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DESIGN INSIGHT

Fragma: A wearable intervention enhancing breast cancer patients to manage fatigue through task segmentation

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SUMMARY

Breast cancer (BC) patients undergoing chemotherapy experience fatigue and cognitive impairments that hinder their ability to complete daily tasks. *Fragma*, a wearable bracelet, provides real-time feedback on energy levels, enabling patients to fragment tasks into manageable steps and align activities with their energy capacity. Patient feedback emphasised the need for tools supporting intuitive task management, with oncology experts endorsing task segmentation as a valuable tool for patient education. *Fragma* helps patients avoid surpassing their physical limits, which are often hindered by BC treatment and sometimes reluctantly acknowledged. Planned improvements to *Fragma* include integrating subjective fatigue measures, expanding testing, and enhancing usability.

Key Words

Cognitive impairment; fragmentation; Task segmentation; patient-centered design; wearable technology

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INTRODUCTION

Breast cancer (BC) affects 1 in 20 women worldwide, with 2.3 million new cases annually.[1] BC is the most common cancer among women in Chile, where incidence and mortality have been rising.[1] Standard treatment often includes surgery, radiation, endocrine therapy, immunotherapy, and chemotherapy. These treatments can significantly impact patients' physical and cognitive health, causing side effects such as fatigue, nausea, and cognitive impairments like difficulty concentrating or memory issues.

Many cancer survivors face physical and cognitive side effects from chemotherapy that disrupt their daily lives.[2] These side effects include cognitive impairments such as reduced attention, concentration, mental processing speed, and short-term memory issues. Patients also experience mental fatigue, making tasks such as remembering appointments, managing grocery lists, or following multi-step recipes challenging to complete.[2,3] As well, physical effects like physical fatigue affect up to 91 per cent of BC patients undergoing chemotherapy.[3] Patients describe this fatigue as persistent tiredness at rest, exhaustion with activity, and a lack of energy that precludes daily tasks, inertia, or lack of endurance.[4]

Since treatment effects vary between individuals and within the same person over time, many patients rely on self-awareness and experiential learning to manage daily life. [5] For example, a patient might learn to identify early signs of fatigue, such as difficulty focusing, and adjust their activities by taking short breaks or rescheduling demanding tasks to times when they feel more energetic. Research has shown that real-

time tracking of specific health data and symptoms through technology can improve patients' quality of life during treatment.[6] However, such tools often require patient data input and are not widely available.[8]

SUMMARY

BC patients undergoing chemotherapy often experience cancer-related cognitive impairment (CRCI), manifesting as difficulties with attention, memory, and mental processing, compounded by severe physical fatigue.[7] These challenges hinder their ability to complete daily tasks and maintain independence, prompting the need for supportive interventions.

As part of a health design class including 15 senior undergraduate design students, we (the researchers) initiated this project by collectively conducting an autoethnographic design probe that included wrist weights to better understand the daily fatigue experienced by BC patients. Here we collected qualitative and quantitative data on how our daily life activities changed and visually analysed patterns to develop key insights. Working as a team, we deepened our insights by conducting semi-structured interviews with BC patients who had gone through BC treatment. During these interviews, we explored the support methods—family, medical, or community-based—that they used to manage daily tasks. Patients reported relying on a variety of strategies, including paper notes, task lists, and online calendars.

Through these interactions, we observed a common behavioural pattern: patients frequently underestimated their fatigue levels and overexerted themselves, often as a means of demonstrating resilience despite their health challenges. One participant expressed overdoing it, but only realising that after feeling exhausted. Fragmentation of tasks emerged as a recurring theme in their management strategies.

As the project progressed, we gathered observations at an oncology fair in Santiago, Chile, where we tested patients' ability to break down tasks by energy demand. Our analysis of the observations and interviews suggested that patients were able to categorise and fragment tasks. However, the results varied significantly, reflecting the unique perspectives and circumstances of each individual.

