Enhancing the Breast Cancer Screening Journey: Exploring Women's Perceptions of Traditional Mammography and Emerging AI driven Thermography

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Submitted to: Journal of Medical Internet Research
on: August 01, 2024

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Abstract

Background: Breast cancer is one of the most frequent causes of mortality among women's population. Early diagnosis is critical for successful treatment, but underscreening is frequent. Novel screening methods that are more convenient, such as thermography, are being developed. They could help a wider group of screeners and they could contribute to better compliance with screening and thus to a decline in breast cancer mortality.

Objective: The study aims to explore the screeners' preferences for the screening process, specifically for a novel screening that utilizes artificial intelligence (AI) and thermal imaging. Furthermore, we explore a better understanding of the barriers and facilitators associated with participation in breast cancer screening by currently used mammography.

Methods: One online focus group with experts and five focus groups with potential screeners on thermography were carried out. Potential screeners were recruited through an online survey (n=228) focused on addressing barriers and motivations related to screening. Survey data were analyzed using SPSS software. Findings from the focus groups were examined by two researchers utilizing open, axial, and selective coding in MAXQDA software.

Results: The information obtained in the focus groups showed that small changes during the procedure (tailored adjustments, such as film or music during the procedure, dimmed light) were appreciated, especially by women without any mammography screening experience. Furthermore, the non-invasiveness of the procedure was seen positively by all participants. Among other important factors that influence the perception of the procedure and can therefore affect the decision whether to go or not, was the way they were treated by medical staff and waiting hours. For certain women, how the interaction goes between them, and the clinicians is more important than the technology itself. Results from the online survey complemented these insights on motivation and barriers. Personal belief in breast cancer prevention was the most indicated motivator for women with mammography experience (44%, n=154), followed by an invitation from a screening program (29%, n=154). Barriers indicated by women without experience were mainly: no recommendation from a doctor (53%, n=74), no warning signals (36%, n=74) or no problem related to breasts (28%, n=74) followed by being too young for mammography (23%, n=74).

Conclusions: Even though the thermography was perceived mainly positively, rather than the technique itself, women prioritized how they were treated by medical staff. This includes detailed information in understandable language, empathetic communication and adjustments that fit personal preferences. As we also saw in the results from the survey, doctors play the leading role in the decision to go to the screening, so their change in the approach can encourage greater participation in breast cancer screening initiatives.

(JMIR Preprints 01/08/2024:64954)
DOI: https://doi.org/10.2196/preprints.64954

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Enhancing the Breast Cancer Screening Journey: Exploring Women's Perceptions of Traditional Mammography and Emerging AI driven Thermography

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Keywords: Breast cancer screening journey; Barriers and motivators in breast cancer screening; Thermography screening; Breast cancer screening with AI; Breast cancer screening experience

Introduction

Background

Breast cancer remains the most common type of cancer, and it is the leading cause of death among European women [13]. It was responsible for nearly one-third of all new cancer cases among women in 27 European countries in 2022 [12]. Early detection of cancer through screening forms a key part of a cancer strategy.

There is evidence that screening is effective at reducing cancer mortality [30]. Therefore, screening programs are developed that organize population-wide screening and guidelines that prioritize who should be invited based on age and risk factor, in the function of cost-effectiveness and that take into account the tradeoff between the harms of overdiagnosis and the reduction of mortality due to early detection [6]. Despite free access to cancer screening programs in many European countries, this offer is not taken up by all women of the target population [9]. Participation rates in cancer screening initiatives are affected by a multitude of factors and impediments, among which the modality of examination plays a significant role, notably encompassing discomfort and concerns regarding radiation exposure associated with mammography [15].

Novel techniques that are less invasive and harmful are being developed to affect participation in screening prevention programs positively. One of those techniques, thermography, is also the main subject of this study. Our main goal is to explore potential gaps in the current screening journey, from the decision to go to the screening through the process to receiving results by listening to the women's perspectives. By doing so, we can learn how to mitigate common barriers and make the new AI driven thermography screening a more pleasant, accessible and less scary experience.

We will first present current screening techniques and related limitations. Secondly, we will discuss insights from prior work on why women decide to participate or not in breast cancer screening. Thirdly, we will take a look at the current literature regarding screening process preferences. Lastly, we will introduce our research design and the goal of this study.

Current Screening Techniques and Their Limitations

Various methods exist for breast cancer screening at present. The most used is mammography, with digital breast tomosynthesis (DBT) emerging as a new diagnostic tool [7]. Secondly, breast ultrasound also progressed beyond its initial role in differentiating cysts versus solid masses [16]. Thirdly, breast MRI is currently the standard supplemental screening tool available for both high and intermediate risk women [24].

Each of these techniques presents advantages and comes with some limitations. Ultrasound is commonly used as a supplemental screening technique for women with dense breasts in whom mammography has a lower sensitivity. However, the US has been criticized for its relatively low specificity, leading to many recalls and biopsies for benign lesions [25]. Breast MRI offers the highest sensitivity for detecting occult cancer, regardless of breast density [24]. However, high costs and the limited tolerability and availability of MRI scanners make population-wide screening difficult.

Studies on mammography raise concerns about overdiagnosis and point out the risk of false positives [19]. Another disadvantage of mammography is the radiation dose needed [25]. Furthermore, experiencing discomfort or pain is an additional factor that could make women refrain from participating in regular screening [22]. Also, mammography is only suitable for some populations and not for certain groups, such as people who are not mobile or women of younger age. Lastly, recent epidemiological data point to a marginal contribution of mammography screening in the decline in breast cancer mortality [3]. If screening mammography has an influence on breast cancer mortality, this influence is fading away with progress in therapies. Because false-positive recalls, unnecessary biopsies, and overdiagnosis remain unaffected while patient management and therapies are improving, the balance in harms and benefits of screening will further deteriorate with increasing efficacy of therapies.

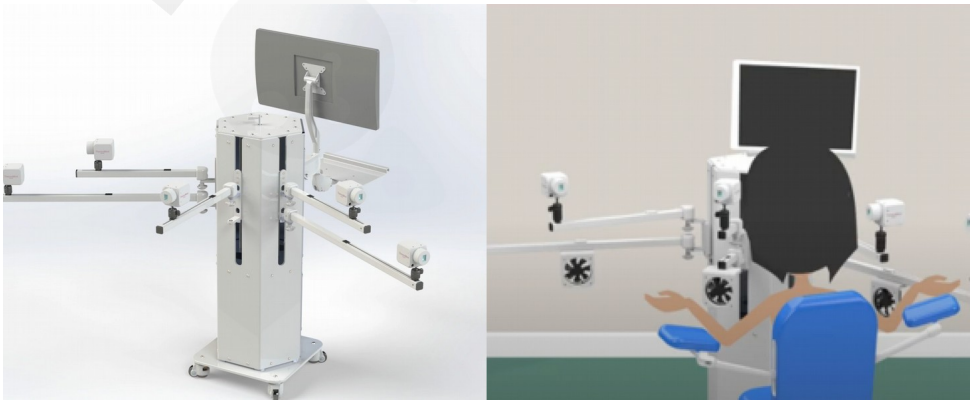
To overcome the limitations of currently used imaging technologies, novel techniques in the field of breast imaging are being developed, and they may soon play a role in breast cancer screening. For example, the combination of AI with radiomics has the potential to improve screening strategies further [25].

