Exploring the Feasibility of Digital Phenotyping for Mental Health Support in Cancer Survivors: A Qualitative Study

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Abstract

Cancer survivors often encounter difficulties such as anxiety, depression, and fear of recurrence, which negatively impact their quality of life. Although these difficulties are prevalent, survivorship care plans frequently neglect them. Digital phenotyping, which leverages data from smartphones and wearable sensors, facilitates continuous monitoring that enhances traditional mental health assessments by delivering insights into behaviours and symptoms. This can lead to timely and targeted interventions. Nonetheless, its successful implementation faces obstacles including the intrusiveness of continuous monitoring and data privacy concerns. Through semi-structured interviews, this study examines the use of digital phenotyping for real-time mental health monitoring in cancer survivors, highlighting key facilitators and barriers to its implementation. The results indicate that digital phenotyping has the potential to enhance mental health monitoring and therapy, contingent upon patient acceptability through security, utility, and ease of use. Despite being confined to a Dutch environment and dependent on self-reported data, the study offers significant insights into the integration of digital tools in survivorship care. Thus, it emphasises the necessity of patient-centred technology that guarantees privacy and delivers clear benefits. This insight is essential for enhancing digital health tools to more effectively assist cancer survivors globally.

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Exploring the Feasibility of Digital Phenotyping for Mental Health Support in Cancer Survivors: A Qualitative Study

Cancer survivors often experience substantial physical and emotional difficulties both during and after treatment (Carreira et al., 2018). Moreover, developments in treatment have resulted in increased longevity, augmenting the risk of long-term side effects and complications (Bodai & Tuso, 2015). Despite their prevalence, mental health issues such as depression, anxiety, fear of recurrence, and post-traumatic stress often go unnoticed (Wikman et al., 2013). The mental health challenges faced by cancer survivors can have a substantial effect on their quality of life and overall well-being (Ochoa et al., 2019). The extended lifespan of survivors underscores the enduring psychological consequences of their illness, which continue to exist long after physical recovery. This emphasises the need to incorporate mental health support into survival care plans (Alfano & Rowland, 2006). Addressing these needs is increasingly seen as a crucial aspect of cancer treatment, highlighting the emerging field of psycho-oncological care aimed at improving the quality of life for survivors.

Mental Health in Cancer Survivors

Despite physical recovery, the process of diagnosis, treatment, and remission often imposes a significant emotional burden (Ochoa et al., 2019). Cancer-related psychological suffering is multifaceted, encompassing feelings of uncertainty, fear, and isolation. For many patients, these emotions progress into clinical mental health disorders such as anxiety and depression (Benedict et al., 2022). Furthermore, cancer survivors are at a higher risk of developing mental health disorders compared to the general population (Lloyd et al., 2019). By examining a large cohort of cancer survivors over a 10-year period, they established that the prevalence of anxiety and depression was significantly higher in cancer survivors. This is specifically the case for survivors who have undergone intensive treatments such as chemotherapy or radiation therapy, as these treatments have been shown to intensify feelings of vulnerability and hopelessness (Mehta & Roth, 2015). Moreover, Ganz et al. (1993) identified various risk factors predictive of poor post-diagnostic coping and quality of life, specifically younger age at diagnosis, multiple life stressors, lack of social support, low sense of control, history of depression, and a hopeless or helpless outlook on life. These risk factors can substantially impact a cancer survivor's ability to cope with the emotional and psychological challenges, illustrating the importance of offering comprehensive support services to address these needs.

The stigma associated with seeking therapy further complicates the effects of mental health issues on cancer survivors (Holland et al., 2010). Individuals struggling with mental health issues may be disinclined to seek assistance due to a fear of judgement or misinterpretation from others (Matthews et al., 2003). As a result, this stigma may hinder cancer patients from accessing the support they need to cope with their mental health struggles, resulting in increased anxiety and decreased quality of life (Pan et al., 2023). Moreover, many survivors hesitate to address their mental health issues, perceiving them as secondary to their physical recovery (Fife & Wright, 2000). This can lead to a delay in receiving appropriate care, worsening the overall quality of life.

Acknowledging the stigma around seeking therapy, it is crucial to acknowledge that the mental health requirements of cancer patients may fluctuate over time (Harrison et al., 2009). This emphasises the necessity of ongoing mental health evaluations and personalised interventions that are responsive to the evolving requirements of each individual. The long-term psychological impact of cancer can be significantly reduced, and the overall quality of life for survivors can be considerably improved by providing tailored interventions (Willems et al., 2017). Tailored interventions can lead to improvements in coping strategies and overall mental well-being (Gautam et al., 2020). Furthermore, tailored interventions result in a significant increase in emotional and social functioning, alongside a reduction in depression and fatigue, when compared to standard care (Willems et al., 2017). Therefore, interventions must be responsive and adaptable in order to be effective. Interventions should incorporate regular mental health assessments and updates to treatment plans as a patient's psychological state changes (Faller et al., 2013). This approach addresses the direct psychological consequences of cancer as well as reducing the secondary effects of stigma associated with seeking mental health care.

Digital tools, like mental health apps and therapy platforms, that facilitate discreet and accessible psychological support have been proven to counteract the emotional burden from the disease and its treatment. Such digital tools effectively address higher risks of anxiety and depression, risk factors like lack of social support and control, and the stigma related to seeking mental health care (Bunyi et al., 2021). Digital tools have the potential to treat mood disorders both generally and specifically in the context of cancer care. The implementation of such tools has gained popularity in recent years (Yevdokymova, 2024). Online therapy facilitates greater accessibility and flexibility when seeking mental health treatment, particularly for individuals who might have difficulty attending in-person meetings due to various reasons like stigma, physical limitations, geographical constraints, etc. (Van Der

Vaart et al., 2014). Moreover, online therapy has demonstrated comparable effectiveness to traditional in-person therapy in numerous instances, making it a significant alternative for individuals seeking mental health care (Lin et al., 2021). For instance, meta-analytic research demonstrated that online cognitive behavioural treatment (CBT) effectively addresses several psychological disorders, including depression and anxiety (Andersson & Cuijpers, 2009). This digital therapy has demonstrated outcomes equivalent to traditional face-to-face therapy while also enhancing accessibility for people encountering obstacles in conventional therapeutic environments. Further, internet-based psychological therapies demonstrate considerable effectiveness across various demographic groups and psychological conditions (Barak et al., 2008). This underscores the value of digital tools in both general and specialised settings, including cancer survivorship care. In addition, online therapy offers a sense of anonymity and privacy, alleviating the stigma often associated with seeking therapy (Moore et al., 2016). Overall, online therapy provides a convenient and effective alternative for cancer survivors seeking mental health support. It can facilitate access to care and offer a beneficial environment for individuals who may be hesitant to seek assistance in traditional settings.

Digital Phenotyping and Mental Health Support

As digital tools like mental health applications and therapy platforms gain popularity, digital health is expanding with breakthrough technologies like digital phenotyping. Digital phenotyping presents a significant opportunity for the objective and passive monitoring of mental health in real time (Onnela & Rauch, 2016). Digital phenotyping measures and analyses physiological and physical behaviour using smartphones and wearable sensors (Perez-Pozuelo et al., 2020). Therefore, this technology allows continuous monitoring of health markers that were previously only measured through sporadic clinical visits or self-reports, which are typically biased (Pratap, 2019). Thus, digital phenotyping can help identify mental health issues early by revealing people's behaviours (Birk & Samuel, 2020).

