Artificial Intelligence (AI) and Machine learning (ML) for optimising cancer imaging: A User Experience (UX) study

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Abstract

Background: The need for increased clinical efficacy and efficiency has been the main force behind the development of Artificial Intelligence (AI) in medical imaging. The INCISIVE project is an EU-funded initiative that aims to revolutionize cancer imaging methods using AI technology. It seeks to address limitations in current imaging techniques by developing an AI-based toolbox that improves accuracy, specificity, sensitivity, interpretability, and cost-effectiveness. To ensure successful implementation of this new AI service, a study was conducted to understand the needs, challenges, and expectations of healthcare professionals (HCPs) regarding the proposed INCISIVE toolbox and any potential implementation barriers. By considering the perspective of end-users, INCISIVE aims to develop a solution that effectively meets their needs and drives adoption.

Objective: To understand the needs, challenges, and expectations of healthcare professionals (HCPs) regarding the proposed INCISIVE toolbox and any potential implementation barriers.

Methods: A mixed-method research study consisting of two phases was conducted. Phase one involved UX design workshops with users of the INCISIVE AI toolbox. Phase two involved a Delphi study conducted through a series of sequential questionnaires. To recruit participants, a purposive sampling strategy based on the knowledge of the project's consortium was employed. Sixteen HCPs from Serbia, Italy, Greece, Cyprus, Spain, and the UK participated in the UX design workshops and 12 completed the Delphi study. Descriptive statistics were performed using SPSS, enabling the calculation of mean rank scores of the lists generated by the Delphi study. The qualitative data collected via the UX design workshops was analysed using NVivo 12 software.

Results: The workshops facilitated brainstorming and identification of the INCISIVE AI toolbox desired features and implementation barriers, while the Delphi study allowed for prioritisation of these features and implementation barriers based on end users' perspective. Key findings indicated that the INCISIVE AI toolbox could assist in areas such as misdiagnosis, overdiagnosis, delays in diagnosis, detection of minor lesions, decision-making in disagreement, treatment allocation, disease prognosis, prediction, treatment response prediction, and care integration throughout the patient journey. Several barriers to successful implementation were identified, including limited resources, lack of organizational and managerial support, and data entry variability. HCPs also had an explicit interest in AI explainability, desiring feature relevance explanations or a combination of feature relevance and visual explanations within the toolbox.

Conclusions: The results provide a thorough examination of the INCISIVE AI toolbox's design elements as required by the end users and potential barriers to its implementation, thus guiding the design and implementation of the INCISIVE technology. The outcome offers information about the degree of AI explainability required of the INCISIVE AI toolbox across the 3 services (Initial Diagnosis, Disease Staging, Differentiation, and Characterization, and Treatment and Follow-up) indicated for the

toolbox. Clinical Trial: Not Applicable

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ABSTRACT

Background: The need for increased clinical efficacy and efficiency has been the main force behind the development of Artificial Intelligence (AI) in medical imaging. The INCISIVE project is an EU-funded initiative that aims to revolutionize cancer imaging methods using AI technology. It seeks to address limitations in current imaging techniques by developing an AI-based toolbox that improves accuracy, specificity, sensitivity, interpretability, and cost-effectiveness.

Objective: To ensure successful implementation of INCISIVE AI service, a study was conducted to understand the needs, challenges, and expectations of healthcare professionals regarding the proposed toolbox and any potential implementation barriers.

Methods: A mixed-method research study consisting of two phases was conducted. Phase one involved UX design workshops with users of the INCISIVE AI toolbox. Phase two involved a Delphi study conducted through a series of sequential questionnaires. To recruit participants, a purposive sampling strategy based on the network of the project's consortium was employed. Sixteen healthcare professionals from Serbia, Italy, Greece, Cyprus, Spain, and the UK participated in the UX design workshops and 12 completed the Delphi study. Descriptive statistics were performed using SPSS, enabling the calculation of mean rank scores of the lists generated by the Delphi study. The qualitative data collected via the UX design workshops was analysed using NVivo 12 software.

Results: The workshops facilitated brainstorming and identification of the INCISIVE AI toolbox desired features and implementation barriers. Subsequently, the Delphi study was instrumental in ranking these features, showing a strong consensus among healthcare professionals ($W = 0.741$, $P < .001$). Additionally, the study also identified implementation barriers, revealing a strong consensus among healthcare professionals ($W = 0.705$, $P < .001$). Key findings indicated that the INCISIVE AI toolbox could assist in areas such as misdiagnosis, overdiagnosis, delays in diagnosis, detection of minor lesions, decision-making in disagreement, treatment allocation, disease prognosis, prediction, treatment response prediction, and care integration throughout the patient journey. Limited resources, lack of organizational and managerial support, and data entry variability were some of the identified barriers. Healthcare professionals also had an explicit interest in AI explainability, desiring feature relevance explanations or a combination of feature relevance and visual explanations within the toolbox.

Conclusions: The results provide a thorough examination of the INCISIVE AI toolbox's design elements as required by the end users and potential barriers to its implementation, thus guiding the

design and implementation of the INCISIVE technology. The outcome offers information about the degree of AI explainability required of the INCISIVE AI toolbox across the 3 services (i)Initial Diagnosis, ii) Disease Staging, Differentiation, and Characterization, and iii) Treatment and Follow-up) indicated for the toolbox. By considering the perspective of end-users, INCISIVE aims to develop a solution that effectively meets their needs and drives adoption.

Key words: Artificial Intelligence, Cancer, Cancer Imaging, UX design workshops, Delphi method, Healthcare professionals.

Introduction

Cancer offers a unique context for medical decisions because of its diverse forms and disease evolution, as well as the requirement to consider each patient's illness, their ability to receive medical care, accurate treatment responses, early detection, tumour classification/characterization, prediction of local, recurrent, or metastatic tumour progression, precise assessment of treatment strategies and the follow-up monitoring of cancer. These hindrances persists despite advancements in technology [1].

Medical imaging plays a crucial role in the comprehensive treatment of cancer procedures as it provides valuable insights into the morphology, structure, metabolism, and functions of cancers [2], [3]. Notably, medical imaging assists healthcare providers in defining treatment plans, assessing their effectiveness, and guiding follow-up interventions. The increasing amount and availability of collected data (cancer imaging data) and the development of novel technological tools based on Artificial Intelligence (AI) and Machine Learning (ML), provide unprecedented opportunities for better cancer detection and classification, image optimisation, radiation reduction, and clinical workflow enhancement [2].