Thermography based on artificial intelligence (AI), currently undergoing clinical trial, is another example and will be the subject of discussion in this study (see Figure 1). The technology combines medical thermography, which uses sensitive infrared cameras to detect temperature differences up to 0.02°C, with a recently developed AI model to analyze dynamic thermal patterns and detect vascular abnormalities caused by malignancy [1].

The screening scenario with the thermography device in this study, expects the screener sits on the chair with arm support with open arms and gets scanned via camera sensors. The whole chest and armpit area is screened via sensors on cameras placed on the device. There is no direct contact with the technology itself. And the whole test takes approximately 12 minutes.

Due to its non-invasive nature and inclusivity, which entails no age or breast size restrictions, this technology holds the potential to revolutionize breast cancer screening. It addresses the limitations of mammography, particularly for women for whom it is not recommended or hold negative perceptions towards the procedure.

Figure 1: Thermography device and procedure demonstration [1]



Prior Work: Awareness, Barriers and Facilitators

First, we will address more general reasons why women choose not to participate in breast cancer screening. The practice theoretical approach [23] revealed that the decision to go to screening entails different groups of reasons, where both individual and societal contexts are involved. Disparities exist in uptake between different sociodemographic groups. Consequently, communication with various groups should be redesigned accordingly [34]. Three types of reasons are distinguished of why women do not participate in breast cancer screening revealed that there are three major types of reasons – *habitual, practical, and emotional* – that influence the formation of the final decision to participate in breast cancer screening [23]. *Habits* are created from the way participants are used to contact physicians and their experiences with the health care system. *Practical aspects* preventing participation during breast cancer screening refer to time and financial constraints. A special group of *emotional reasons* are related to fears, such as radiation or those related to the painful procedure of mammography.

To explore factors further that influence uptake, we refer to the transversal theory [20] that uses three types of constructs related to cancer screening participation: *awareness, facilitators/motivators and perceived barriers.* We, however, consider awareness belonging to the list of necessary facilitators. We bring the practice, theoretical approach and transversal theory together in one table (Table 1).

Awareness is considered a necessary condition for women to participate in screening. Despite a high level of breast cancer awareness, a lack of knowledge is frequently reported as a reason for non-attendance for screening [18, 21]. Additionally, the worry of having cancer does motivate people to proceed to breast cancer screening [34]. However, high levels of worry are uncommon [14].

Facilitators/motivators that encourage women to participate in breast cancer prevention are the healthcare professional's recommendations and the quality of the communication between the patient and the healthcare provider, which were identified to influence participation [5]**.** Trust in the healthcare professional and standard routine care is thus key [2]. The prompt to action, such as an invitation is a critical determinant of participation. Nevertheless, participants often need to be invited several times before acting [4]. Moreover, women who were experiencing signs felt encouraged to go to a screening [31]. Lastly, the uptake of breast cancer screening seems to increase with age [34].

Barriers to lower screening uptake are related to the lack of family support, such as a husband's disapproval [10]. People with low risk for developing breast cancer are also less open to tailored (risk based) screening [32]. Another reported barrier refers to the individual's assumptions about the screening behavior of peers, more specifically the inaction of others can lead to the non-attendance of screening examination [9]. Furthermore, women who perceived mammography as embarrassing [21] or experienced discomfort or pain [17] were less likely to attend screening. Lastly, women who fear medical examinations are less inclined to seek knowledge about risk and, as a consequence, develop less awareness. Ackerson and Preston [2] mention that "Adherence is achieved when women fear cancer but trust care providers, seek knowledge, understand risk and frame routine care as the status quo" (p. 1130).

Table 1. Factors influencing uptake of screening

	Facilitators/motivators	Inhibitors

Awareness	Awareness (necessary)	
Knowledge & risk perception	Knowledge, understanding risks	Lack of knowledge
		Member of a low-risk group
	Experiencing signs	
Socio-economic	Higher age	Lower age range
	Higher socio-economic status	Lower socio-economic status
		Time and financial constraints
Support	Family support	Lack of family support
	High screening behaviour of peers	Low Screening behaviour peers
	Health care professional recommendations	
	Quality of communication with health care provider	Negative Experiences with the health care system
	Prompts to action: invitations, repetitive	
Emotions towards screening	Fear of cancer (not too high)	Embarrassing
		Fear of medical examination

Preferences of Patients Going Through the Screening Process

The next step in the participant's journey through screening is the diagnostic process itself. A study by Sicsic et al. [33] explores the preferences of women in terms of the harms and benefits of different techniques and identifies relevant factors: the number of deaths, the number of false positives, the risk of overdiagnosis, the time to go through screening, and the total number of mammographies as attributes that influence the experience of the women undergoing screening. Additionally, a factor more specific to the screening process itself is related to the anxiety provoked by the delay in getting results of diagnostic tests that was highlighted as a significant burden. Women emphasize the need for rapid screening and clear and efficient communication and, therefore, are willing to accept some discomfort [27].

Nevertheless, fewer studies have examined the effect of healthcare delivery attributes, such as attributes related to the appointment or the doctor or the communication of results. The results from these studies are mixed. There is a need for preference studies, for example, inpatient and physician communication, that may become more important as patient-centred care gains more prominence [26].

Recently, a protocol was issued [11] considering the full patient care approach, from entry to discharge, and aimed to focus on the interventions that can more directly contribute to improving the

patient experience throughout the examination. They mentioned that the following attributes may be relevant: 1) patient-staff interaction, 2) staff education, 3) breast compression and positioning, 4) patient preparation for mammography, 5) examination procedure, 6) physical environment and equipment, 7) relaxation techniques and analgesic care. The protocol also aims to identify outcomes related to the patient experience, such as *stress, discomfort, or pain.*

Goal of This Study

Even though breast cancer screening has the potential to reduce mortality due to cancer, many women do not go to screening due to several barriers, motivators and attributes related to the screening procedure itself. New techniques are being developed, and we would like to explore if they could encourage women to go to a screening and how we could organise the patient (=screener) journey to become more patient-centred. Additionally, we would like to address what attributes are relevant regarding patient preferences to render the screening process more patient-centred. Moreover, as novel techniques uses artificial intelligence (AI), we would like to find out what women need to trust this new diagnostic tool.

Our research questions, therefore, are:

What are the factors that influence undergoing screening?

How can we further enhance the screener experience for breast cancer screening in case of a novel procedure using AI?

Methods

Study Design

To answer the research question, we set up a study consisting of 4 parts (see Figure 2).