By analysing data on health parameters like sleep, physical activity, social interactions, and smartphone usage, healthcare professionals can gain a deeper understanding of patients' mental health and well-being (Moura et al., 2022). Actionable sensing enhances these benefits by providing real-time and actionable feedback based on the data collected (Vaidyam et al., 2019). Actionable sensing, an advanced concept within digital phenotyping, facilitates adaptive interventions tailored to the individual’s current mental state and health patterns (Adler et al., 2024). These interventions often align with Just-In-Time Adaptive

Interventions (JITAIs), which deliver support precisely when it is needed, based on triggers identified through continuous monitoring (Nahum-Shani et al., 2016). For instance, a JITAI might recommend relaxation exercises or therapeutic prompts during periods of heightened anxiety, enhancing the responsiveness and relevance of mental health care (Vaidyam et al., 2019) This real-time adaptability fosters proactive health management and promotes patient engagement by offering quick, personalised interventions that respond to evolving needs (Mohr et al., 2017; Perez-Pozuelo et al., 2020).

Digital phenotyping argues that continuous monitoring and analysis of digital traces can provide mental health insights that traditional diagnostic methods cannot (Onnela & Rauch, 2016). The process begins with the raw data gathered from smartphones, wearables, and other connected technologies, which track movement, location, communication patterns, among other factors. Digital phenotyping tools use advanced algorithms and machine learning techniques to identify patterns and abnormalities that align with symptoms of mental health issues (Mohr et al., 2017). For instance, sleep and physical activity changes may suggest depression, while social interaction changes may indicate anxiety or social phobias (Choi et al., 2024). These patterns are vulnerable to within-person variability, underscoring the need for personalised digital phenotyping (Onnela, 2020). This makes it difficult to balance continual monitoring with privacy and autonomy. Developing and implementing digital phenotyping technologies requires considering how much data to obtain and what patients are prepared to provide. Thus, if privacy and autonomy concerns are addressed, digital phenotyping can improve the monitoring and treatment of psychological ailments including depression, anxiety, and stress (Onnela & Rauch, 2016).

The success of digital phenotyping relies on its capacity to deliver real-time, continuous insights on patient behaviour and mental state while maintaining privacy (Mohr et al., 2017). Digital phenotyping is in the early stages of development within mental health care, yet it offers advantages over traditional episodic assessments, which can overlook symptom changes and the context of behaviour changes (Pratap, 2019). Digital phenotyping promises personalised and proactive mental health monitoring and therapy that adapts to an individual's evolving mental health situation. Due to the focus on physical health during treatment and recovery, cancer survivors' mental health needs may be overlooked or devalued (Oudin et al., 2023). Using digital phenotyping to monitor and detect behavioural changes in cancer survivors can help close this gap.

Digital phenotyping has significant promise to improve traditional mental health

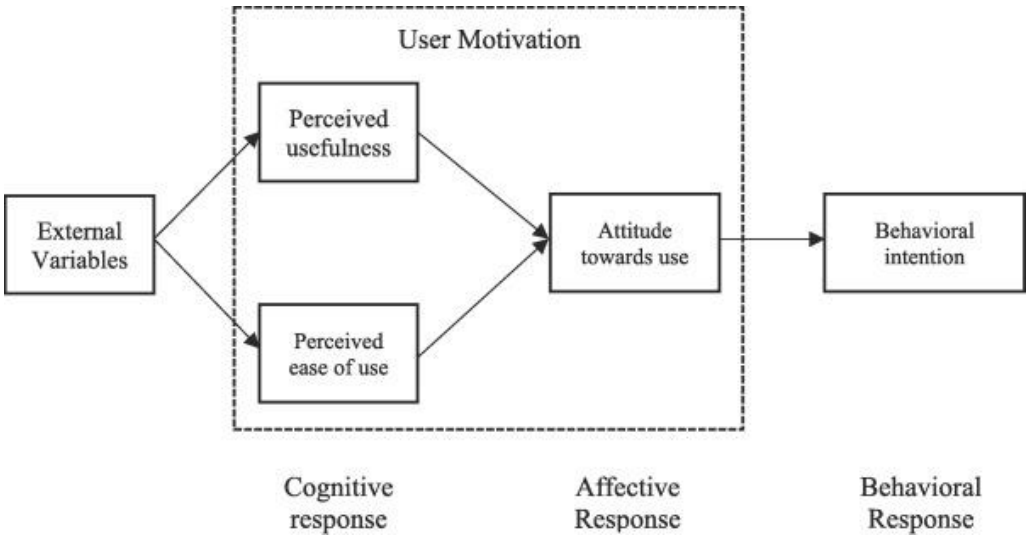
interventions. Digital phenotyping may improve mental health care for cancer survivors (Birk & Samuel, 2020). It may help reduce stigma and the difficulty of attending in-person therapy (Volpe et al., 2024). Digital phenotyping can also improve mental health early identification and intervention (Tekin, 2020). By continuously monitoring behavioural data, it helps those in need receive care before they ask for it. Consistent feedback and monitoring enable proactive treatment of physical and mental health, which could improve patient habits using digital phenotyping (Perez-Pozuelo et al., 2020). Traditional therapy paradigms can become more preventive, customised, and accessible with this combination.

Acceptability of Digital Phenotyping

The successful implementation of digital phenotyping to enhance the mental health of cancer survivors is contingent upon its feasibility, particularly in terms of acceptability. Acceptability is the degree to which the stakeholders, in this case cancer survivors, view a new intervention as appropriate, acceptable, or satisfactory (Bowen et al., 2009). Acceptability in the context of technology has been widely studied. Accordingly, Davis (1989) developed the Technology Acceptance Model (TAM). This model has been one of the most influential in understanding technology acceptance, identifying perceived ease of use and perceived usefulness as two key factors of an individual's intention to use new technologies (see Figure 1). Despite its widespread application, the TAM has faced criticism that it oversimplifies the complex implementation of technology acceptance (Shaw et al., 2018). Critics argue that the TAM fails to adequately account for external factors, including social pressures, individual attitudes towards technology, and situational constraints, which may significantly impact the adoption process (Venkatesh & Bala, 2008). Hence, it may not adequately address the complexities of human behaviour (Taherdoost, 2018). Critics further argue that the TAM fails to consider the affective responses users may experience towards technology, such as excitement or anxiety, which can significantly influence acceptance (Partala & Saari, 2015). Yet, the TAM remains a useful general framework and aligns with several studies examining the factors that influence an older individuals' intentions to use new technologies (Braun, 2013).

Figure 1

The Technology Acceptance Model



Acceptability in the context of digital phenotyping encompasses a variety of factors, such as cancer survivors' willingness to use digital devices for mental health monitoring, the technology's perceived utility, and the degree of comfort patients feel disclosing their data (Pratap, 2019). Therefore, for an intervention to be effective, it must not only be technically feasible but also acceptable to the target population (Yardley et al., 2015). This involves assessing the emotional and psychological readiness of cancer patients to utilise digital phenotyping tools (Partala & Saari, 2015). Therefore, collaboration with the target group is essential when developing mental health interventions to ensure that the digital phenotyping tools are relevant and impactful for this specific population (Huckvale et al., 2019). This highlights the importance of considering user perspectives and preferences in the design and implementation of digital phenotyping interventions for cancer survivors. Thus, thoroughly examining factors such as willingness, perceived utility, and degree of comfort ensures that digital phenotyping aligns with the needs and preferences of the patients, effectively enhance survivorship outcomes and overall well-being.

