusive or too demanding? Were you interrupted in your activities by responding to the questions? How did you feel about answering the questions over a more extended period?	Evaluate intrusiveness and impact on daily activities.
Potential Applications	The questions you received were tailored for people facing challenging days. Can you think of other ways or contexts this technology could be applied? (*For headache diary users*: Which questions would you wish to answer if you had been instructed by a doctor to keep a diary for a month?)	Identify potential use cases and preferences for diary questions.

Appendix C

Expert interviews

Table C.1: Interview guide with medical experts

Part 1: Backround and Experience		
Section	**Description**	**Purpose**
Introduction	Greet and thank the expert for participating. Confirm consent to record the session. Brief introduction of the researcher and explanation of the research context.	To provide background information and set the stage for the discussion.
Expertise and Experience	Inviting the expert to share their experiences with self-report tools and diaries.	To understand the expert's background and their perspective on self-reporting in their field.
Compliance and Adherence	Discussing observations on adherence rates and challenges in self-reporting.	To identify common issues with compliance and understand potential areas for improvement.
Clinical vs. Research Settings	Comparing the use of self-report tools in clinical and research settings.	To explore how context affects the use and effectiveness of self-report tools.
Part 2: NOW Interactions Evaluation		
Section	**Description**	**Purpose**
Demo of NOW Interactions	Showcasing the functionality of NOW Interactions.	To demonstrate the tool being researched and its intended use.
Feedback on NOW Interactions	Soliciting the expert's feedback on the design and application of NOW Interactions.	To gather expert opinions on the potential effectiveness and usability of NOW Interactions.
Specific Use-Cases	Discussing how NOW Interactions could fit into current clinical practice.	To assess the practicality of NOW Interactions and explore potential implementation scenarios.
Catch-All	Space for any unanticipated topics or questions that may arise during the interview.	To ensure that the interview is comprehensive and allows for unexpected but valuable insights.

Table C.2: Interview guide with expert user

Section	Questions	Purpose
Introduction	Greet and thank the user for participating. Confirm consent to record the session.	To set a comfortable tone for the interview and ensure ethical research practices.
Background information	Which medical diary app have you been using to register headaches?	To establish context and identify the specific app the user has experience with.
Overall experience	How would you describe your overall experience? What was positive? Were there any negatives?	To assess the user's satisfaction and any potential issues with the app.
Frequency of logging	Did you log as often as you wanted? Did you ever forget to make an entry?	To understand the user's logging habits and factors affecting consistency.
Potential improvements	If you could change anything in the app, what would it be?	To identify user-driven improvements for the app.
Detail and content of entries	How detailed were your entries? What information did you provide?	To gauge the depth of information the user typically records and sees as relevant.
Timing of logging	When did you usually log your headaches?	To determine the user's approach to logging and how it fits into their routine or symptom experience
Demo of NOW Interactions	Let me show you a demo of a new registering method for headaches. What are your thoughts on this approach?	To introduce the expert user to the NOW Interactions concept and gather initial reactions and feedback.
Catch-All	Is there anything else you would like to share about your experience?	To capture any further insights or suggestions the user may have.
Closing remarks	Thank the user for their participation and discuss next steps.	To conclude the interview positively and explain how the feedback will be used.

Part II

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