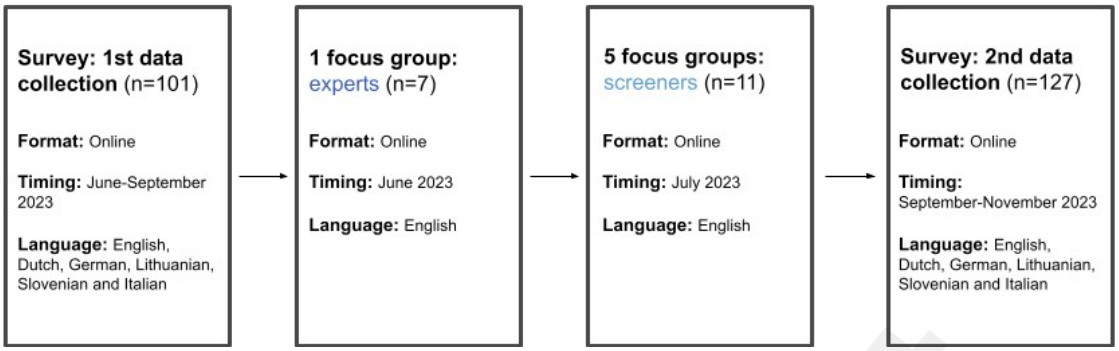
1. *Online survey* (N=101), which was used as a recruitment tool for focus groups. The topics addressed in the survey focused on awareness, facilitators and barriers towards mammography, which is the current most used screening technique and therefore the biggest competitor for thermography. Questions used were mainly inspired by a validated questionnaire by Mohamed et al. [29] and Kim's study [18]. Besides the recruitment, the survey serves as additional resources of information about barriers and facilitators in breast cancer screening.

2. *Online focus groups with experts* (N=7), digital health and human-computer interaction professionals, all women and part of the Vrije Universiteit Brussel (Belgium). The main goal was to gain explorative expert opinion about thermography with AI and serve as a pilot for the online focus group format. It helped to refine the focus group guide for the following phase.

3. *Online focus groups with potential screeners* (N=11 in total) across the ages and experience with breast cancer screening. During five focus group sessions, we collected feedback on improving the experience, covering the entire patient journey as suggested in Ding's [11] protocol above.

4. Second data collection for the *online survey* from the first part was done (N=127) which allowed us to gain more quantitative insights, resulting in 228 survey participants.

Figure 2: The overview of the study design including timing and number of participants.



Ethical Approval

Prior to the research, an approval [1] from the Health Research Ethics Board of University Hospital Brussels (UZ Brussels) was obtained on 22.6. 2023. All participants in both research methods (survey and focus groups) were provided with an informed consent form where they were informed of the purpose and procedures of the study, risks and benefits, the right to withdraw, confidentiality and privacy regulations. The survey answers of the participants were recorded anonymously to protect the identity of each participant. The collected email addresses for contacting participants interested in the focus groups were processed separately. The focus groups were recorded and subsequently transcribed verbatim by researchers, but the participants names were pseudonymized.

Sample Characteristics

Inclusion Criteria

To be included in this study, participants needed to be female, and 18 years old or older. This criterion allowed us to reach as many women who could potentially participate in the screening as possible. As the project [name not mentioned due to the blind review process], which this study is part of, aims to reach young women, it was important to highlight that all women older than 18 were welcome to participate, not only those considered at high risk. Although we acknowledge breast cancer among men, we decided to exclude them from the study and first focus only on women to cover the most significantly affected population.

For inclusion in the focus groups, the participants had to speak English to enable participation across Europe and gain diverse insights. The original English survey was also translated by project partners into Dutch, German, Lithuanian, Slovenian and Italian. By doing so, invitations for the survey were found to be inclusive for individuals of different backgrounds and cultures.

Dissemination

Participants for the survey were found through an email campaign, the project website, and a social media campaign posted on Facebook, WordPress, and LinkedIn. Once the survey was completed, participants were asked if they were willing to participate in an online focus group session and could indicate their preferences in time and date. The contact information was sent via Qualtrics to the study research team. The researchers contacted the participants to provide more information on the following phase of the study, including the link to the online focus group and to confirm their eligibility.

It is important to mention that the sample of this study should be perceived as a convenient sample and not a representative one, as we primarily attracted women who are digital literate (online survey

[1] No. 14320023000111

& focus group), already knowledgeable about breast cancer screening, have had an experience or are breast cancer believers.

Procedure

Survey: Conceptional Framework

The themes of the questions were adapted mainly from Kim's [18], Lim et al.'s [12] and Mohamed et al.'s [29] studies, such as *attitudes, awareness and knowledge* [18, 21]; *social networks and healthcare service providers* [18]; *personal and sociocultural factors* [13]; *cues to action* [22] that influence the motivators and barriers towards mammography, including also socio-demographic questions.

Participants were asked to complete a 10-minute survey consisting of 24-item questions ranging from multiple-choice and open questions to a five-point scale. Responses were collected and anonymized through an encrypted Qualtrics system.
11 questions were targeted to all respondents, while three questions were used for filter purposes. Six remaining questions were designated for women with mammography experience. At the same time, four were intended for women without prior mammography experience (the list of all questions can be found in the Multimedia Appendix 1).

Survey: Data Collection

The data collection was done continuously from 26.6. 2023 until 7.11. 2023, while the first part of the data collection (n=101) was analyzed at the beginning of September for preliminary results. Second data collection (n=127) was subsequently added to the dataset and was analyzed together, resulting in 228 valid answers.

Focus Groups: Conceptional Framework

In contrast to the survey, the focus groups' primary emphasis was on the thermography process itself, supplemented by insights gleaned from current practices. After the participants' introduction of participants and sharing of their past screening experiences, a short video that explained the novel thermography procedure was shown as a prompt to start the discussion.

Subsequently, the researcher moderated the discussion according to the semi-structured topic guide. These consisted of the following topics: first impression of this novel technique and the perceived comfort, the use of AI and trust in technology, the communication of the results afterwards and the different attributes of the process such as *patient-staff interaction*, *patient preparation for mammography examination procedure* (e.g. waiting time, examination time, clinical breast examination); *physical environment* (e.g. dressing room, decoration, music, lightning) and *relaxation techniques*, inspired by Ding's protocol [11].

Participants were invited via online Microsoft Teams invitation. Each session lasted for 60 minutes and was recorded with participants' consent to facilitate in-depth analysis. The focus groups were facilitated by a moderator, guiding the discussion, and a note-taker responsible for documenting key points.

Focus Groups: Data Collection and Participants

The pilot consisted of one group with seven women of different age groups. Two women had experience with screening, and five participants were non-screeners. The online focus groups with potential screeners contained data of 11 women who participated in five different groups. All participants had some screening experience (clinical examination, MRI, ultrasound,

mammography….). The names were pseudonymized, and E (for expert) and P (for participant) were abbreviations. For more details of the participants, please consult Table 2 below.