Nevertheless, while digital health tools are generally well-received by cancer patients, there are potential barriers to their widespread adoption (Alruwaili et al., 2023; Blagec et al., 2016). For cancer survivors, concerns about privacy, data security, and the intrusiveness of continuous monitoring may hinder the acceptability of digital phenotyping (Mendes et al., 2021). Even though data protection regulations like the General Data Protection Regulation (GDPR) have been implemented to safeguard data, there is still a lack of trust in the security measures of digital health platforms (Paul et al., 2023). Moreover, cancer survivors'

experiences with mental health conditions may shape their attitudes toward using technology in their care (Rossen et al., 2020). Those who have experienced long-term psychological distress might be more open to innovative approaches that offer continuous support, while others may be hesitant, preferring traditional in-person therapy, these differences can stem from personal preferences, past experiences with mental health care, or trust in the efficacy of digital phenotyping tools (Huckvale et al., 2019). Conversely, certain traits may make individuals more receptive to digital phenotyping. Individuals who are more likely to accept digital phenotyping often exhibit certain traits or are in circumstances that make this technology particularly appealing or necessary (Onnela, 2020). Factors that increase the likelihood of acceptance include a high level of comfort with technology, positive attitudes towards innovation in healthcare, and a perceived benefit that digital monitoring can offer more personalised and timely care (Onnela, 2020). Additionally, those who have experienced chronic conditions or require continuous health monitoring may see more value in such systems due to their potential to provide ongoing support and early detection of complications (Albrechta et al., 2024). These factors contribute to the growing demand for and acceptance of digital phenotyping in the healthcare industry.

Expanding Applications of Digital Phenotyping in Oncology

In the context of mental health, digital phenotyping has been extensively studied among populations suffering from chronic mental health disorders such as depression and bipolar disorder. Several studies have demonstrated how digital tools can effectively monitor mood variations and detect early signs of depressive episodes by analysing patterns in smartphone usage, mobility data, physical activity, and sleep (Brietzke et al., 2019; Wang et al., 2018). These studies highlight the effectiveness of continuous, real-time monitoring for predicting and detecting mental health episodes before they escalate, thus enabling timely interventions and personalised treatment plans (Tekin, 2020).

However, the application of digital phenotyping within the oncological setting, particularly for cancer survivors, remains underexplored. Cancer survivors face unique psychological and physical challenges post-treatment, including the fear of recurrence, existential concerns, and the mental health burden associated with intensive treatments like chemotherapy and radiation (Lloyd et al., 2019; Mehta & Roth, 2015). These complexities demand tailored mental health interventions that address both their fluctuating psychological states and the long-term effects of cancer treatment. The continuous monitoring capabilities

of digital phenotyping could play a critical role in managing these challenges by offering personalised support and early detection of mental health issues.

To address this gap, the current study investigates the acceptability, barriers, and facilitators associated with adopting digital phenotyping for mental health care among cancer survivors in the Netherlands. It aims to explore how these tools can be integrated into survivorship care to better accommodate the evolving mental health needs of this population. In order to accomplish this objective, the following research questions have been developed:

RQ 1: What are the perceived barriers and facilitators to implementing digital phenotyping for mental health support among cancer survivors in the Netherlands?

Sub-RQ 1.1: To what extent are cancer survivors willing to adopt digital phenotyping?

Sub-RQ 1.2: What are the specific barriers that cancer survivors perceive when considering the use of digital phenotyping for mental health monitoring?

Sub-RQ 1.3: What facilitators do cancer survivors identify that could promote the integration of digital phenotyping into their healthcare routine?

Sub-RQ 1.4: How effective do cancer survivors believe digital phenotyping is in detecting early signs of mental health deterioration?

Sub-RQ 1.5: What role does digital phenotyping play in the personalisation of mental health interventions for cancer survivors?

Methods

Qualitative Approach and Research Paradigm

This methodology section adheres to the Standards for Reporting Qualitative Research (SRQR) (O'Brien et al., 2014). This study employs a qualitative research approach using semi-structured interviews conducted in individual sessions to explore the perceptions of Dutch cancer survivors regarding digital phenotyping. The research follows an interpretivist paradigm. This paradigm best studies the complexity of human thoughts and behaviours in their natural environments. It stresses the necessity of viewing phenomena through the participants' eyes and acknowledging that people make meaning from their experiences. This paradigm aligns with the study's aim of examining how cancer survivors perceive and ascribe meaning to digital phenotyping in their mental health care, recognising that personal history, culture, and social connections influence these perceptions (Creswell & Poth, 2024).

Researcher Characteristics and Reflexivity

The primary researcher is a bachelor student of the programme Psychology at the University of Twente. The researcher has prior experience in health-related qualitative research methods but no direct professional experience in oncology or digital phenotyping. Reflexivity was maintained through regular supervisory guidance, which enhanced the credibility of findings by addressing potential biases.

Sampling Strategy and Context

The study was conducted as an optional activity for cancer survivors from the Netherlands who have completed their treatment and are navigating the challenges of survivorship with previous or ongoing psychological struggles. A purposive sampling strategy was employed to recruit participants with diverse experiences. Inclusion criteria required adult cancer survivors (18+ years) fluent in Dutch, who have received mental health care services due to psychological distress related to their cancer treatment and were willing to discuss their mental health and experiences with digital phenotyping tools. Inclusion criteria pertaining to cancer status required a diagnosis of any cancer type occurring within the previous five years. These inclusion criteria allowed for a broad representation of individuals with varying cancer experiences and ensured that participants had recent and relevant experiences with both cancer and mental health care services. Exclusion criteria ruled out individuals undergoing acute psychological distress that could worsen through participation. Sampling continued until data saturation was reached with a total of 10 participants. The decision to include two additional participants beyond the intended sample size of 10 was made to ensure comprehensive representation. This approach aligns with Guest et al. (2005), which suggests thematic saturation typically occurs within 10 interviews.

Interviews were conducted remotely via Microsoft Teams to ensure accessibility and convenience for participants. The interviews were scheduled at the convenience of the participants. Each session was expected to last approximately 45-60 minutes. The use of Microsoft Teams also ensured secure storage of recorded data, adhering to confidentiality standards.

Ethical Issues Pertaining to Human Subjects

Ethical approval was obtained from the Ethics Committee of the Faculty of Behavioural, Management, and Social Sciences at the University of Twente (Approval No. 240928, November 25, 2024). Informed consent was obtained from all participants before

their involvement. The consent form detailed the study's purpose, procedures, potential risks, benefits, and participants' rights, including confidentiality and anonymisation measures (see Appendix A).

Data Collection, Processing, and Trustworthiness

Data was collected through recorded semi-structured interviews conducted in Dutch. Data collection lasted from October 4 until October 11, 2024. The interview guide, developed based on Charron et al. (2023), included open-ended questions about participants' attitudes toward digital phenotyping, perceived benefits, and barriers. Prompts were used to encourage elaboration and clarify responses (see Appendix B). As the interviews were conducted in Dutch, the interview guide was translated into Dutch to ensure clear communication with participants (see Appendix C). Real-time transcription tools and external recorders ensured data accuracy and security.

Post-interview, participants were debriefed to address any concerns and ensure their comfort with the process. Transcriptions were anonymised, with unique codes assigned to each dataset. Anonymised data were stored on encrypted servers accessible only to the research team of the University of Twente.

To enhance trustworthiness, an audit trail documented all research decisions and data changes. Regular supervisory meetings were conducted to review the research process and findings. During these sessions, the supervisor provided feedback to ensure the accuracy and validity of the research. The feedback helped to address any potential errors or biases in the research, and suggestions for improvement were discussed and implemented. Additionally, the supervisor's guidance ensured that ethical considerations were carefully considered throughout the research process.