The current imaging methods may be improved by identifying findings either detectable or not by the human eye and moving from a subjective perceptual skill to a more objective one [2]. To date, related existing research and innovation initiatives, are only limited to small scale demonstrations, without adequately being validated for reproducibility and generalisability and without exploring large datasets [4]. Therefore, the INCISIVE project [5] has been designed in order to explore the full potential of AI based solutions/technologies in cancer imaging. The main outcome of this project is to design and develop an improved AI-based technology in order to address the ongoing challenges of accurate and early detection of cancer, recurrence and treatment success/failure.

The design and functionalities of the INCISIVE AI toolbox was developed by incorporating the users' perspective and experiences. Therefore, the main objective of this study was to gain a comprehensive understanding of the needs of the users, with a specific focus on healthcare professionals who would utilize the INCISIVE AI toolbox. Additionally, insights from healthcare professionals were sought to achieve consensus on crucial features of the toolbox, barriers to implementation and potential users.

An overview about the INCISIVE project

The INCISIVE project [5], funded by the EU's Horizon 2020 programme across nine European nations, aims to develop and validate an AI-based toolbox to enhance the accuracy, sensitivity, specificity, interpretability, and cost-effectiveness of cancer imaging methods. The project focuses on breast, prostate, lung, and colorectal cancers [5,].

Methods

This was a two-phase study conducted concurrently. Phase one entailed conducting UX design workshops, whereas phase two entailed leading a Delphi study with healthcare professionals who were the potential users of the INCISIVE AI toolbox.

Phase one: User Experience (UX) design workshops for INCISIVE AI toolbox potential users- i.e.: healthcare professionals

Study design

A qualitative research approach was used to facilitate UX design workshops across the five validation countries of the INCISIVE project (Greece, Cyprus, Spain, Italy, and Serbia), in addition to the United Kingdom (UK), which is also a partner of the INCISIVE project. The workshops followed a structured design thinking [6],[7] approach, utilizing various methodological tools to guide participants through the problem-solving process. Techniques such as empathizing with users, defining the problem, brainstorming ideas, prototyping, and testing were employed. As the project was in the concept stage, the design thinking method was applied up to the ideate stage, focusing on generating innovative solutions for the development of the INCISIVE AI toolbox for cancer care.

Participants and recruitment

A purposive sampling strategy based on the network of the INCISIVE consortium was used to recruit participants. Eligibility criteria included being a medical professional, specifically a general practitioner, radiologist, oncologist, or nuclear medicine physician. Participants were also required to have no prior involvement or affiliation with the INCISIVE project. Through nominations from the INCISIVE partners, potential participants were invited to the workshops via email, receiving a detailed participant information sheet (PIS), a consent form, and a link to access the workshop meetings. The PIS outlined the study's objectives and workshop agenda, while the consent form ensured volunteer participation. The participants were required to send their consent form prior to conducting the workshops.

Data collection tool

Different use case scenarios (Appendix 1) were prepared to facilitate discussion for each workshop with potential users of the AI toolbox. The use case scenarios focused on the patient journey and aimed to elicit information about practice challenges, needs, design features for the AI toolbox, and the level of AI explainability required for the different services suggested to be offered by the toolbox, which were: initial diagnosis, disease staging and characterization, and treatment and follow-up. The use case scenarios were circulated by the research team among the consortium for feedback and refinement. The definite issues (practice challenges, needs, INCISIVE AI toolbox design features, and the level of AI explainability required from the toolbox across potential services) that emerged during various work packages in the INCISIVE project were included in the workshops.

Sample size

The sample size in the present study did not depend on statistical power, but rather on group dynamics among experts [8]. Group discussions in UX design workshops allowed for exploration of user’s experiences, concerns and opinions about specific topics and were distinguished by the explicit use of group interaction to generate rich experiential data. Therefore, the current study involved a small number of representative end users in each workshop. This approach ensured that there was adequate time for in-depth discussions when addressing requirements. Importantly, this method followed a qualitative approach that relied on the concept of data saturation, rather than sample size.

Data collection

Data collection took place between August and September 2021. Workshops were conducted online using Microsoft (MS) Teams. The meeting link was sent via email by the research team. Four workshops were conducted, one workshop for each cancer type targeted by INCISIVE (breast, lung, colorectal, and prostate cancer). The research team facilitated and moderated workshops. Each workshop consisted of a panel of 4 participants. Some members from the INCISIVE consortium joined as observers and were able to ask questions and contribute to the discussion in the workshops via the chat functionality. Each workshop lasted an average of 60–90 minutes. The participants were provided with a small presentation about various techniques and terminologies to facilitate discussion about AI explainability during the workshops.

Data analysis

The workshops were audio-recorded and transcribed verbatim for analysis. Transcripts were entered into the NVivo 12 software for data organisation and management. This was followed by collating, synthesizing, and editing emergent ideas to achieve consistent terminology among items expressing similar ideas. The final step involved grouping the generated ideas and items into emerging categories.

Ethical considerations

Ethical approval for conducting this study was granted by the Research Ethics Committee at Kingston University on August 11, 2021 (reference no. 2877). All other INCISIVE partners did not require any extra layer of ethics for this study. Informed consent forms were provided to participants prior to the commencement of the study. Participant information was safeguarded through coding, encryption, and secure storage practices. No compensation was provided for study participants.

Phase two: Delphi study- Identification and prioritisation of INCISIVE features, implementation barriers and potential user groups.

Study design

This phase employed a mixed methods approach, specifically a modified Delphi approach. The Delphi approach is a systematic method for obtaining, exchanging, and developing informed opinions on a specific issue or set of issues [9]. In this study, a modified ranking-type Delphi approach was used, which aimed at developing group consensus on the relative importance of INCISIVE features, barriers and potential user groups [8]. It consisted of four rounds. Round 1 involved administering an open-ended questionnaire to the healthcare professionals (Appendix 2). Round 2 entailed circulating the anonymized summaries of responses back to the experts for verification. Rounds 3 and 4 involved distilling the most important items chosen by the participants followed by ranking these items.

Participants and recruitment

Healthcare professionals involved in cancer care were included in this phase. The recruitment of healthcare professionals was done through nominations by INCISIVE partners, following the same inclusion criteria of the UX workshops. The nominated participants received the necessary documentation, including the consent firm and the PIS from the research team and were required to sign the consent form before starting the study.

Sample size

The sample size in the Delphi method does not depend on statistical power but rather on group dynamics for achieving consensus among experts [8].Thus, the Delphi literature recommends 10–18 experts for a panel or group of experts within a specific discipline [8], [10].