Table 2: List of participants in the online focus groups

Focus group #	Participant	Nationality	Age	BC Screening Experience
Pilot	E1	Dutch	32	None, but breast cancer in the family
	E2	Brazilian	33	Clinical examination; mammography experience heard from mother
	E3	Belgian	48	MRI, mammography, ultrasound
	E4	Dutch	25	None; experience heard from the family
	E5	Dutch	37	None
	E6	Belgian	45	None
	E7	Belgian	37	None, but breast cancer in the family
1	P1	Belgian	57	Regular mammography screener, breast cancer in the family
	P2	Dutch	49	BC patient, various screening experience: mammography, ultrasound, tomosynthesis, MRI
2	P3	US	63	MRI, mammography
3	P4	Montenegrin	25	BRCA gene; ultrasound, MRI
	P5	UK	49	BC patient, mammography, MRI, ultrasound
4	P6	/	54	BRCA gene, mammography, MRI, ultrasound
	P7	Spanish	25	Clinical examination
	P8	Dutch	55	BRCA gene, mammography
5	P9	/	62	Mammography
	P10	Spanish	66	History of BC, regular screener
	P11	Irish	53	Mammography

Analysis

Survey

Prior to the analysis, the data was cleaned. The responses that were not 100% finished were filled in by people identified as ‘man’ or ‘other’, who did not agree with informed consent or were try-out responses made by researchers (N=40) excluded from the analysis. In total, 40 responses were excluded. The final record of the finished responses after data cleaning was 228.

Open answers were extracted, coded in Microsoft Excel and subsequently added to the dataset. Given the nature of the sample, only descriptive statistics, such as frequencies and cross-tabulations were generated by SPSS software, version 29.0.

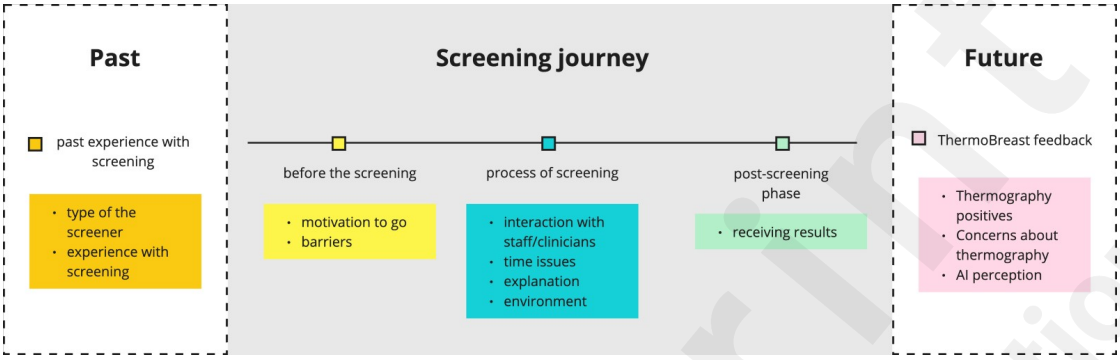
Focus Groups

The verbatim transcriptions were coded, which was done three phases (open coding, axial coding and selective coding) by two researchers [8] in MAXQDA2022 software. During coding, the research team developed a coding scheme inductively from the data and established a consensus on the final

coding scheme. This stage also included defining and naming the themes. In the final step, a written report of the final themes was produced.

The coding process resulted in 5 main categories: *past experience with screening*, *thermography feedback*, *before the screening*, *process of screening and post-screening phase*. While the two first codes refer to sharing previous experience and reaction to the new technology, the other three together refer to the ideal screening journey based on participants' suggestions. The coding scheme, including the subcodes, can be found in Figure 3 below.

Figure 3: Coding scheme based on the focus groups data



Results

Survey Results

Socio-economical Characteristics of the Sample

Women (n=228) in the sample were divided into two groups: screeners, who had previous experience (68%) with mammography and non-screeners (33%), who have not experienced the mammography screening yet.

Most of the participants were European and currently lived in Europe, in the city and had a university degree. For more details about the socio-economical characteristics, see the Table 3: Socio-economical Characteristics of the SampleTable 3.

Table 3: Socio-economical Characteristics of the Sample

Socio-economical Characteristics of the Sample (n=228)			
Average age	47,2 (SD=12)		
Screeners	53 (SD=8.8)		
Non-screeners	36 (SD=9.7)		
Origins			
European	94%		
Outside Europe (Congo, Pakistan, Peru, Philippines, UK, USA)	6%		
Current country of residence			
European	98%		
		Italy	55%
		Belgium	11%

		Ireland	11%
		Lithuania	7%
Outside Europe (USA, Australia)	2%		
Place of residence			
City	57%		
Rural areas	26%		
Towns and suburbs	17%		
Education			
University degree (bachelor's or higher)	69%		
Upper-secondary education and post-secondary education	28%		
Lower secondary education	2%		
Primary education	1%		

Awareness and Attitude Towards Screening

Even though most women (64%, n=228) were aware of what breast screening procedures were available near them, 36% did not know about their options or were not sure what was available. However, majority of women (98%, n=228), including those who were not aware of their options, found breast screening important.

The most frequent sources of information about breast cancer screening for women, who already experienced screening (n= 154) were doctors (79%), family and friends (41%) and internet (36 %). Among others (7%) work experience, screening programs, friends/family who had breast cancer and consultation with doctor were mentioned.

Motivators and Barriers Towards Mammography

Motivators

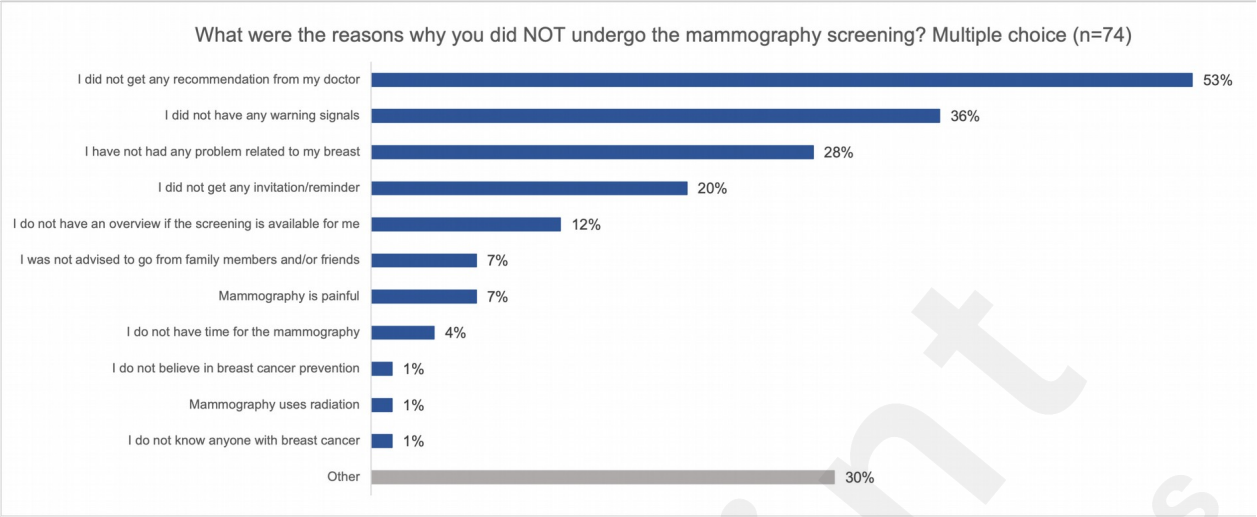
Personal values, such as belief in breast cancer prevention, were indicated as the main motivators (44%, n=154). The invitation from a screening program was selected by 29% of participants (n=154). Doctor's recommendation (20%) and breast cancer in the family (12%) were mentioned as other important factors.