Data Analysis

Thematic analysis was conducted using ATLAS.ti software (version 25, ATLAS.ti). A charting technique (Onwuegbuzie et al., 2009) was used to capture the diverse perspectives and engagement levels of participants. Theoretical realism guided the analysis, valuing participants' subjective opinions without inferring hidden motives (Maxwell, 2008). This approach is crucial when analysing acceptability, as it values subjective opinions inherently. Realism also suggests that part of making an intervention acceptable may involve clear education about aspects of the intervention to the participants. Codes were iteratively refined

and grouped into broader themes that captured the facilitators and barriers to the adoption of digital phenotyping.

Although one researcher conducted the coding, a subset of the data was recoded by the researcher to ensure inter-rater reliability. This process involved comparing the initial coding with the recoding to identify any discrepancies and resolve them. Iterative refinement of the codebook helped ensure accurate representation of themes. Findings were contextualised within existing literature to highlight how they aligned or diverged from prior studies.

Results

The final sample included 12 participants, consisting predominantly of females, with a gender distribution of 83.3% female and 16.7% male. The participants' ages ranged from 32 to 68 years, with an average age of 51 years. Each participant was a cancer survivor, having been diagnosed with various types of cancer including breast, ovarian, skin, prostate, and lung cancer. The years since diagnosis varied from 1 to 5 years, while the years since treatment completion ranged from 1 to 4 years. This provides insights into both short-term and long-term treatment experiences. The use of digital phenotyping tools varied, as three out of twelve participants reported using such tools (see Table 1).

Table 1

Demographics of Patients Included in Study

Participant ID	Gender	Age	Type of Cancer Diagnosis	Years Since Diagnosis	Years Since Treatment Completion	Usage of Digital Phenotyping
P1	Female	52	Breast Cancer	3	2	No
P2	Female	46	Breast Cancer	5	3	No
P3	Female	35	Breast Cancer	2	1	Yes
P4	Female	42	Breast Cancer	5	4	No
P5	Female	58	Ovarian Cancer	4	3	No
P6	Female	38	Skin Cancer	1	1	No
P7	Female	55	Breast Cancer	4	2	No

P8	Male	68	Prostate Cancer	3	2	No
P9	Female	50	Breast Cancer	2	1	Yes
P10	Female	32	Breast Cancer	4	2	Yes
P11	Male	65	Lung Cancer	5	3	No
P12	Female	62	Breast Cancer	4	4	No

The thematic analysis revealed nuanced perspectives on the integration of digital phenotyping in managing mental health after cancer treatment. Key themes emerged around the acceptability, concerns, and potential benefits of digital phenotyping, each supported by direct quotes from participants. Several subthemes were also derived (see Table 2).

Table 2

Overview of Themes

Theme	Subtheme	Quotes
Acceptance and Utility	Continuous support	"I think that digital phenotyping would provide a sense of security knowing that someone is always looking out for me."
	Early detection	"Having access to such tools could potentially prevent relapses in the future, which is reassuring."
Barriers	Data privacy	"I am quite concerned about who will have access to my data and how it could be protected."
	Security	"Hacking and data breaches are becoming more common, so I do not know if I would trust such tools as the data is really sensitive."
	Technological barriers	"I often already struggle with simple functions on my laptop or phone, let alone if I were to use digital phenotyping tools. The tools should be really user-friendly for me to be able to use them."

	Lack of trust in accuracy	"I would rather not use a tool if I do not know how reliable it is. What if I receive inaccurate information and I make decisions based on that?"
Perceived Benefits	Understanding of health patterns	"Having access to real-time data about my mental health could empower me to take more control over my own well-being and make informed decisions about my treatment."
	Timely interventions	"I believe that if my therapist could see such data, they can alert me to potential issues."
	Personalised healthcare	"If timely updates are sent to my psychologist, my therapy sessions could focus more on my specific needs."

Acceptance and Utility

The first theme captures participants' perceptions of digital phenotyping as a beneficial tool for continuous support and early detection of mental health issues after cancer treatment. It reflects the value participants place on tools that can enhance their sense of control and provide reassurance during their recovery.

Continuous support through digital phenotyping was highly valued by participants, who appreciated the constant monitoring it offered. This continuous support is seen as a means to mitigate the uncertainty and anxiety associated with post-treatment phases, where physical visits to healthcare providers can decrease. P1 expressed: *"I am open to using these tools because they give me a sense of control over my health that I didn't feel I had during chemotherapy."* P2 added: *"It would be reassuring to know that there is continuous support available even after treatment ends."* Many participants shared this perspective. The consensus among participants was that digital phenotyping could offer a sense of security and comfort in knowing that their mental health is being monitored even after the conclusion of treatment.

Early detection is another critical aspect highlighted by participants. They recognised the potential of digital phenotyping to identify health issues before they become severe, thus facilitating timely interventions. P5 stated: *"Having something like this could help catch any*

issues early on before they become too overwhelming." P9, who already made use of a smartwatch, shared how digital phenotyping tools helped manage their health: *"The information provided about my sleep and activity levels helped me manage my anxiety better. Most days that I feel anxious I can trace it back to not sleeping well or not exercising enough. Now, when I feel anxious, I more often make some time to relax or go for a walk."* Moreover, P10, who utilises a mental health app, stated how this helped them identify patterns in their mood fluctuations and allowed them to track their progress over time. P10: *"I found that by tracking my mood daily, I was able to see what factors were contributing to my low moods and make changes in my daily routine."*

In addition, a significant concern expressed by participants throughout the interview was not merely the challenge of discussing their mental health with others, but rather their difficulty in identifying the signs and symptoms, as well as determining the appropriate assistance or resources to seek. P4 stated: *"Most of the times I do not even know that my mental health is deteriorating until it becomes overwhelming, and then I do not know the best steps to take as most psychologists have a waiting list."*

While many participants saw significant benefits in digital phenotyping, there were also concerns about the over-reliance on technology, which some felt could not fully replace human interactions. P8: *"I believe that relying on technology for mental health monitoring may overlook important nuances that can only be picked up in person. Human connection and empathy are crucial for me and digital phenotyping feels like it would be a cheap substitute for genuine human interaction."* Still, several participants acknowledged that technology could offer valuable data and insights that traditional monitoring methods might overlook. P7: *"While I value face-to-face interactions, technology can offer unique benefits in mental health monitoring. Maybe a balance between the two approaches would be most effective as this combines the personal touch of in-person interactions with the efficiency of technology."*

Barriers

This theme concerns the significant challenges identified by participants regarding the adoption of digital phenotyping tools. These include concerns over data privacy, security, technological usability, and the trustworthiness of health data, all of which represent significant challenges to the wider acceptance and use of these technologies.

Data privacy emerged as a crucial barrier, with participants expressing apprehension

about the intrusiveness of data collection methods and the sensitivity of the information collected. Concerns mainly focused on the consent process, the clarity of data use, and the control individuals have over their own information. P11: *"This is very sensitive data that should be handled with care."* P4 shared similar concerns: *"I feel uncomfortable sharing such personal information if it is not clear how it will be used or protected."* Thus, participants emphasised the significance of establishing unambiguous guidelines for the use and protection of their data. Therefore, privacy is about the right to control and consent to data use, focusing on respecting and safeguarding user autonomy and confidentiality in the handling of personal information.