We finally developed *Fragma*, a wearable bracelet designed to assist patients in managing fatigue through real-time feedback on energy levels. By visualising fatigue, *Fragma* enables users to fragment tasks into smaller, more manageable steps, aligning their activities with their available energy and promoting task completion. The final prototype integrates peripheral capillary oxygen saturation (SpO2) technology, which estimates how much oxygen your red blood cells are carrying compared to their maximum capacity, heart rate (HR) sensors, and an accelerometer to provide actionable fatigue data (Figures 1 and 2).

LESSONS LEARNED

While we successfully developed a mock-up and defined a value proposition, extensive testing is still required to fully validate its effectiveness. Early feedback from limited user interactions suggests that the bracelet's features—real-time fatigue monitoring and task segmentation—hold promise in helping BC patients manage their energy and daily tasks. However, broader development is necessary to confirm its full impact and functionality.

Figure 1: Informative brochure on the use of the bracelet and task fragmentation

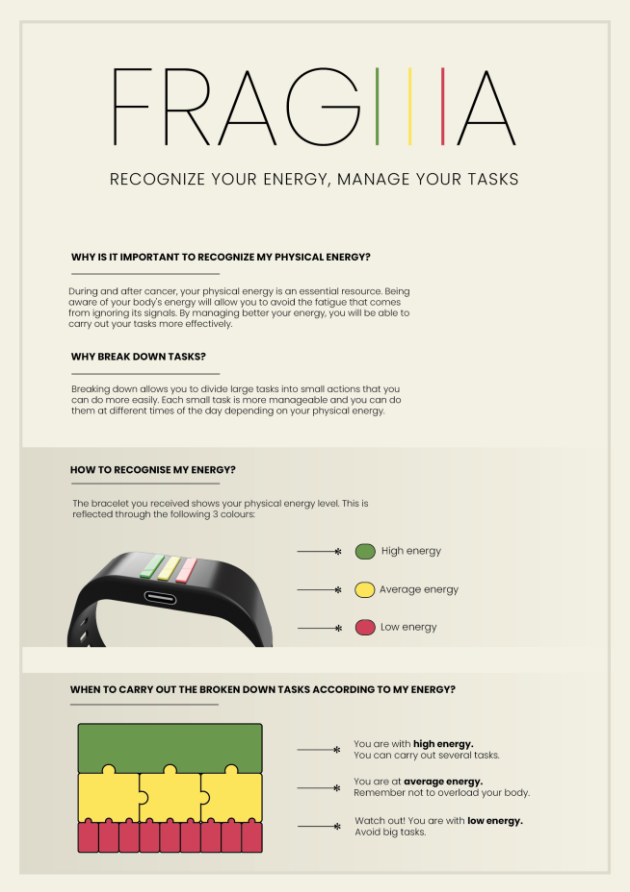
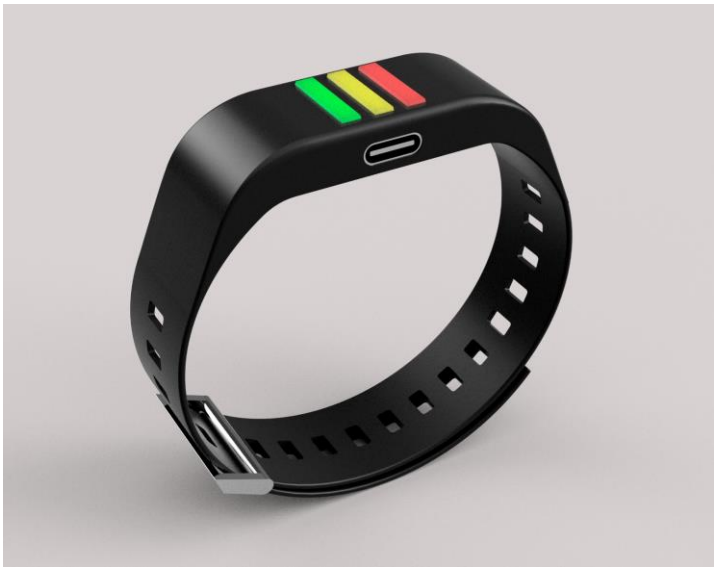


Figure 2: Fragma bracelet



Note: Fragma bracelet counts with a sensor for: Sp02, HR, and accelerometer; 7-day battery duration and a USB-C port for being charged and controlled. The chassis is made out of hypoallergenic silicone.