Barriers

Most of the women who underwent the procedure did not indicate any discouragement from the mammography (86%, n=154). However, 21 screeners (14%, n=154) indicated the following barriers: pain during the procedure (n=7), long waiting for the appointment and availability (n=5), radiation and invasiveness (n=3), fear of cancer (n=2), not sufficient evidence (n=6), high cost (n=2) and behaviour of medical staff (n=1).

The most chosen reason for non-screeners (N=74) was no recommendation from a doctor (53%), no warning signals (36%) and no problems with breasts (28%), for more details see Graph 1.

Graph 1: Reasons why women did not go to the mammography; multiple choice question, non-screeners (n=74).



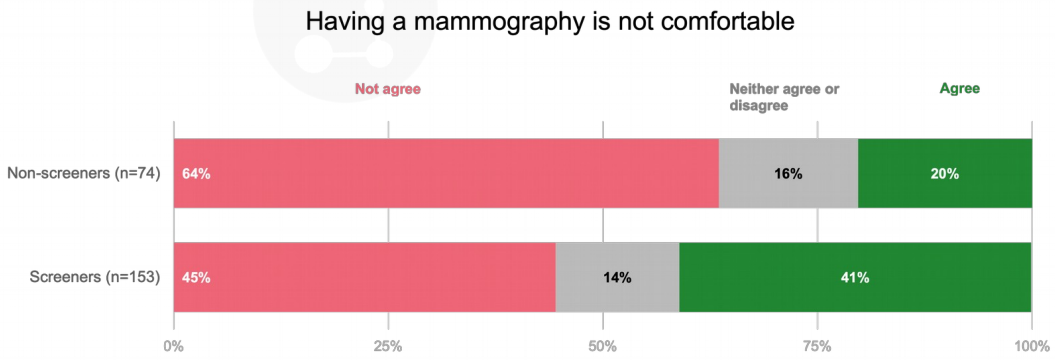
30% (n=74) of non-screeners indicated other barriers, which were not suggested in the survey, such as not sufficient age for mammography (23%, n=74), not thinking about the screening, cancelation of appointment due to covid, or medical condition that does not allow it. From women with no experience with mammography, only 3 indicated possible physical obstacles, such as “pain”, “prosthetics” and “depending on how long the procedure takes”.

Financial barriers were found to be insignificant factors in the decision-making process for mammography in this sample. A significant majority of respondents, 62% (n=227), disagreed that mammography is expensive, while only 12% (n=227) agreed. Additionally, concerns related to language, cultural understanding, and religious beliefs were not prominent deterrents. Specifically, 88% (n=227) of women in this sample expressed no fear that their doctor would not understand their language. Similarly, 89% (n=227) disagreed that their doctor would not understand their culture, and 93% (n=227) declined that mammography is not align with their religious beliefs.

Screening Experience

A larger proportion of screeners agreed with the statement that a mammography is not comfortable (see Graph 4), than non-screeners Graph 2.

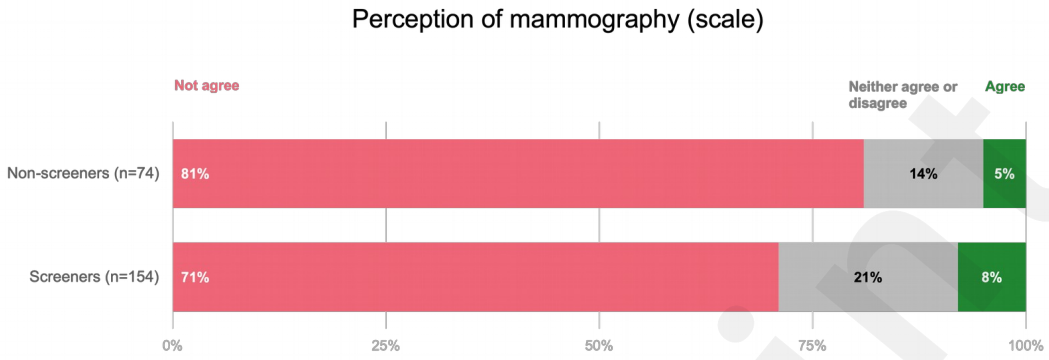
Graph 2: Results of the statement: Having a mammography is not comfortable, all women



Similarly, the scale of mammography perception adapted from Mohamed’s study [29] with four items, such as: “Having a mammography is embarrassing” or “Having a mammography is painful”,

scored negatively in both groups. As Cronbach's alpha score was 0.725, none of the items were removed. However, many of the participants did not agree with the statements. Concretely, 71% (n=154) for screener group and even bigger percentage 81% (n=74) in the non-screeners group (see Graph 3). Nevertheless, no significant difference, measured by a t-test was found.

Graph 3: Perception of mammography; scale results, comparison between screeners and non-screeners



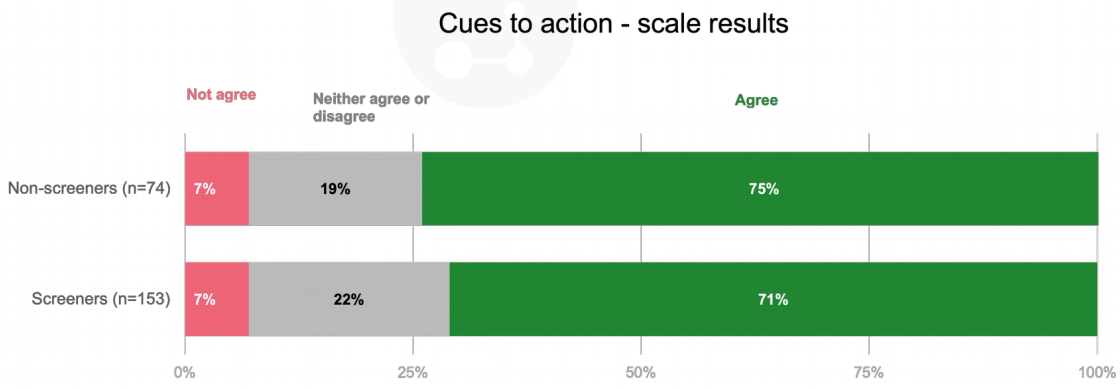
Furthermore, most screeners (59%, n=154) did not indicate any physical issues that would prevent them from having mammography. Five respondents mentioned specific obstacles, such as the size of their breasts and the inability to move their arm due to a frozen shoulder.