Security concerns were centred around protecting data from external threats such as unauthorised access, breaches, and hacking. These concerns are about safeguarding data integrity and preventing unauthorised access that could undermine user trust in digital phenotyping tools. Participants highlighted the need for robust security measures to protect their information. P9 stated: *"My main worry is who else is seeing the information about my health."* Some were also worried about the vulnerability to hacking. The increasing number of cyberattacks on healthcare organisations in recent years has heightened this concern. P11: *"I have heard about several data breaches in the news, and it makes me concerned about the safety of my personal information."* Furthermore, establishing trust among users hinges on transparency in the collection, storage, and sharing of data. P5 mentioned: *"I would use it if I were assured that my data is protected and will not be misused in any way."* P12 emphasised the importance of ongoing security measures: *"I think it's important for healthcare providers to continually update their security measures to protect patient data."* Many participants echoed this sentiment, emphasising the need for proactive measures to prevent data breaches. Thus, security is about the technical and procedural measures taken to protect data from unauthorised access and breaches.

Participants identified user interface design and data interpretation as significant technological barriers. Participants frequently cited the need for more intuitive and user-friendly interfaces as essential for facilitating the broader adoption of health technologies. P9 explained the frustration with complex data: *"Sometimes, I find all the data overwhelming and hard to interpret which can be frustrating. I think having more simplified data displays would greatly improve the user experience for individuals like me."* This suggests that simplifying the presentation of data and providing guidance on how to interpret it could enhance the user experience and encourage more widespread adoption of health technologies. Furthermore, P9 underscored the importance of receiving guidance on how to interpret the

data, indicating a potential barrier for users who may feel overwhelmed by the information presented.

A lack of trust in the accuracy and reliability of the data provided by digital tools was also a major concern. Participants were hesitant to rely on technology that might not accurately reflect their health status or behaviours. P12 stated: *"If I am not sure how accurate it is, I am less likely to trust the device with my health data."* This concern was shared by P7: *"I am hesitant to rely on health technologies if I am unsure about their reliability."* This implies that the perceived trustworthiness of health technologies plays a crucial role in participants' willingness to share their personal health data.

Another barrier that was identified is the tendency to become fixated on the data. One participant that already utilised a fitness tracker expressed that they found themselves constantly checking their data and becoming fixated on the numbers rather than focusing on their overall health and well-being. P3: *"It became a source of stress for me, as I felt like I had to constantly meet certain goals. This led to feelings of guilt and disappointment if I did not reach them. This affected my mental health negatively."* In that case, reliance on data for one's self-improvement can actually have detrimental effects on mental well-being.

Perceived Benefits

This theme explores the significant advantages that participants attribute to digital phenotyping, emphasising the ways in which this technology can enhance the management of health care for cancer survivors. Benefits highlighted include improved understanding of health patterns, timely interventions, and personalised healthcare strategies.

Participants valued the ability of digital phenotyping to track and analyse personal health data, which can uncover patterns not easily detectable through conventional methods. This capability is seen as critical for developing more effective and personalised health management strategies. P10 shared: *"I like tracking my mood via the mental health app, but I believe that it can also help me identify triggers and patterns that affect my mental well-being.*" P3 also expressed: *"Being able to see the patterns in my mood and activity levels has made it easier for me to anticipate and manage difficult days."* This perspective was shared by many participants who believed that digital phenotyping could provide valuable insights into their health and well-being beyond what traditional methods offer. For instance, P1 stated: *"Technology has the potential to track subtle changes in my behaviour and mood that I may not even be aware of, thus symptoms can be detected and addressed earlier than with traditional therapy."*

Timely interventions facilitated by digital phenotyping are appreciated for their potential to enable proactive and preventative healthcare. Participants expressed enthusiasm for real-time data's ability to inform quicker and more targeted responses to emerging health issues. P6 stated: *"I would like to use digital phenotyping to track my mood and energy levels throughout the day to better understand how my mental health is affected by different factors."* P7 shared this sentiment: *"If my therapist had access to real-time data on my mood and behaviour, they could provide more targeted and effective interventions."*

The capability of digital phenotyping to inform and enhance personalised healthcare was a recurrent theme. Participants highlighted how continuous data collection could lead to tailored treatment plans that align closely with individual health dynamics. P4: *"As data is continuously collected, it could simplify the treatment process and make it more convenient for both me and my psychologist."* Additionally, P2 noted: *"Digital phenotyping could also help identify patterns and triggers that may not be immediately apparent, leading to more accurate diagnoses and treatment recommendations."* This emphasises the need for patients to engage in shared decision-making. Moreover, P1 mentioned, *"It is kind of like having a doctor who knows what is going on with me all the time without me having to constantly update them on my symptoms."* These insights showcase the potential of digital phenotyping to enhance the management and treatment of mental health.

Technology Acceptance Model (TAM)

Digital phenotyping in cancer survivors' mental health care shows a complex connection between cognitive, emotional, and behavioural factors. These results align with the TAM by Davis (1989) which states that perceived usefulness, ease of use, and trust in digital health technologies determine their acceptance. This model proposes that individuals are more likely to adopt new technologies if they perceive them as easy to use and beneficial. In this study, cognitive readiness involves participants' understanding of digital phenotyping and its benefits. When users perceive a tool as beneficial for achieving their goals, they are more likely to use them. Participants appreciated how real-time data from digital phenotyping could allow for early detection of mental health issues, demonstrating cognitive comprehension of its practical benefits. For instance, P5 stated: *"This kind of monitoring tool would give me a sense of control over my health."*

Affective readiness refers to the emotional response to digital phenotyping. Affective readiness is strongly tied to ease of use as an intuitive and user-friendly interface can foster positive emotions, whereas a challenging interface can evoke negative emotions. Participants

expressed a range of feelings, from reassurance provided by continuous monitoring to concerns about privacy and the intrusiveness of constant data collection. P3: *"Sometimes, all the data feels complex to make sense of. A simplified display makes it much easier to use."* Balancing these emotional responses is crucial for acceptance.

Behavioural readiness is demonstrated by participants' willingness to integrate digital phenotyping into their daily routines. Some participants were already using health apps and smartwatches, indicating readiness to engage with the technology. However, the need for clear, transparent information about data use and robust privacy measures was emphasised to enhance this readiness. Thus, trust is needed as it encourages users to integrate the technology into their daily lives. P8: *"I would feel more comfortable using digital phenotyping tools if I knew exactly who was accessing my data and how it was protected."*

Discussion

This study explored the receptivity towards digital phenotyping among cancer survivors, focusing on how this technology is perceived in the context of managing the mental health challenges associated with cancer survivorship. The aim was to identify potential barriers and facilitators to the adoption of digital phenotyping tools in this vulnerable population. Accordingly, key themes were identified throughout a thematic analysis.

Participants demonstrated a significant interest towards the adoption of digital phenotyping tools, attributing this interest to the tools' ability to offer continuous support and facilitate early detection of mental health issues following cancer treatment. The advantages of continuous monitoring were often emphasised, as participants indicated that these tools provided a sense of control and reassurance throughout the recovery process, particularly in instances where physical meetings with healthcare providers were reduced. The identification of early detection was recognised as a significant advantage, with participants acknowledging the importance of recognising health issues prior to their escalation, thereby facilitating timely interventions. The potential of digital phenotyping to reveal nuanced health patterns and facilitate tailored healthcare strategies was also acknowledged by participants. The potential to personalise treatment plans based on real-time data was highly valued, as it could streamline the treatment process and enhance convenience for both patients and providers.