Simplifying the project while ensuring its usability and intuitiveness for patients presented a significant challenge throughout the design process. Early exploration included a range of concepts, such as stress-reducing aromatherapy necklaces, non-invasive visual reminders, and task templates tailored to energy levels. To validate these prototypes, we engaged directly with patients, presenting templates to assess the practicality and relevance of our value proposition. Patient feedback revealed a critical insight: task fragmentation was already an organic part of their daily routines. This discovery reframed our approach, shifting the focus of the template to a supportive tool rather than the central feature. This refinement not only enhanced our value proposition but also led us to prioritise affordability and accessibility. Task categorisation was intentionally simplified to avoid unnecessary complexity, ensuring the solution remains both intuitive and effective for patient use. Oncology experts highlighted the innovativeness and usefulness of educating on this fragmentation process.

A key aspect to be considered in subsequent development stages is to incorporate the subjective nature of fatigue: experts' validation confirmed that there are still no reliable fatigue measurements based only on physiological parameters and physical activity levels. Therefore, *Fragma* should include a Borg scale[9] to provide an accurate fatigue measurement. Future steps include expanding the testing pool to gather diverse and representative feedback, enhancing the accuracy of the fatigue measurement system, and optimising the bracelet's comfort and usability. These refinements aim to deliver a final product that is not only effective but also adaptable to the needs of a broad user base.

The insights we have gained from *Fragma's* development can benefit other designers, researchers, and healthcare professionals. Specifically, this project has demonstrated the utility and benefits of combining technology with thoughtful design to address specific patient challenges. It is crucial to emphasise the relevance of the design intervention allowing for self-learning, ensuring that the solution can be adapted to the patient's context. Additionally, making previously invisible symptoms visible empowers patients by giving them agency in how their condition is understood and managed within their family context. By sharing what we have learned, we hope to inspire others to explore creative and innovative solutions that improve the experiences of patients facing similar difficulties.

DESIGN INSIGHT

This design insight article presents a great example of the importance of conducting a thorough design process when developing a product that considers a variety of factors that influence patients'/users' daily activities. Considerations that include providing live feedback alongside integrating subjective fatigue measures, expanding testing, and enhancing usability are essential considerations for patient/user monitoring devices. The insights generated through the design and research processes have allowed the design team to identify the critical user needs and requirements while also balancing the insights gained from patients/users to supplement primary and secondary research approaches; this is a key process that all designers and researchers should undertake.

The lessons learned from the approaches undertaken are valuable for designers and medical professionals to reflect upon, especially where approaches such as autoethnographic research are integrated into the design process. The lessons learned also highlight the importance of understanding the value proposition when designing a medical device/wearable. It is important that the diverse needs of the varying stakeholders

are considered while also reflecting upon key factors such as creating new innovations that have the potential to provide not only enhanced patient monitoring but also commercial opportunities; this is clear in the development of *Fragma* to allow for the development of a wearable intervention that supports breast cancer patients. Critically, by fully understanding the value proposition, the needs/requirements of the patients, and the key healthcare stakeholders, the unique benefits of the device can hopefully be leveraged in the future to allow for clinical effectiveness and cost-efficiency, which are crucial factors for any medical device's potential market success and adoption.

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PEER REVIEW

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CONFLICTS OF INTEREST

The authors declare that they have no competing interests.

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ETHICS COMMITTEE APPROVAL

Written and/or verbal consent was obtained from all participants, including patients and healthcare providers, before their involvement in this project, following the formats and recommendations of the Pontificia Universidad Católica de Chile Ethics Committee. While this preliminary phase did not require formal ethics approval, the study is expected to undergo ethics review for a clinical trial after prototypes of the intervention are finalized.