Prevention and Cues to Action

58% (n=228) of the participants had already received a reminder for breast cancer screening, and 2% (n=228) did not remember. For those who received the reminder (N=132), 88% of respondents indicated that the reminder helped them to make an appointment for the screening, while for 12% did not make the reminder a difference.

To see whether reminders would have an impact in the future, we used a cues-to-action scale from Mohamed's study [29] with five items, such as: "Reminder letter would help me to get a mammogram", "Routine educational talks regarding breast cancer awareness would help me to get a mammogram". After a Cronbach's alpha test, we excluded one item to enable the scale to perform better, resulting in a 0.746 score. Most respondents (72%, n=228) agreed with the statements, see Graph 4.

Graph 4: Cues to action; comparison between screeners and non-screeners, scale results



Focus Group Results

Past Experience with Screening

Most of the participants did experience some kind of screening (such as mammography, MRI, ultrasound and tomography). Some participants (P2, P5, P6, P9, P11) shared problems with discomfort and pain during the mammography, described as: “squeezing”, “smashing”, and “panini experience”. A few participants also mentioned their concerns about using X-rays and their willingness to understand why this is needed. More discomfort and “traumatic experience” were assigned to MRI, which was mentioned by four participants (E3, P2, P4, P5). On the other hand, ultrasound was described several times as the most comfortable method. Overall, almost all participants were well-disposed towards the idea of screening and found it important.

Before the Screening Phase

The motivation to go to the screening among our participants differed: two participants referred to the screening as their duty and something that they were supposed to do (P1, P3). Current patients of breast cancer (P2, P5) mentioned that once they went through all the screenings, they got used to it and did not think about it anymore (routine without thought). One of the main motivations to undergo the screening was breast cancer history in the family or genetic predisposition (P1, P4, P8, E1, E7). P1 also mentioned that people around encouraged her to go because of the cancer in her family.

The barriers mentioned by the participants were not so extensive, but several participants (P2, P10) pointed out the long waiting time for the screening appointment. For example, P2 said: “My most important problem was that I had to wait half a year... So, I felt something about a year ago and then it took six months before I could get a screening.”

Other participants also mentioned no need to go to the screening because they did not experience any problems (P2), were not old enough for mammography (P4), or were concerned that their breast size (both too big or too small) would not be ideal for screening (P1). One participant (P5) described the screening as “it's the worst day of the year … you know, you go for that screening, and you go with an elevated level of fear,” as she was referring to worry that the cancer would be found.

Process of Screening

The screening process consists of four main subtopics: interaction with staff/clinicians, time issues, explanation before and during the procedure and environment where the screening takes place. The results presented in following parts per topic.

Interaction with Medical Staff

During the focus groups, interaction with staff emerged as a prominent topic of discussion and was perceived as a potential barrier to screening. Most of the participants emphasized the *importance of good communication* and *sufficient explanation.* Notably, some participants (P3, P5) indicated that the quality of interaction and how well they were treated by medical staff is more important for them than the process of screening itself.

Participants across multiple focus groups (FG2, FG3, FG4, FG5) attributed ideal qualities to doctors, including being *friendly, kind, nice, empathetic, helpful, respectful,* and *positive*. They emphasized the importance of being able to ask questions and get full, comprehensible information. The guidance and explanation before and during the procedure were also positively perceived. For instance, one participant (P1) shared an experience where despite seeking clarification on the use of X-rays, the

explanation provided by the doctor remained unclear to her.: "…I don't understand, but I have to believe it."

Additional factors that could influence their interaction and level of comfort and trust during screening were identified by participants. These factors included the duration of their relationship with the doctor (P3, P5), the gender of the doctor (P4), and the doctor's level of experience (P3). For instance, P4 expressed initial apprehension about being examined by a male practitioner due to concerns about potential sexist behavior and the feeling of vulnerability it causes, while another (P3) emphasized the importance of the screener having experience in conducting breast examinations. Additionally, the inconsistency in seeing the same practitioner was noted as a potential factor affecting trust (P5).

Environment

Another important topic discussed among the participants was the environment where the screening takes place and how this could influence screeners' comfort during the procedure. Many participants (E3, P1, P2, P3, P4, P5, P9) welcomed the idea of possible adjustments according to their needs, such as *choice of music/podcast during procedure* (P1, P4, P5), *choice of (informative) movie/short film playing on the screen* (P2, P3, P9), *possibility to turn the lights on or off* (E1) or having the option to wear an additional robe for feeling less exposed (E1, E6).

Participant E6 highlighted the importance of inclusivity, suggesting that focus and distraction methods should be adjusted to the individual's needs (for example for those people with hearing impairment). Furthermore, E6 recommended creating a less clinical atmosphere, advocating for a spa-like experience with sauna robes for increased comfort.

"… I think it would be very nice if it would be both robes like in a sauna condition, because it gives a more cosy kind of feeling, more sheltered, because in an operation robe, I always feel very exposed even when I'm still wearing my trousers. So, I think that could be an extra added like more like agreeable. I don't say it will be a spa experience, but it will be more like a spa experience. And it's also, yeah, white robes are very cleanable, So, for medic… yeah, for hygiene standards, I think it's achievable."

However, some participants (E6, E5) expressed concerns that offering too many options might be overwhelming or trigger feelings of shyness during the procedure. Participants with prior screening experience, like P1 and P2, indicated they did not require extra care and prioritized efficiency over additional amenities. P1 stated, "Well, we are not small children where you have to pamper them..."

Regarding exposure and privacy during the screening, some participants (P2, P4, E6) were comfortable with nudity during the procedure, others viewed it as a sensitive issue. Suggestions to maintain dignity included providing additional robes, curtains, or private rooms without interruptions from other staff. See for instance, P9: "… just to make sure … because you're sitting there with nothing from your waist up that, that your… dignity is maintained ... and remember, this is for everybody, regardless of their race or their creed."

In summary, participants voiced varying preferences regarding environmental adjustments during screenings. While some advocated for personalized options to enhance comfort and inclusivity, others prioritized simplicity and efficiency. Additionally, concerns about maintaining privacy and dignity were underscored, prompting suggestions for measures to address these issues.

Explanation

Most participants emphasized the importance of understanding the procedure's steps and being informed about what occurs during the screening. They stressed the need to comprehend both the process beforehand and the ongoing events while undergoing the procedure. P7 specifically highlighted the significance of using clear and simple language during explanations: “[should be explained] in a simple language, not really using any jargon, any technical words, I think it would be very helpful, especially for older patients.” Participants 9 and 3 also stressed the value of enabling screeners to pose questions regarding the procedure and ensuring they receive satisfactory responses.

Time Issues

Some participants (P3, P6) highlighted the importance of minimizing the duration of the procedure. They suggested that screeners should be informed about the estimated length of the screening or any potential delays. For instance, participant P6 expressed frustration with lengthy wait times for receiving results, stating: “What I hate is that every time when I have to go for my results, I have to wait like a couple of hours before the doctor invites me in. So that's not that nice that there's no timing. So, I always have to calculate in half day.” Participant P2 also pointed out that shorter procedures help alleviate discomfort, saying, “…the mammography is very uncomfortable, I would say, but then it lasts only a few seconds, so it's not such a big deal.”