Despite the facilitators, several barriers to the adoption of digital phenotyping were identified. Participants indicated several apprehensions regarding privacy and security, which, although related, pertain to diverse aspects of data management. Privacy concerns focused on

the right to control and consent to the collection, storage, and use of personal data. Participants underscored the necessity for transparent consent procedures and clear communication regarding the utilisation of personal data. These issues align with the broader definition of data privacy, which emphasises user autonomy, secrecy, and respect for personal boundaries. Conversely, security concerns centred on safeguarding data from external threats, including unauthorised access, breaches, and hacking. Participants indicated a lack of trust in the robustness of existing security protocols, considering the increasing prevalence of cyberattacks within the healthcare industry. This highlights the apprehension associated with the possible exploitation of health data. Security, therefore, prioritises technical and operational measures to maintain data integrity and prevent breaches. Consequently, digital phenotyping technologies must preserve privacy through the assurance of autonomy and transparent permission, while also enhancing security by implementing robust measures against external threats.

Moreover, the participants recognised that user interface design and data interpretation represent considerable technological barriers to the implementation of digital phenotyping tools. The necessity for interfaces that are more intuitive and user-friendly was consistently highlighted, as participants conveyed their frustration regarding the complexity inherent in data presentation. This underscores the significance of not merely streamlining data presentation but also offering explicit guidance to assist users in effectively interpreting their data, thereby mitigating potential feelings of overwhelm and enhancing usability. Alongside usability concerns, participants articulated reservations regarding the accuracy and reliability of the data generated by these technologies. The absence of trust has surfaced as a significant barrier, affecting individuals' readiness to interact with digital health tools. The aforementioned perspectives highlight the significant importance of perceived trustworthiness in promoting user acceptance. Addressing these barriers by ensuring accuracy, reliability, and user-friendly design could significantly enhance the adoption and effectiveness of digital phenotyping tools in mental health care.

Thus, the results suggest cautious acceptance, with participants acknowledging the possible advantages of continuous support, early detection, and personalised treatment plans to enhance mental health management. However, significant concerns surrounding data privacy, security, usability, and trust emerged as critical barriers. These different perspectives demonstrate the challenges related to the integration of innovative digital health technologies within sensitive care domains, such as mental health for cancer survivors.

The findings align with and builds upon previous studies conducted by Onnela and

Rauch (2016) and Perez-Pozuelo et al. (2020), which highlighted the significant potential of real-time data collection in the monitoring of mental health. Moreover, it also corresponds with existing research suggesting that the acceptability of digital phenotyping is contingent on a clear understanding of its purpose and potential benefits, as well as the assurance of privacy and data security measures. For instance, a study by Mendes et al. (2021) similarly demonstrated that privacy concerns, technological barriers, and a lack of trust in the accuracy are critical factors influencing user acceptance. Moreover, participants expressed a desire not only to send their data to healthcare providers but also to engage actively with this information. This reflects a growing demand for transparency and control over personal health data. This underscores the need for systems that facilitate patient access to and engagement with their personal health data to foster a sense of agency and empowerment.

Accordingly, the findings indicate a framework in which the acceptance of digital phenotyping tools is shaped by variables including perceived usefulness, ease of use, privacy concerns, and technological usability. Therefore, this study aligns with the TAM. Perceived usefulness emerged as a central theme, with participants emphasising the potential of digital phenotyping to offer continuous support and enable early detection of mental health challenges. This perception aligns with TAM's assertion that users are more likely to adopt technologies they believe will improve their outcomes. Similarly, ease of use was a critical factor, with participants stressing the importance of intuitive interfaces and clear data presentation. This highlights the importance of designing systems that accommodate varying levels of technological literacy, reinforcing TAM's claim that ease of use significantly impacts attitudes toward technology adoption. Moreover, trust and its connection to data privacy and security emerged as crucial for building participants' confidence in using these tools.

Therefore, the findings of this study underscore the critical role of the TAM constructs in fostering cognitive, affective, and behavioural readiness among cancer survivors for the adoption of digital phenotyping tools. These findings align with Davis (1989), who emphasises the importance of these constructs in technology acceptance. Participants stressed the significance of user-friendly interfaces and intuitive designs, reflecting Braun's (2013) insights on accommodating diverse technological literacy levels, particularly among older adults. Trust also emerged as a pivotal factor, especially concerning data privacy and security, with participants advocating for rigorous data security measures and transparent usage policies, supporting conclusions by Mendes et al. (2021) and Paul et al. (2023). Moreover, the need for clear communication regarding the benefits and functionalities of

digital phenotyping tools aligns with findings by Huckvale et al. (2019), highlighting the importance of education and collaboration to enhance user engagement.

While the TAM provides a valuable foundation for assessing technology acceptance, its limitations suggest the need for more nuanced approaches in health research. The study identified actionable areas, including simplifying user interfaces, educating users about the tools, and addressing privacy concerns, as key to improving cognitive and affective readiness. This aligns with research by Brietzke et al. (2019) and Wang et al. (2018), who emphasise the importance of continuous monitoring and personalised mental health interventions. By implementing these strategies, the integration of digital phenotyping into mental health care for cancer survivors can be optimised, addressing their unique challenges while enhancing its acceptability and utility.

This study contributes uniquely to the understanding of how digital phenotyping can be integrated in survivorship care. The identification of these specific facilitators and barriers offers targeted recommendations for the integration of technology in the mental healthcare sector. The findings highlight the significance of user-centred design principles in facilitating the acceptance and effectiveness of technology, especially within a healthcare environment that is progressively dependent on digital tools to enhance outcomes and experiences. The ethical management of patient data, in conjunction with usability, is a critical focus in these advancements.

Moreover, this research addresses the specific needs of cancer survivors, emphasising critical aspects of acceptability and significantly contributing to the literature. It provides insights into the customisation of digital phenotyping for this population. The study highlights the potential of actionable sensing in digital phenotyping to deliver real-time, actionable feedback, thereby enhancing traditional monitoring methods. This promotes collaborative decision-making and supports Just-In-Time Adaptive Interventions (JITAIs), allowing for personalised care that adjusts to changing patient needs. These constructs facilitate the acceptance of digital health technologies and inform future interventions to enhance usability, transparency, and user engagement, thereby prioritising patient-centred demands in the development and implementation of innovative healthcare technologies.

Limitations and Future Research

While this study offers valuable insights, it is important to acknowledge its limitations. Although the sample size was sufficient to achieve thematic saturation, it was relatively small and geographically limited to the Netherlands. This may affect the

generalisability of the findings. Reflecting on the inclusion criteria, since all participants had experienced mental health challenges, the findings might not reflect the experiences of all cancer survivors, particularly those from different cultural backgrounds. This specificity should be considered when generalising the results, as this could influence perceptions and interactions with digital health tools. Furthermore, the reliance on self-reported data in the study can lead to potential biases and inaccuracies, given that participants may have different interpretations of the questions or may not recall their experiences accurately. While efforts were made to ensure the trustworthiness of the findings through thorough data analysis and validation techniques such as reflexivity and iterative questioning, these measures cannot entirely eliminate the possibility of bias. Moreover, the inclusion of a single coder in the thematic analysis might also limit the interpretative breadth of the results. Thus, involving multiple coders in future studies could help validate the coding process and enhance the reliability of the findings.

Future research should aim to include a more diverse and representative sample to ensure the findings can be applied more broadly. In addition, future research should consider practical trials where participants use digital phenotyping tools before providing feedback to validate their experiences in actual use rather than abstract concepts. For future research, a thorough assessment of the extent to which the TAM captures the adoption intentions of cancer survivors would be insightful. Moreover, further exploring patients' desires to not merely send data to providers but also to receive insights themselves could drive advancements in the emerging field of actionable sensing in digital phenotyping. Employing a combination of qualitative and quantitative methods like surveys and interviews could thus provide a more comprehensive understanding of the experiences of cancer survivors.