Data collection and data collection tools

Data collection took place between August and September 2021. Delphi is a form of iterative enquiry that builds on ongoing data collection. Its primary research tool is a series of questionnaires built from participants' stepwise input [10].Questionnaires were electronically administered via email. The sequence of administration of these questionnaires (i.e., data collection) was in accordance with the Delphi literature as highlighted in figure 1 [8], [10].The first questionnaire was sent once the participant agreed to take part and signed the consent form. Questionnaire 1, focused on item generation, required a maximum of 15 minutes to complete, while questionnaires 2 to 4, which involved verification and ranking, took no more than 10 minutes unless participants chose to provide additional explanations for their answers.

Questionnaire 1: generation of items/ initial collection of items

This questionnaire included three open-ended questions (Appendix 2), about anticipated barriers for the toolbox implementation, essential features required in the INCISIVE AI toolbox, and healthcare professionals who should use the INCISIVE AI toolbox. Healthcare professionals were asked to list at least six items for each question, followed by a brief explanation of their choices.

Questionnaire 2: validation of categorised items

This questionnaire was designed based on the responses obtained from the first round and aimed to strengthen the construct validity according to the concept of "member checking" [10]. This questionnaire included all the consolidated lists obtained from the first questionnaire, with the corresponding categorization. For each list, each item was presented with a brief explanation based on information provided by healthcare professionals in the first round. Healthcare professionals were sent questionnaire 2 alongside an exact copy of their responses to the first questionnaire and were asked: (1) to verify their responses and confirm that items have been placed in an appropriate category and (2) to review the categorizations and suggest refinements or additional items if necessary.

Questionnaire 3: prioritising items/ choosing most important items.

Questionnaire 3 presented the refined, consolidated lists produced from questionnaire 2. Each participant was asked to select (not rank) 10 items from each list that they considered the most important.

Questionnaire 4: ranking items

The questionnaire was designed based on the responses obtained in round 3. The experts were sent the relevant lists with the most important items. Each expert was instructed to rank items in numerical order (importance ranking) by putting the number 1 for the first most important item, 2 for the second most important item, 3 for the third most important item, and so on, with a lower ranking indicating more importance. Hence, each expert individually submitted a rank order of the items of each list, one for each of the relevant lists. They were also requested to provide comments justifying their rankings.

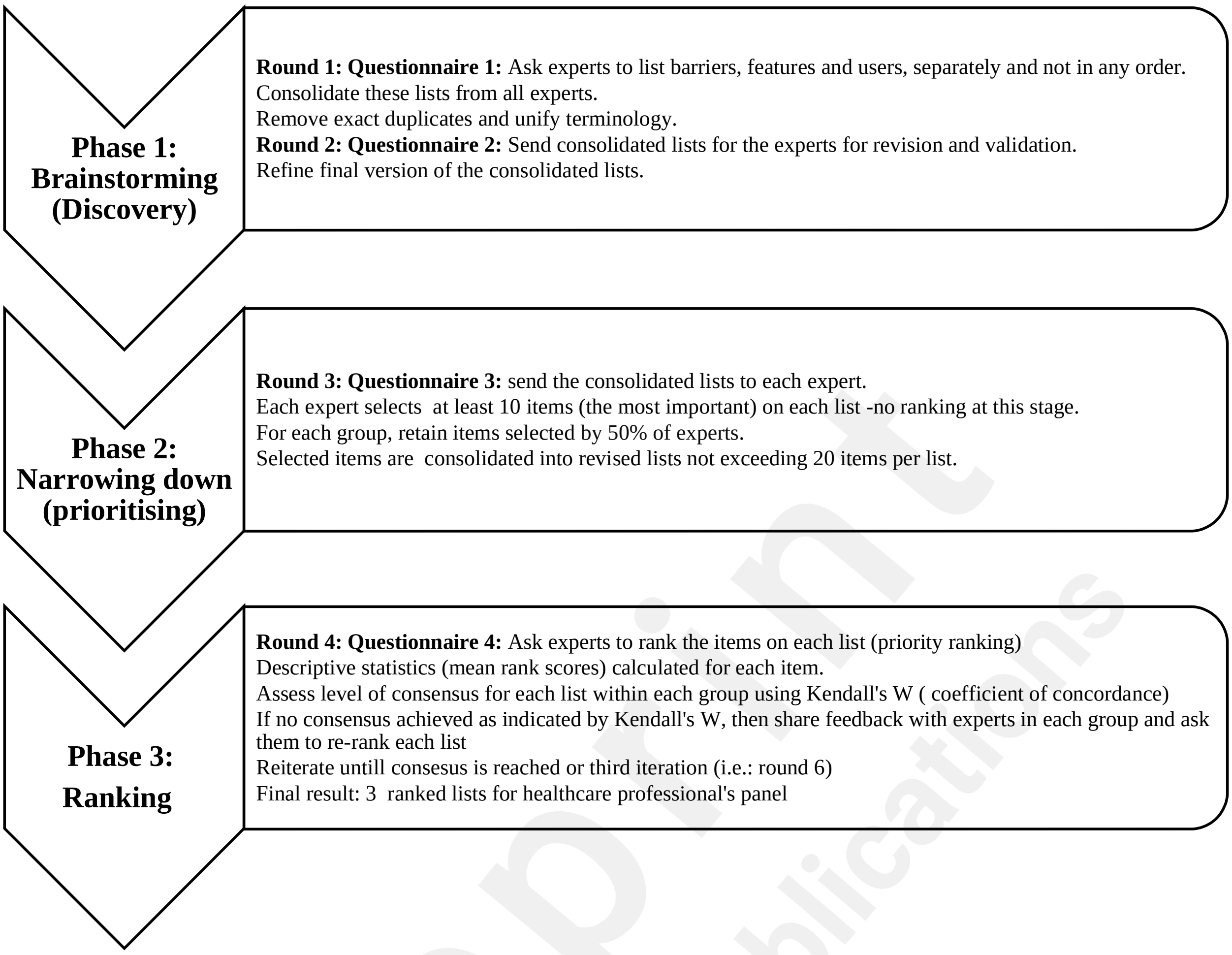

Figure (1): Delphi study administration process [adapted from [8], [10]]

Data analysis

Questionnaire 1: All data (items and explanations) were entered into the NVivo 12 software for data organisation and management. The analysis entailed the removal of identical responses, then collating, synthesising, and editing the remaining ideas to achieve consistent terminology among items expressing similar ideas. The final step entailed grouping items into emerging categories. As a result, a consolidated preliminary version of the lists with relevant categories was created.