Post-screening Phase

Receiving Results

In the post-screening phase, particularly emphasized by participants with breast cancer experience, receiving results and the timing thereof emerged as a crucial aspect. Waiting for results was described as a stressful period, as described by P4:

“…there was an issue…, I mean, she put the wrong email. I don't know. So, they [the results] came three weeks later, and those two weeks that I had to wait extra were like a nightmare. Every notification I get on my phone. I thought it's the results and then disappointment that there were not.”

Preferences for receiving results varied, with some favoring a phone call for positive test results[2] (P8, P10), while others preferred email or text message for negative results (P8, P6, P10). However, the consistency of the communication channel was deemed more crucial (P4, P5), with a pre-agreed approach followed by doctors when conveying results.

Participants P2, P3, P10, and P11 stressed the importance of face-to-face explanation and interpretation of results by experts. Additionally, P1 and P2 suggested receiving a written summary of the results from the doctor during the meeting, facilitating retention of important information: “It would be nice to get some text you can remember afterwards... so you can tell your family” (P1).

Perception of Thermography

Thermography Positives

In general, the first impression after viewing the video about AI driven thermography was positive by all participants. They described the procedure as a good idea (P6, P10), game changer (P9), they liked that the procedure is noninvasive, there is no breast manipulation and it seems more comfortable (P2, P3, P4, P5, P8, P7, P9, P10, P11, E1, E2) than the regular ones they already heard

[2] By positive test result, we mean that cancer was found.

about. It was generally perceived as an “easier procedure” (P4, P8), “better experience” (P11) and “less traumatic” (P4). Several participants (P1, P3, P6, P9, E6) also mentioned the advantage of not using the radiation.

Concerns about Thermography

Various concerns were raised in the focus groups regarding the new technology. One concern is its novelty, with participants expressing the need for clinical evidence to assess its effectiveness and reliability before fully trusting the procedure (P2, P3, P5, P8, P10, P11, E6). Participants 2 and 3 also pointed out that the novelty of the machine can potentially affect other circumstances, such as the waiting time and the length of the procedure, see for instance P2:

“indeed this is one of the concerns that I would have... Is this a very expensive machine? Meaning that the hospital would have only one... Meaning, you'd have longer waiting list than the current methodology. Um... so this definitely would be a concern like, because it seems to be taking longer, you know...”

Some participants mentioned that being exposed in front of a camera could also be an issue for some women (P5, E1, E2, E3, E7, E6). See for example P5:

“I mean I think any screening device especially like MRI is really scary when you when you first look at it …you know to have these like cameras and then these fans, it might be a little bit overwhelming for some people as well.”

Participants P2, P4, P5, E3, E5, E6, E7 mentioned a need for more information about data sharing, concretely what data is collected exactly and how is it processed and stored, see for example E5:

“Even though it's a heat sensor, it will be like a heat based picture of your [breasts] So I mean, I know it's for health related reasons, but it's still a picture of your [breasts] even though it's not like a normal picture.”

Finally, many participants highlighted a cold temperature during procedure as a possible problem (P1, P2, P5, P9, P10, P11, E4, E7). As a possible solution, Participants 1 and 2 suggested to show countdown of the cold air on the screen.

AI Perception

The usage of artificial intelligence was perceived rather neutrally (P4, P5, P9, E5) to positively (P1, P2, P3, P6, P8, P10), however participants were seeking more information and explanation of how the AI in the thermography work (P2, P3, P4, P11), see for instance P2:

“I mean I would like to know a little bit more about the AI, I guess I mean it's just a very brief mention at the end like then I will look at it and you know... Voilà... everything will be solved... [laugh] and I would like to perhaps know a little bit more about how that works.”

Nevertheless, certain conditions in order to trust the thermography with AI were mentioned, such as it is well trained on a large data set (P2, P8) and it relies on collaboration with a human expert; doctor (P2, P3, P5, P10, E1, E4).

Discussion

Principal Results

In this study, we explored women's experience of mammography screening and the motivators and barriers that influence undergoing it. These quantitative and qualitative insights helped us to discover crucial factors that affect the screener journey and which of these should be taken into account developing new screening technologies.

The results from the survey revealed that personal values (such as believing in breast cancer prevention) was the main reason for going to the screening together with invitation from a screening program and recommendation from a doctor. In addition, information about breast cancer screening is mainly gained from doctors, following family and friends and internet, as indicated by screeners in the sample. Reminder from screening program also showed a positive impact on prevention, as a vast majority of women agreed that it would help them to get a mammography.

On the other hand, the main reasons not to go to screening were no doctor's recommendation or warning signals or considering they did not have any problem with their breasts. Trust in the healthcare system, good relationship with the doctors is therefore critical, as they can influence the decision. Among other barriers, older age was indicated as another important factor, which signs an opportunity for thermography, as mammography is not suitable for young women yet.

Overall, women who already had an experience did not indicate any discouragement from mammography. However, some of these women indicated the following issues: pain/discomfort, long waiting for the appointment, radiation, fear, not sufficient evidence, cost, and behavior of medical staff.

Regarding perception of mammography screening, the majority did not see the procedure as embarrassing, source of worry or time consuming, with only slight differences between women who underwent mammography already or not towards more positive perception of women without experience. Specifically, 41% (n=153) of screeners perceived it as a not comfortable procedure in comparison to 20% (n=74) of no screeners. We can therefore conclude that after experiencing mammography, pain is rated higher as a barrier and the perception of discomfort is stronger. Nevertheless, no significant difference was found. The remaining barriers, such as religion, language or culture, and financial aspects, were not relevant to this sample. However, the sampling method did not target vulnerable groups, such as women with migration backgrounds or economically disadvantaged women, for whom these factors could be crucial.

Mammography remains the most recognizable screening technique among participants, recognized by 93% (n=228). Most women also indicated they know what options are available near them (64 %, n=228). However, we found a group of women (36 %, n=228) who, despite their belief in breast cancer prevention, did not know what procedures were available for them, which can indicate a problem of not reaching all women with information about prevention programs and their options.

Findings also suggest that pain and discomfort are the most relevant barriers for a group of regular screeners who display a high level of awareness, especially after a mammography experience. However, in the case of a strong belief in prevention might have little influence on the decision to proceed with screening. The insights align with the literature that women are prepared to tolerate

[26] pain and discomfort that goes with mammography to have peace of mind. Moreover, this pain and discomfort are rather underestimated in the absence of experience.
To improve the uptake for screening in a population of aware and educated women, one should focus on invitations and recommendations by the doctor via various channels (such as a letter, e-mail, online invitation,…). As long waiting and availability were also identified as barriers for screeners (24%, n=21); therefore, focusing on making an overview of availability, for example, via the online calendar, to avoid confusion, simplify the booking and provide realistic expectations is also critical.