Future research should also address patients' awareness of data protection regulations, such as the General Data Protection Regulation (GDPR), and evaluate whether these measures are sufficient from the perspective of those they aim to protect. Additionally, examining how personal characteristics and traits influence experiences may provide important insights for future research and support tailored interventions designed to meet the varied needs of cancer survivors. Longitudinal studies could further explore how attitudes towards and usage of digital phenotyping evolve over time, especially as individuals navigate different stages of cancer survivorship. This approach would allow for a more nuanced interpretation of the data and potentially uncover hidden patterns or correlations that may not be apparent through a single method alone. By considering both the subjective experiences of

individuals and the objective data collected, researchers can gain a more comprehensive understanding of the complex factors influencing the experiences of cancer survivors.

Conclusion

In summary, this study illustrated that the monitoring and management of mental health conditions among cancer survivors can be substantially improved through the implementation of digital phenotyping. By utilising data from smartphones and wearable devices to gain real-time insights into patients' behaviours and symptoms, healthcare providers can develop more personalised and effective treatment. This approach has the potential to enhance the assessment and treatment of mental health by ensuring continuous, objective monitoring. Nevertheless, in order for digital phenotyping to be more widely accepted, it is crucial to address data privacy and security concerns in a comprehensive manner and to personalise the technology to accommodate the unique requirements of each individual. Fostering trust necessitates robust data privacy and transparent communication regarding data utilisation. Furthermore, the integration of user feedback mechanisms can provide patients with a sense of empowerment, enabling them to feel more in control of their health data and connected to their healthcare providers. In addition to enhancing our comprehension of digital health interventions, this research also served as a guide for future research to more effectively implement these technologies into cancer survivor care, thereby enhancing patient outcomes and quality of life. Thus, this study served as a foundation for additional research and development in the field of digital health technologies that are specifically designed to address the distinctive requirements of cancer survivors.

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Appendix A
Informed Consent Form

Geachte deelnemer,

U wordt uitgenodigd om deel te nemen aan een onderzoek naar de haalbaarheid van het gebruik van digitale fenotypering om de geestelijke gezondheid van overlevenden van kanker te monitoren en te ondersteunen. Dit omvat het verzamelen van gegevens van digitale apparaten (smartphones of wearables) om passief gedrag zoals slaap, fysieke activiteit en stemming te monitoren. Ik ben geïnteresseerd in uw ervaringen met geestelijke gezondheid tijdens en na uw kankerbehandeling en uw mening over de integratie van deze technologie in uw geestelijke gezondheidszorg.

Als u akkoord gaat met deelname, wordt u gevraagd deel te nemen aan een semigestructureerd interview van ongeveer 45-60 minuten. Het interview wordt online afgenomen via Microsoft Teams en met uw toestemming opgenomen. U wordt gevraagd naar:
- Uw ervaringen met geestelijke gezondheidszorg na de behandeling van kanker.
- Eventueel gebruik van digitale hulpmiddelen om uw gezondheid te monitoren.
- Uw gedachten over de mogelijke voordelen en zorgen met betrekking tot digitale fenotypering.
- Uw bereidheid om dergelijke technologie toe te passen in uw geestelijke gezondheidszorg.

Wat betreft de verwerking en opslag van gegevens: het interview wordt opgenomen met Microsoft Teams, met een externe recorder als back-up. Uw antwoorden worden tijdens de transcriptie geanonimiseerd om uw identiteit te beschermen. De gegevens worden veilig opgeslagen in een met wachtwoord beveiligde server en zijn alleen toegankelijk voor bevoegde onderzoekers. Tot slot worden alle persoonlijk identificeerbare gegevens verwijderd en worden de resultaten in geaggregeerde of geanonimiseerde vorm gepresenteerd in publicaties of presentaties.

Het grootste risico van uw deelname is de mogelijkheid van emotioneel ongemak bij het bespreken van gevoelige onderwerpen, zoals uw geestelijke gezondheidsproblemen na de behandeling van kanker. Als u zich op een bepaald moment angstig of ongemakkelijk voelt,

kunt u ervoor kiezen om het interview te onderbreken of te stoppen. Daarnaast wordt u indien nodig doorverwezen naar uw psycholoog voor ondersteuning.

Hoewel er geen directe persoonlijke voordelen verbonden zijn aan deelname, kunnen uw inzichten bijdragen aan het verbeteren van toekomstige ondersteunende diensten op het gebied van geestelijke gezondheid voor overlevenden van kanker.

Uw deelname is geheel vrijwillig. U hebt het recht om:
- Deelname te weigeren zonder consequenties.
- U op elk moment uit het onderzoek terug te trekken, zelfs nadat het interview is begonnen, zonder dat u hiervoor een reden hoeft op te geven.
- Specifieke vragen tijdens het interview niet te beantwoorden.

We zullen al het mogelijke doen om uw vertrouwelijkheid te waarborgen. Uw naam en andere identificerende gegevens worden niet gebruikt in de rapportage van de bevindingen. De geanonimiseerde gegevens worden uitsluitend gebruikt voor academische doeleinden en kunnen worden opgenomen in toekomstige publicaties of worden gedeeld in academische settingen. Er wordt geen persoonlijke informatie gedeeld buiten dit onderzoek.

Aangezien dit onderzoek over geestelijke gezondheid gaat, kunnen er zorgen over privacy ontstaan. Uw gegevens worden geanonimiseerd om het risico op identificatie te beperken. De opname en alle identificeerbare gegevens worden veilig opgeslagen en vernietigd na afloop van het onderzoek, in overeenstemming met de regelgeving voor gegevensbescherming (bijv. GDPR).

Als u vragen of zorgen heeft over dit onderzoek of uw deelname, neem dan gerust contact op met een van de volgende personen:
- Onderzoeker: I.J.M. Beukeveld, i.j.m.beukeveld@student.utwente.nl.
- Begeleider: J. Piano Simoes, j.pianosimoes@utwente.nl.

Voor bezwaren met betrekking tot de opzet en of uitvoering van het onderzoek kunt u zich ook wenden tot de secretaris van de Ethische Commissie/domein Humanities & Social Sciences van de faculteit Behavioural, Management and Social Sciences op de Universiteit Twente via ethicscommittee-hss@utwente.nl. Dit onderzoek wordt uitgevoerd vanuit de

Universiteit Twente, faculteit Behavioural, Management and Social Sciences. Indien u specifieke vragen heeft over de omgang met persoonsgegevens kunt u deze ook richten aan de Functionaris Gegevensbescherming van de UT door een mail te sturen naar dpo@utwente.nl.

Door hieronder te ondertekenen, bevestigt u dat:
- U de hierboven verstrekte informatie hebt gelezen en begrepen.
- U de gelegenheid hebt gehad om vragen te stellen en deze te laten beantwoorden.
- U vrijwillig instemt met deelname aan het onderzoek.
- U begrijpt dat u zich op elk moment zonder gevolgen uit het onderzoek kunt terugtrekken.

Naam deelnemer: _____
Handtekening deelnemer: _____
Datum: _____

Naam onderzoeker: _____
Handtekening onderzoeker: _____
Datum: _____

Hartelijk dank voor uw deelname. Uw inbreng is waardevol voor ons bij het onderzoeken van nieuwe manieren om de geestelijke gezondheidszorg voor overlevenden van kanker te verbeteren.