Questionnaire 2: Based on responses from questionnaire 1, items were further refined. This resulted in the formation of the final consolidated lists.

Questionnaire 3: Items selected by over 50% of the experts in the panel were retained. According to the literature, the list size should not exceed 20 items to avoid burdening the participants in the next round [8], [10].

Questionnaire 4: Descriptive statistics, such as mean rank scores, were calculated to assess the relative importance of items within each list, and Kendall's W coefficient of concordance was used to measure consensus among the experts. The ranking process was repeated until a strong level of agreement (W ≥0.7) was achieved or until the third iteration was reached. The research team obtained three ranked lists, providing valuable insights and consensus on important aspects of INCISIVE implementation and the AI toolbox.

Ethical considerations

Ethical approval for conducting this study was granted by the Research Ethics Committee at Kingston University on August 16, 2021 (reference No. 2863). All other INCISIVE partners did not require any extra layer of ethics for this study. Informed consent forms were provided to participants prior to the commencement of the study. Participant information was safeguarded through coding, encryption, and secure storage practices. No compensation was provided for study participants.

Results

Phase one: User Experience (UX) design workshops for INCISIVE AI toolbox potential users- i.e.: healthcare professionals

1.1 Participants' characteristics

Four workshops were conducted for the INCISIVE AI toolbox; one workshop for each cancer type targeted in the project: breast, lung, colorectal and prostate cancer. A total of 16 healthcare professionals participated in the four workshops. Table 1 provides a summary of the participants' characteristics.

Table 1: Characteristics of healthcare professionals who participated in the INCISIVE AI toolbox workshops (n=16)

Participants' characteristics		Number
Gender	Male	8
	Female	8
Country	UK	1
	Serbia	1
	Italy	5
	Greece	6
	Spain	1
	Cyprus	1
Speciality/	General Practitioner/ doctor	3

occupation	Radiologist	5
	Oncologist	4
	Radiation oncologist/ therapeutic radiographer/ radiotherapist	1
	Nuclear medicine physician	2
	Urologist	1

Features of the INCISIVE AI toolbox, irrespective of cancer type

Generic features required for the INCISIVE AI toolbox: The below section details the practice challenges, needs, and generic design features required from the INCISIVE AI toolbox across the 3 main potential services.

Service 1: Initial diagnosis

Several challenges were highlighted by the participants at this stage. These included lack of resources in terms of necessary tests in primary care, especially in rural areas, misdiagnosis, delay in diagnosis, lack of expertise/failure to recognise potential cancer symptoms, and low sensitivity of some imaging modalities. In order to tackle these issues, the participants envisaged that INCISIVE AI toolbox can help in several ways including: guiding healthcare professionals in primary care in the management and referral of patients mainly in terms of providing a clear protocol on the next steps to be done based on the available data at this stage, reduce the chances of misdiagnosis, reduce the chances of overdiagnosis as well avoiding unnecessary anxiety among patients. In order to promote the efficiency of the pathway, it was discussed that if all health care professionals involved in the pathway have access to INCISIVE AI toolbox, secondary care health professionals can view the tests and images that have already been performed in primary care and take appropriate action to prevent work duplication and loss of time and money. The detailed explanation of this can be found in Multimedia Appendix 1.

Multimedia Appendix 1: Practice challenges, needs, and generic features of the INCISIVE AI toolbox at initial diagnosis

Service 2: Disease staging, differentiation, and characterisation

At this point, several issues were also brought to light, including a lack of resources, particularly imaging equipment, which can cause delays in obtaining the necessary images in a timely manner. Additionally, the proficiency of radiologists in interpreting imaging results and histopathologists in interpreting biopsy results was emphasized as a critical component. Consequently, finding the most accessible/suitable site/area to do a biopsy, lack of experience among some radiologists and histopathologists, certain imaging modalities such as CT, MRI, and US, have low sensitivity, making it difficult for healthcare professionals to distinguish between benign and malignant lesions. The participants anticipated that the INCISIVE AI toolbox would benefit them in a number of ways, such as enhancing the accuracy of the current imaging tests by identifying small lesions that health care professionals might otherwise overlook or lesions that are difficult or confusing for them to identify using the current imaging modalities, assistance with TNM staging and categorization, advice regarding the best places to biopsy, guidance regarding the best imaging tests to run on the patient, support decision making in cases of disagreement or contradiction of the results generated by the different imaging modalities and tests. For instance, when the results of an imaging test and a biopsy contradict. Multimedia Appendix 2 has an extensive overview of this service. Multimedia Appendix 3 contains specific features needed for each type of tumour.

Multimedia Appendix 2: Practice challenges, needs, and generic features of the INCISIVE AI toolbox at Disease staging, differentiation, and characterisation

Multimedia Appendix 3: Specific features required for the INCISIVE AI toolbox at disease staging, differentiation, and characterisation.

Service 3: Treatment and follow-up

The challenges in this stage were disease treatment in terms of timing, best treatment options/choices and response, in addition to disease prognosis. Certain participants asserted that treatment options were typically decided upon at multidisciplinary team (MDT) board meetings, which could be cumbersome to set up and coordinate in terms of paperwork and board member availability, among other factors. This in return might lead to delay in treatment initiation for patients. Fragmentation of care occurs when healthcare professionals are unable to see or do not have access to the detailed work performed by other healthcare professionals, which is crucial for supporting treatment decisions.

The INCISIVE AI toolkit was envisaged by the participants to be helpful in a variety of ways at this point, such as aiding in the allocation of treatments, serving as a guide for decision support, predicting the prognosis of the disease and the response to treatment, assisting in risk stratification, and supporting MDT board meetings at institutions both physically and virtually, enabling all MDT board members to access the patient's holistic profile simultaneously. Thus again, the vision is that the INCISIVE toolbox can support electronic access to patient profile across the journey thus promoting the integration of care allowing for continuity and efficiency. A detailed description of this service can be found in Multimedia Appendix 4.

Multimedia Appendix 4: Practice challenges, needs, and generic features of the INCISIVE AI toolbox at treatment and follow-up.

Data input and output requirements of INCISIVE AI toolbox, irrespective of cancer type

Several input and output requirements were identified at each of the 3 services proposed for the INCISIVE AI toolbox. Interestingly, the participants articulated some suggestions which would make the INCISIVE toolbox more HCP friendly across the 3 services. The data input and output requirements at three services are summarised in Multimedia Appendix 5.