Following the problem with the waiting time and availability, it was also a point of discussion during the focus groups. Overall, the data showed that attributes that women valued most during the screening process were related to the interaction with staff, timely organization, and the debriefing of the results.

Regarding the interaction with staff, screeners expect the medical personnel to be kind and provide full information in understandable language. Moreover, the way how screeners are treated by medical staff is more important than the technology itself. Additional factors such as a longer relationship with the doctor, his/her experience or gender constitute possible factors of trust.

For regular screeners, an efficient organization of the screening process, in terms of waiting time on the appointment and the screening being performed as quickly as possible, is welcomed. Similarly, they appreciated being informed over the duration of the screening or being alerted about a delay.

The third attribute that was crucial to them was how the results were communicated. Although they expressed different preferences regarding the channel of communication, speed, pre-agreed way of communication and full explanation are key. This is in line with previous research that refers to the anxiety that goes with waiting for the results experienced as a significant burden [28].

Additional elements related to the environment, such as the choice of music, a movie, a robe, or a less clinical decoration, were appreciated, too, providing a sense of control in the process. Similarly, women appreciate an explanation of the process so they know what will come. We would like to mention, however, that these topics were proposed mainly by a group of experts who had less experience with screening. Similarly, the cold and the exposure that might constitute possible negatives from the novel technique were issues being discussed mostly by the group of experts. This is in line with previous studies indicating that women are willing to accept some discomfort in return for the benefit of earlier diagnosis, which might be more pronounced for the participants of the focus group, where women are patients, have family members with cancer, or genetic mutations are present [28].

We assume that first-time screeners may appreciate explanations and small changes in the environment more than regular screeners, who are personally involved, which was also supported by quantitative data, where non-screeners perceived mammography procedure more positively than women who already experienced it.

In general, we observed a positive reaction towards the new technique, which is perceived as non-invasive and more comfortable than current mammography. Also, the absence of radiation was appreciated. However, we noticed some concerns that this technique is relatively new, which could influence the time to appointment and the reliability of the results in terms of clinical proof.

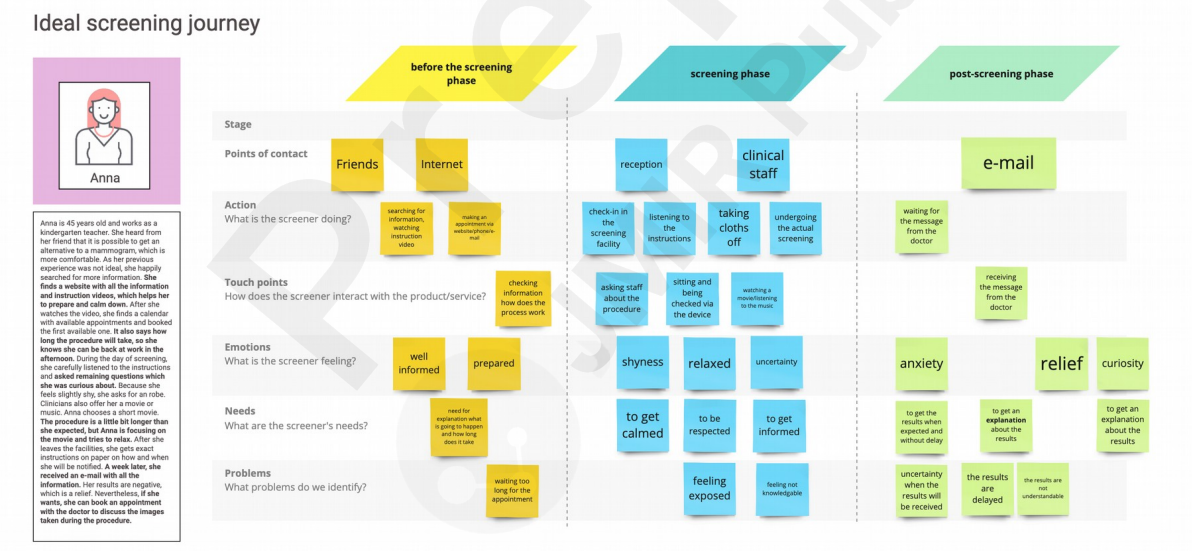
Ideal Screening Journey and Future Research

Based on the insights from the focus groups and the survey, we suggest an updated breast cancer screening journey (see Figure 4). As our sample was mainly highly educated breast cancer prevention believers, their barriers were limited. However, one of the frequent barriers mentioned in the non-screeners group was age (77 %, n=22), which varies in most European countries from 45 to 50. We focused on a target population who is 45 years old and is looking for an alternative to a mammogram. The slight differences in each phase include sufficient preparation and information before the procedure, which is easily available because, as we found out in the survey, even though women were screening believers, they did not know what options were available.

Moreover, booking the procedure has multiple options based on convenience: booking online, via phone or e-mail. The screening phase is enriched by empathetic interaction with clinical staff so she can feel calm and respected, which was identified as a crucial factor during focus groups. Receiving results in a pre-agreed way was another important factor mentioned in the focus groups; therefore, we added in the post-screening phase that Anna receives her results when expected and how expected with a sufficient explanation.

This enhanced breast cancer journey specific to thermography experience, however, still needs to be validated. Furthermore, as we discovered slight differences between the women of the focus and the expert's group, we would like to explore the creation of different screener journeys for different personas.

Figure 4: Proposed screening journey based on the insights from both qualitative and quantitative data



Conclusions and Limitations

As thermography can be a future alternative to mammography for a broader audience, the current mammography experience, including barriers and motivators, helped us understand the current procedure's limitations and room for improvement, such as a regular invitation for screening, time efficient organization, empathetic interaction with the clinical staff and an informative and consistent feedback of results.

Even though thermography offers an opportunity for certain groups who currently cannot undergo

mammography, such as younger women and immobile women, there are still barriers mentioned (such as frozen shoulder remarked in the survey) for which this technology cannot help. Moreover, there was a need for evidence of the reliability of the technique in order to trust it more. Also, as we found out, the technology itself is only part of the procedure, and there are other relevant factors that need to be taken into account, such as the atmosphere and treatment from medical staff. Still, many women welcomed the idea of a less invasive and simpler procedure than current practices.

In future research activities, we would like to find ways to mitigate underrepresentation of different groups: to get enough feedback from people with lower educational degrees and disadvantaged socioeconomic characteristics, as well as men and younger women with a lower awareness of the new potential for their target group with the new screening technologies under development.

Acknowledgements

We would like to thank all women, who participated in our research.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Health and Digital Executive Agency (HaDEA). Neither the European Union nor the granting authority can be held responsible for them (grant agreement no. 101096329).

Conflicts of Interest

None declared.

Abbreviations

AI – artificial intelligence
BC – breast cancer
DBT - digital breast tomosynthesis
E - expert
MRI – magnetic resonance imaging
P - participant

Multimedia Appendix 1

See the supplementary material document.

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Supplementary Files

Multimedia Appendixes

Survey questions and focus group guide.
URL: http://asset.jmir.pub/assets/8f47d88a0f1c66049524514f6386a97d.docx