Appendix B

Interview Procedure: English Questions

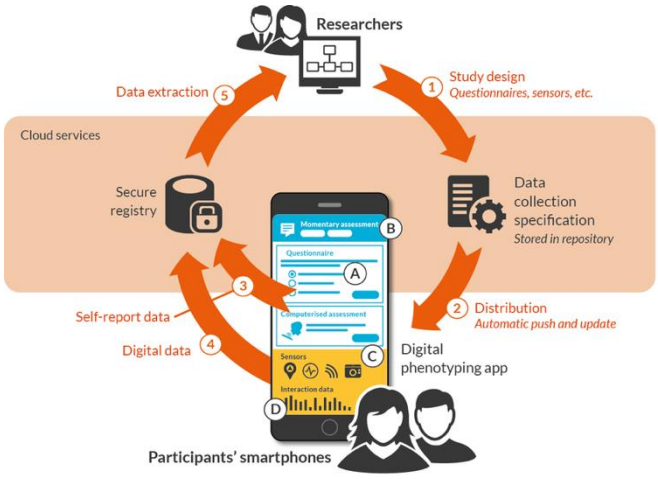
1. Can you describe your experience with managing your mental health after your cancer treatment?

   - *Prompt: Could you share any specific challenges or support systems that were particularly helpful during this time?*

2. Have you used any digital tools (like smartwatches) or apps to monitor your health, either physical or mental, during or after your treatment? If so, what has been your experience?

   - *Prompt: Can you mention any specific apps that track your mood, exercise, or sleep, and how they helped or did not meet your expectations?*

3. As demonstrated in this figure, digital phenotyping involves collecting data such as your physical activity, sleep patterns, and mood from devices like smartphones or wearables. It relies on digital data and self-reported data. Digital data consists of objective information that devices' sensors automatically generate, such as step counts or screen time, while self-reported data consists of subjective information that users themselves input, such as mood or stress levels. What kind of data would you be comfortable sharing with your healthcare team?



   - *Prompt: Consider the types of information you might be okay with sharing, like your daily steps or sleep quality.*

   - *Prompt: Are there any types of data you would be hesitant to share? Why?*

4. How do you feel about using digital devices, like a smartphone or wearable, to monitor aspects of your health like mood, sleep, physical activity, eating habits, etc.?

   - *Prompt: What potential advantages or concerns do you foresee with this type of monitoring?*

5. What concerns, if any, might you have about healthcare providers using data from your devices to monitor your mental health?

   - *Prompt: Are there any specific security and privacy issues that worry you?*

6. If these tools could help detect early signs of mental health issues (such as anxiety, depression, and sleep disorders) and provide timely support, how likely would you be to use them?
   - *Prompt: What features or conditions would make you more or less likely to use these tools regularly?*
   - *Prompt: Think about how this might change your current care regimen.*
7. What do you think would be the biggest benefits of using digital phenotyping for monitoring your mental health during and after treatment?
   - *Prompt: How do you think this could change your treatment or support experience? Or could it be more timely interventions or a better understanding of your own health patterns?*
8. What might prevent you from using digital phenotyping tools regularly?
   - *Prompt: Are there any barriers like technological issues, lack of trust in the technology, or something else?*

Appendix C

Interview Procedure: Dutch Questions

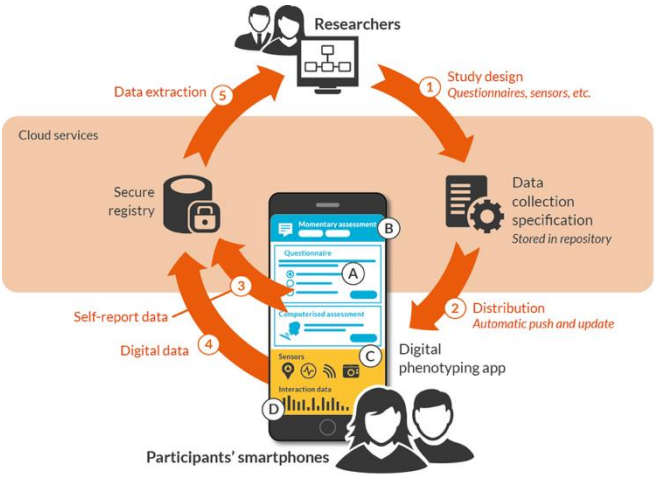
1. Kunt u uw ervaring beschrijven met het omgaan met uw geestelijke gezondheid na uw kankerbehandeling?

   - *Vraag: Kunt u specifieke uitdagingen of ondersteuningssystemen delen die behulpzaam waren tijdens deze periode?*

2. Heeft u digitale hulpmiddelen (zoals smartwatches) of apps gebruikt om uw lichamelijke of geestelijke gezondheid tijdens of na uw behandeling in de gaten te houden? Zo ja, wat waren uw ervaringen?

   - *Vraag: Kunt u specifieke apps noemen die uw stemming, lichaamsbeweging of slaap bijhouden, en hoe ze u hebben geholpen of niet aan uw verwachtingen voldeden?*

3. Zoals deze afbeelding laat zien, houdt digitale fenotypering in dat gegevens zoals je fysieke activiteit, slaappatronen en stemming worden verzameld via apparaten zoals smartphones of wearables. Het is gebaseerd op digitale gegevens en zelf gerapporteerde gegevens.



   Digitale gegevens bestaan uit objectieve informatie die de sensoren van apparaten automatisch genereren, zoals het aantal stappen of schermtijd, terwijl zelf gerapporteerde gegevens bestaan uit subjectieve informatie die gebruikers zelf invoeren, zoals stemming of stressniveaus. Welk soort gegevens zou u graag delen met je zorgteam?

   - *Vraag: Bedenk welke soorten informatie u goed zou vinden om te delen, zoals uw dagelijkse stappen of slaapkwaliteit.*

   - *Vraag: Zijn er soorten gegevens waarvan u zou aarzelen om ze te delen? Waarom?*

4. Hoe denkt u over het gebruik van digitale apparaten, zoals een smartphone of wearable, om aspecten van uw gezondheid te monitoren, zoals stemming, slaap, lichamelijke activiteit, eetgewoonten, etc.?

   - *Vraag: Welke mogelijke voordelen of zorgen voorziet u bij dit soort monitoring?*

5. Welke eventuele zorgen heeft u over zorgverleners die gegevens van uw apparaten gebruiken om uw geestelijke gezondheid te monitoren?
   - *Vraag: Zijn er specifieke beveiligings- en privacy kwesties die u zorgen baren?*
6. Als deze hulpmiddelen zouden kunnen helpen om vroegtijdige signalen van psychische problemen (zoals angst, depressie en slaapstoornissen) op te sporen en tijdig ondersteuning te bieden, hoe waarschijnlijk zou u ze dan gebruiken?
   - *Vraag: Welke kenmerken of voorwaarden zouden u meer of minder geneigd maken om deze hulpmiddelen regelmatig te gebruiken?*
   - *Vraag: Bedenk hoe dit uw huidige zorgregime zou kunnen veranderen.*
7. Wat zijn volgens u de grootste voordelen van het gebruik van digitale fenotypering voor het monitoren van uw geestelijke gezondheid tijdens en na de behandeling?
   - *Vraag: Hoe denkt u dat dit uw ervaring met behandeling of ondersteuning zou kunnen veranderen? Zouden dit bijvoorbeeld meer tijdige interventies of een beter begrip van uw eigen gezondheidspatronen kunnen zijn?*
8. Wat zou u ervan kunnen weerhouden om regelmatig digitale fenotyperingtools te gebruiken?
   - *Vraag: Zijn er barrières zoals technologische problemen, gebrek aan vertrouwen in de technologie, of iets anders?*

Appendix D
AI Statement

During the preparation of this work, the author used Scribbr and Grammarly in order to receive feedback on the structure or flow of the text and for the purpose of copy editing, including minor revisions for conciseness and clarity of writing and reformatting references. After using this tool, the author reviewed and edited the content as needed and takes full responsibility for the content of the work.