Multimedia Appendix 5: Data input and output requirements of INCISIVE AI toolbox.

Explainable AI (XAI): Explainability of the INCISIVE AI toolbox, irrespective of cancer type

Participants were asked about the explainability techniques they would like to have in the INCISIVE AI toolbox at each stage/service. During the workshops, the participants were prompted with three different XAIs techniques: (1) feature relevance explanation which attempts to explain a model's decision by quantifying the influence of each input variable (importance of input features in predicting the output), (2) visual explanation aims at generating visualizations that facilitate the understanding of a model, and (3) explanations by simplification refers to the techniques that approximate an opaque model using a simpler one, which is easier to interpret. Figure 2 explains the options selected by the majority of the participants.

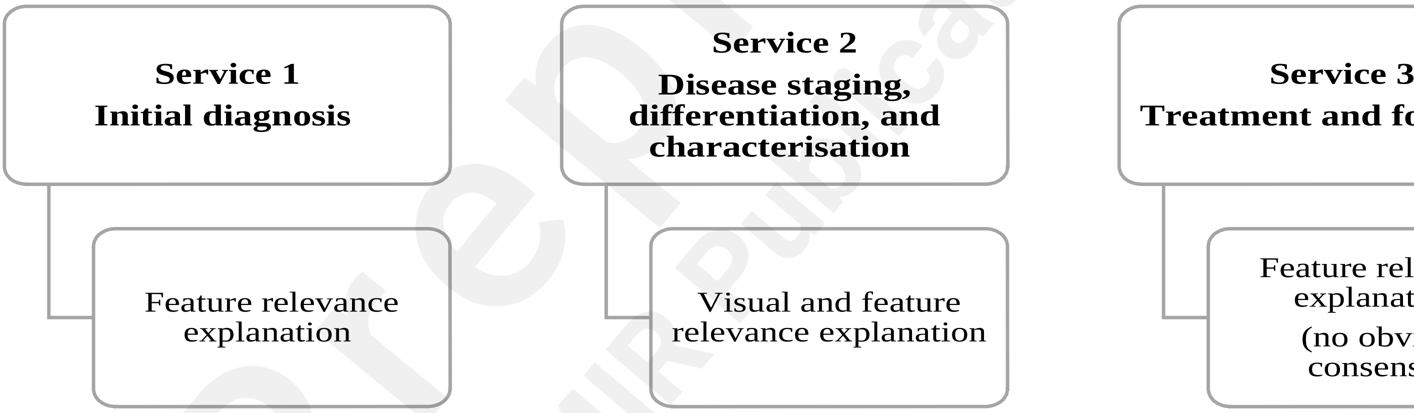

Figure (2): Explainability techniques preference in the INCISIVE AI toolbox across the 3 proposed services.

Potential users/ access to INCISIVE AI toolbox

1. **At initial diagnosis:** according to the participants, GPs were highlighted as the potential users of the INCISIVE toolbox at this stage and the best healthcare professionals to access and upload information into the system. Some participants highlighted that radiologist would also benefit from having access to the INCISIVE AI toolbox at this stage especially if basic imaging modalities are done in primary care, for example chest x-ray in case of lung cancer.
2. **At disease staging, differentiation, and characterisation:** radiologists, pathologists and nuclear medicine physicians were among the suggested users at this stage. The participants highlighted a very important point which is the need for

minimal data input by healthcare professionals in order to make the INCISIVE AI toolbox as much HCP friendly as possible. Pertaining to this, some participants suggested to assign the responsibility of data uploading to a nurse or a junior doctor/HCP in order not to increase workload. Nevertheless, the participants envisaged radiologists, pathologists, and nuclear medicine physicians as the most appropriate healthcare professionals for accessing and data processing at this stage. This is because processing images prior to uploading requires expertise from radiologists and nuclear medicine physicians in terms of: identifying which images to be processed and uploaded to the system (i.e., the areas of concern) and identifying which parts of the image to be contoured. The same applies for pathologists in terms of processing histopathological results.

3. **At treatment and follow-up:** radiologists, radiation oncologists, oncologists and surgeons were among the suggested users at this stage. Another interesting finding which emerged out of the 4 workshops was the importance of using INCISIVE at the MDT meetings when deciding treatment options for each patient. According to the participants, all healthcare professionals involved in patients care need to have access to the INCISIVE AI toolbox and to be able to see what other healthcare professionals have done during the patient's journey. According to the participants, if the INCISIVE AI toolbox can provide a comprehensive profile for the patient during the MDT meeting including all tests and imaging conducted with the relevant timepoints, so having all those information in one screen, then this would facilitate these meetings to a great extent. Again, these findings are interesting and related to features requested/desired by the participants mainly: provision of a comprehensive profile for each patient /complete portfolio, ability to see the history of all entries done by all healthcare professionals involved in the care of the patient.

Holistic concerns emanating from the workshops

Several concerns were identified throughout the workshops. One main concern was closely intertwined with the minimal data input requirement identified earlier. The concern was related to the amount of time that healthcare professionals will need to dedicate to the INCISIVE AI toolbox. According to participants, currently healthcare professionals are increasingly getting involved in what they consider non-medical work (mainly data entry) which is affecting their workload. As such, if the INCISIVE toolbox requires too much data input and attention from healthcare professionals (attention theft) then this would affect healthcare professionals ' willingness to use the proposed toolbox. Another concern was related to the fear that AI technologies such as the INCISIVE AI toolbox can be perceived as a replacement to healthcare professionals in clinical decisions.

Phase two: Delphi study- Identification and prioritisation of implementation barriers, INCISIVE features and user groups

Participants' demographics

A total of 12 out of the 16 healthcare professionals completed the Delphi study. Participants' characteristics are summarised in table 2.

Table 2: Characteristics of healthcare professionals who completed the Delphi study (n=12).

Participants' characteristics		Number
Gender	Male	6
	Female	6
Country	Serbia	2
	Italy	3
	Greece	5
	Cyprus	2
Specialty/ occupation	General Practitioner/ doctor	1
	Radiologist	4
	Oncologist	3
	Radiation oncologist/ therapeutic radiographer/ radiotherapist	1
	Nuclear medicine physician	2
	Surgeon	1

Features of INCISIVE AI toolbox

The first and second rounds of questionnaires (questionnaire 1 and 2) involved brainstorming of potential features of the INCISIVE AI toolbox and validation. In the first questionnaire, a total of 20 features were generated by the participants and then subsequently validated with no change (via questionnaire 2). In the third round (questionnaire 3) which entailed narrowing down the list, a total of 11 features were retained and prioritised for the INCISIVE AI toolbox.

In the fourth round, those 11 features were ranked in terms of importance with a strong consensus among the participating healthcare professionals (W =0.741, *P*<.001) (table 3).

Table 3: List of the features in order of importance (priority ranking). A lower mean ranking score indicates a more important feature.

Item importance	**Item description**	**Mean rank score**
1	Ability to classify the lesion as benign or malignant and probability of lesion malignancy.	2.25
2	Automated lesion spotting and contouring (i.e. annotation).	3
3	Automated grading and staging of the disease.	3.83
4	Ability to suggest appropriate course of action during diagnosis and treatment (whilst keeping final decision to the clinician).	4.08
5	Ability to link proposed suggestions to established clinical evidence (studies or guidelines).	4.58
6	Ability to predict prognosis.	4.75
7	Ability to define response to therapy/treatment.	6.92
8	Ability to compare imaging tests and laboratory tests at different time points.	7.33
9	Ability to predict the possibility of recurrence.	8.75
10	Integration and display of a comprehensive patient profile.	9.92
11	Multimodality	10.58

Implementation barriers

Healthcare professionals were asked about the barriers that would affect the successful implementation of the AI toolbox proposed by INCISIVE in order to identify why similar AI solutions usually fail. The first and second rounds of questionnaires (questionnaire 1 and 2) involved brainstorming of potential barriers for the successful implementation of the INCISIVE AI toolbox and validation. In the first questionnaire, a total of 23 barriers were identified and then subsequently validated with no change (via questionnaire 2). In the third round, a total of 10 barriers were distilled. In the fourth round, those 10 barriers were ranked in terms of importance with a strong consensus among the participating healthcare professionals (W =0.705, *P*<.001) (table 4).

Table 4: list of barriers to successful implementation of INCISIVE AI toolbox in terms of importance (with priority ranking). A lower mean ranking score indicates a more important barrier.

Item importance	**Item description**	**Mean rank score**
1	Lack of resources	1.17
2	Requirement of too much data input from healthcare professionals	2.75
3	Lack of organisational and management support	3.58
4	Medico-Legal issues/concerns: accountability and liability in case of disagreement.	4.25
5	Lack of visible advantage of the AI toolbox	5.92
6	Compatibility and integration concerns	6.08
7	Complexity and difficulty of operating the AI toolbox.	6.67
8	Concerns related to GDPR (patients' privacy and confidentiality) and further legal matters in individual countries	6.92
9	Hardware requirements	8.33
10	Data entry bias and variability	9.33

User groups for INCISIVE AI toolbox

The first and second rounds (questionnaires 1 and 2) involved a brainstorming of potential user groups of the INCISIVE AI toolbox and validation. In the first round, a preliminary list of 20 potential user groups was identified. After responses validation in the second round, a final consolidated list of 18 potential user groups was identified. In the third round (questionnaire 3) a total of 13 user groups were retained. In the fourth round, those 13 user groups ranked in terms of importance with a strong consensus among the participating healthcare professionals (W =0.767, *P*<.001) (table 5). As expected, higher importance was given to physicians who are common across all tumour types starting from radiologists to nuclear medicine physicians. Whereas lower importance/ranking was provided to tumour specific healthcare professionals /specialists mainly: pneumologists, gastroenterologists, urologists, and gynaecologists.

Table 5: The list of INCISIVE AI toolbox users in terms of priority (with priority ranking). A lower mean ranking score indicates a more important user group.

Item importance	Item description	Mean rank score
1	Radiologists	1.5
2	Oncologists	2.5
3	Surgeons (specialised in oncology)	3.42
4	Radiotherapists/ radiation oncologists	4.67
5	General Medicine practitioners (GPs)	5.75
6	MDT (multidisciplinary team) board	6.17
7	Pathologists	6.58
8	Nuclear Medicine physicians	7.83
9	Internists (Specialising in oncology)	8.92
10	Pneumologists	10.08
11	Urologists	10.33
12	Gastroenterologists	11.08
13	Gynaecologists	12.17

Discussion

The results of the study focussed on the specification and prioritization of features guided by the design of the INCISIVE platform. The key findings indicated that the INCISIVE AI toolbox could assist in areas such as misdiagnosis, overdiagnosis, delays in diagnosis, detection of minor lesions, decision-making in disagreement, treatment allocation, disease prognosis, prediction, treatment response prediction, and care integration throughout the patient journey. In addition, the results also provide an insight into the implementation barriers that affect the success of solutions such as, limited resources, lack of organizational and managerial support, and data entry variability.

In fact, the UX design workshops were an answer to many challenges and problems identified. During the stage of initial diagnosis, healthcare professionals highlighted that the toolbox could help in reducing the chances of misdiagnosis and overdiagnosis. Studies highlighted a lack of measures to address diagnostic errors[11], [12] and the far-reaching implications of misdiagnosis [13], [14], [15] and overdiagnosis[16], [17]. The AI toolbox can also guide healthcare professionals in primary care in patients' management, thus addressing challenges related to delays in diagnosis, accuracy of imaging modalities and lack of expertise. During the disease staging, differentiation, and characterization stages, healthcare professionals highlighted that the toolbox could aid in the identification of small lesions that would otherwise be missed by healthcare professionals or lesions that are not very straightforward or easily identified by healthcare professionals , guidance in TNM classification and staging, and the most suitable areas for biopsy, in addition to supporting decisions in cases of disagreement among healthcare professionals or results of the different imaging modalities and tests. Healthcare professionals also stressed that the INCISIVE AI toolbox can assist in treatment allocation, disease prognosis prediction, treatment response prediction, and multidisciplinary team meetings during the third stage of the pathway, which is treatment and follow-up, by addressing issues like lack of expertise, inaccurate imaging methods, and delays in treatment initiation. An interesting finding emanating from the current work is the vision that AI can support the integration of care across the patient journey, allowing for continuity and efficiency. A feature that proved successful in other chronic conditions in healthcare [17], [18], [19] but has yet to be fully adopted in cancer care in the future.

Several desired features for the INCISIVE AI toolbox were outlined through the Delphi study and the UX design workshops. Interestingly, it can be argued that some of these features are applicable to the patient's journey regardless of the journey stage; these include: (i) integration and display of a comprehensive patient profile; (ii) ability to link proposed suggestions to established clinical evidence (studies or guidelines); (iii) ability to check drug interactions; (iv) notification of the user of the final outcome at each stage; (v) ability to see detailed input from the other healthcare professionals involved in the care of each case; and (vi) multimodality. On the other hand, and as highlighted earlier in the results section, some of the features desired by the participants are not feasible within the timeframe of INCISIVE. However, these findings are important and may be considered/viewed within the context of future sustainability of AI in cancer care.

Some features were commonly identified from the Delphi study and the UX design workshops, and the Delphi study provided a chance to prioritise these features in terms of importance from healthcare professionals’ perspective, which in return would guide in the design of the INCISIVE AI toolbox. Multimedia Appendix 6 provides a mapping of these features against the users’ requirements identified in the INCISIVE project.

Multimedia Appendix 6: Mapping user requirements related to features of the INCISIVE AI toolbox.

Several barriers were identified to affect the successful implementation of the proposed INCISIVE AI toolbox, thus giving an insight into why similar solutions to the one proposed by INCISIVE usually fail. The participants initially highlighted 23 barriers, which were then distilled down to 10 barriers. Among the most important barriers were lack of resources, lack of organisational and management support, and data entry variability, which are barriers related to the organisational environment. This is not surprising given previous findings in the literature about technology implementation in healthcare [19]. In previous research by Odeh et al [19] exploring nurses’ perceptions towards a telehealth service, the nurses reported a lack of resources, a lack of organisational support, and a lack of technical support among the major issues impacting the service's implementation. On the other hand, 5 out of the 10 barriers were related to the technology itself, mainly hardware requirements, a lack of proven or established advantages of the AI toolbox, compatibility and integration concerns, the complexity and difficulty of operating the AI toolbox, and the requirement of too much data input from healthcare professionals.

The concern expressed by workshop participants about the possible replacement of healthcare professionals if the INCISIVE system or similar technologies proved successful was a noteworthy finding. This apprehension was further echoed in a cross-sectional web-based survey [18] conducted to investigate physicians' perceptions of Chatbots in healthcare. Another study [20] has made a positive observation, noting that clinicians demonstrate significant openness when it comes to considering the utilization of AI-based decision support. This finding emphasizes that AI-based technologies should not be seen as a replacement for healthcare professionals’ expertise of in decision-making processes. Instead, it should be regarded as a complementary tool that can assist and augment healthcare professionals’ abilities, ultimately improving the quality and efficiency of healthcare delivery.

Regarding data input, the healthcare professionals recognised the need for multiple data input throughout the patient journey, which can be argued to be essential for creating a holistic personalised profile for each patient. These data inputs include medical history, lab results, histopathological results, imaging results, etc. But during the workshops, one recommendation made by the healthcare professionals was to entrust the duty of data uploading to a nurse or a junior HCP. The remaining two barriers were related to medical and legal issues, including medico-legal issues in terms of accountability and liability in case of disagreement and concerns related to GDPR (patients' privacy and confidentiality) and further legal matters in individual countries. However, this is not new; similar ethical and legal challenges posed by AI in healthcare have been reported in the literature [21].

Interestingly in terms of explainability of the proposed AI toolbox, the healthcare professionals expressed interest in having feature relevance explanation or a hybrid approach that combines feature relevance with visual explanation. This preference aligns with another study [22] that emphasizes the significance of visually directive data-centric explanation methods. In some instances, this preference was driven by speciality and expertise. For instance, during disease staging and characterisation (i.e., service 2), radiologists were more interested in visual explanation given their speciality and the fact that a lot of imaging tests take place during this stage of the pathway.

Strengths and limitations

The study used both quantitative (Delphi study) and qualitative (UX design workshops) methodologies, which aided in triangulating the data and improved the reliability and reliability of the findings. Healthcare professionals from a variety of specializations participated in the study from several countries. This diverse perspective is guaranteed to be reflective of a broad spectrum of possible users and situations.

It is also essential to recognize the study's limitations. The study focussed only on the specification and prioritization of features guided by the design of the INCISIVE platform, without taking into consideration what would be defined as success criteria for the overall implementation. Another notable constraint is the lack of a comparison to evaluate if the perspectives about the suggested INCISIVE AI toolkit were better or distinct from those regarding other AI solutions. Due to the limited sample size and geographical representation, the findings may not be universally applicable. The cross-sectional assessment of the user requirements sets the stage for continuous monitoring and evaluation of the user demands across time.

Conclusion

This paper outlined analysis with regards to the user requirements definitions of the INCISIVE system. The current work has identified several features for the INCISIVE AI toolbox that are deemed important to guide in the development of the toolbox. Although some of these features may not be pertinent within the remit and duration of the INCISIVE project, they ensure the sustainability of AI in meeting user needs in the future. These features were prioritised and distilled down according to the universal MoSCoW [23] prioritisation technique into four categories: "must-have," "should-have," "could-have," and "won't-have," or "not have right now" in a follow-up research pertaining to the INCISIVE project. This step determined the features that would be achievable within the lifespan of the INCISIVE project and which features are part of the futuristic development of AI in cancer care. Data input and output requirements were also elicited for the INCISIVE AI toolbox. Similarly, these requirements will be prioritised according to the universal MoSCoW prioritisation technique to determine what is feasible and can be achieved within the timeframe of the INCISIVE project. Additionally, the current paper identified several barriers that would affect the successful implementation of INCISIVE. These barriers will be taken into consideration during the development and implementation phases of the project. Additionally, the current paper provided an insight into the level of explainability required from the toolbox and potential users across the 3 services suggested for the toolbox, which are also crucial for guiding the design of the toolbox.

Declarations

Ethics approval and consent to participate

All methods were performed in accordance with the Declaration of Helsinki and has been approved by Kingston University (KU) Research Ethics Committee. Ethical approval for conducting this study was granted on August 11, 2021 (reference no. 2877) and August 16, 2021 (reference No. 2863). All partners involved in the study did not require additional ethical clearance. Informed consent forms were provided to participants prior to the commencement of the study. Participant information was safeguarded through coding, encryption, and secure storage practices. No compensation was provided for study participants.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors contributions

IH, SNG and RK were involved in study design and conceptualisation. IH conducted the research and collected the data. AC, ML, ES, WA, JB, TA were also involved in data collection. Data analysis was completed by IH, SNG and RK. IH and LZ were responsible for drafting and finalising the manuscript. All authors were involved in data interpretation, manuscript writing, and critical review. All authors read and approved the final manuscript.

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Multimedia Appendix

Multimedia Appendix 1: Practice challenges, needs, and generic features of the INCISIVE AI toolbox at initial diagnosis

Multimedia Appendix 2: Practice challenges, needs, and generic features of the INCISIVE AI toolbox at Disease staging, differentiation, and characterisation

Multimedia Appendix 3: Specific features required for the INCISIVE AI toolbox at disease staging, differentiation, and characterisation.

Multimedia Appendix 4: Practice challenges, needs, and generic features of the INCISIVE AI toolbox at treatment and follow-up.

Multimedia Appendix 5: Data input and output requirements of INCISIVE AI toolbox.

Multimedia Appendix 6: Mapping user requirements related to features of the INCISIVE AI toolbox.

Appendix

Appendix 1: Use case scenarios for AI toolbox users' (healthcare professionals) workshops.

Appendix 2: The first Delphi questionnaire for healthcare professionals - Questionnaire

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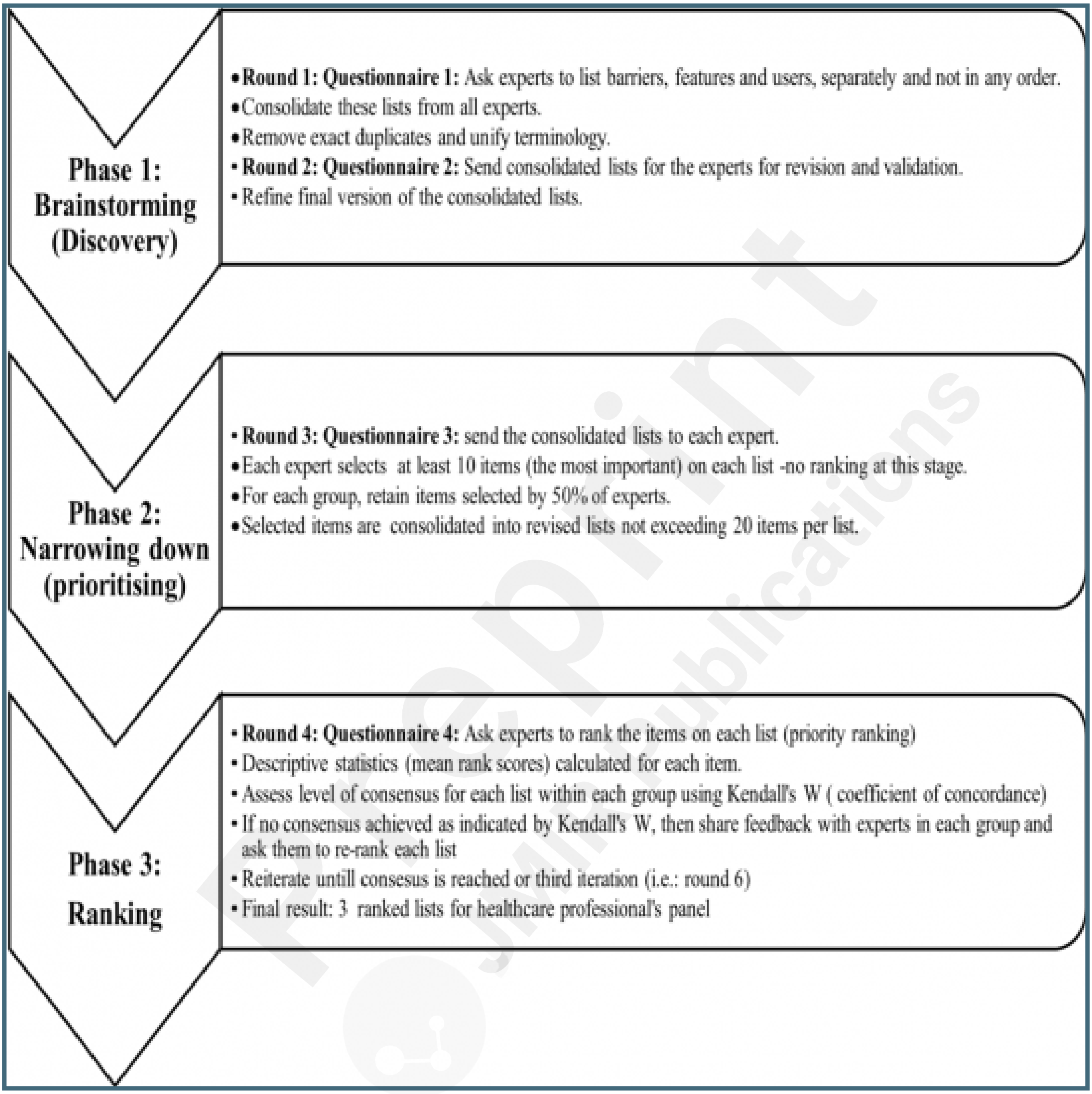
Supplementary Files

Figures

Delphi study administration process.



Explainability techniques preference in the INCISIVE AI toolbox across the 3 proposed services.

Multimedia Appendixes

Practice challenges, needs, and generic features of the INCISIVE AI toolbox at initial diagnosis.
URL: http://asset.jmir.pub/assets/b2760db8f45fa8683c42ce30c6a98c12.docx

Practice challenges, needs, and generic features of the INCISIVE AI toolbox at Disease staging, differentiation, and characterisation.
URL: http://asset.jmir.pub/assets/16718b87d838d840cddfc4527fdd7843.docx

Specific features required for the INCISIVE AI toolbox at disease staging, differentiation, and characterisation.
URL: http://asset.jmir.pub/assets/db941cfa101efd1f6b911df484cc915b.docx

Practice challenges, needs, and generic features of the INCISIVE AI toolbox at treatment and follow-up.
URL: http://asset.jmir.pub/assets/ae911bd5b54ef6c59fe152018ce852ef.docx

Data input and output requirements of INCISIVE AI toolbox.
URL: http://asset.jmir.pub/assets/e7b8a484449057fa00034b2ea3eddd3c8.docx

Mapping user requirements related to features of the INCISIVE AI toolbox.
URL: http://asset.jmir.pub/assets/4f8daf856db226b65304d34c8697d27d.docx

Use case scenarios for AI toolbox users' (HCPs) workshops.
URL: http://asset.jmir.pub/assets/a00caf6d2f7f6c609fae718a667302ef.docx

The first Delphi questionnaire for healthcare professionals.
URL: http://asset.jmir.pub/assets/1b2a70816e2d28eef301f2229172d689.docx