Understanding patient views and acceptability of predictive software in osteoporosis identification

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ABSTRACT

Introduction: Research into patient and public views on predictive software and its use in healthcare is relatively new. This study aimed to understand older adults' acceptability of an opportunistic bone density assessment for osteoporosis diagnosis (IBEX BH), views on its integration into healthcare, and views on predictive software and AI in healthcare.
Methods: Focus groups were conducted with participants aged over 50 years, based in South West England. Data were analysed using thematic analysis. Analysis was informed by the theoretical framework of acceptability.
Results: Two focus groups were undertaken with a total of 14 participants. Overall, the participants were generally positive about the IBEX BH software, and predictive software's in general stating '*it sounds like a brilliant idea*'. Although participants did not understand the intricacies of the software, they did not feel they needed to. Concerns about IBEX BH focussed more on the clinical indications of the software (e.g. more scans or medications), with participants expressing less trust in results if they indicated medication. Questions were also raised about how and who would receive the results of this software. Individual choice was evident in these discussions, however most indicated the preferences for spoken communication '*But I would expect that these results would be given by a human to another human.*'
Conclusions: Focus group participants were generally accepting of the use of predictive software in healthcare.
Implications for practice: Thought and care needs to be taken when integrating predictive software into practice. Focusses on empowering patients, providing information on processes and results are key.
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Introduction

Osteoporosis is a debilitating disease characterised by loss of bone mass and deterioration of the bone structure, resulting in a significantly increased risk of fragility fractures.[1] Early intervention of lifestyle advice around falls and bone health, and bone sparing medications, reduce the risk of primary fragility fractures and therefore reduces the cost to the NHS.[2]

Current gold standard for bone density assessment and subsequent fracture risk calculations is Dual energy absorptiometry (DXA). Although DXA is a low radiation method of assessing bone mineral density (BMD), many patients in the UK are having to wait >6 weeks on average for an appointment.[3] Further, referral to DXA is often too late for early intervention with most patients being referred to DXA services after they experience their first fragility fracture. To address these issues in the osteoporosis diagnostic pathway, IBEX innovations have developed a software (IBEX Bone Health (BH)) solution that provides areal BMD estimates from a standard digital radiograph.[4] Their aim is that the software can be used to opportunistically screen patients who are undergoing routine X-rays for any number of referral reasons, rather than awaiting a fracture as an indication for DXA.

Patient views and acceptability of new products, interventions and diagnostic tools are paramount as research indicates that patients are more likely to adhere to treatment and medication recommendations if they consider an intervention acceptable.[5] This is specifically important when looking at interventions relating to osteoporosis diagnosis, as the many people who would benefit from osteoporosis drugs are not receiving them,[6] and this treatment gap has been described as an 'osteoporosis crisis'.[7]

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Abbreviations

NHS	National Health Service
DXA	Dual energy X-ray
IBEX BH	IBEX Bone Health
FG	Focus groups
U3A	University of third age
ROS	Royal Osteoporosis Society
SILS	Single Item Literacy Screener
eHEALS	eHealth Literacy Scale
TFA	Theoretical Framework of Acceptability
TA	Thematic analysis
PPI	Public and patient Involvement
MAGPIE	Modelling Advisory Group Public Involvement and Engagement
TREE	Translational Research Exchange @ Exeter
BMD	Bone Mineral density
HCP	Health care practitioner
GP	General Practitioner

Research into patient perceptions of predictive software and artificial intelligence in health care is relatively new.[8] In relation to radiology specifically, a systematic review of stakeholders perspective of AI in radiology[9] only found two papers assessing patient views[10,11] and one on general public views.[12] Themes identified in such studies have been relatively consistent in indicating both 'positive' and 'negative' views on such technologies. Patients have previously identified a belief in a more accurate diagnosis[13–15] and increased efficiency of predictive diagnostic tools.[10,14,16] Concerns have included aspects of such as reliability,[17] trust/accountability,[13,17] depersonalisation,[10,11] and communication.[16,18]

Therefore, this study aims to understand participant's views on predictive software's in general, the IBEX BH software, and IBEX BH integration into health care.

Materials and methods

A qualitative study using semi-structured focus groups was conducted with a range of members of the public over the age of 50 years. The COREQ list for reporting qualitative studies has been utilised and included in supplementary material 1.[19] Ethical approval was obtained from the University of Exeter Ethics Committee (reference 291,122).

Setting and participants

Convenience sampling strategy was used; participants were recruited from established channels of the University of the Third Age (U3A, newsletter and email list) and local Royal Osteoporosis Society (ROS, in person invite at meeting) Patient Advocacy group to recruit both those with and without osteoporosis diagnosis. As both these organisations have worked with the university regularly, some of the participants may have been involved in the clinical trial of the IBEX BH product. Participants were required to be > 50 years old and able to attend one of the scheduled focus group dates in person. Focus groups were held in person to reduce digital exclusion and a £25 thank-you payment in accordance with NIHR guidance to ensure accessibility.

Data collection

Focus groups were held in Jan—Feb 2023, led by an experienced qualitative researcher (FM) who has experience of running Focus groups and has previously worked in an osteoporosis clinical setting. A second researcher (AM), acted as a 'facilitator/observer'. Both researchers are female with no previous relationship with participants. Participants were asked to provide basic demographic information as well as a single item literacy screener questionnaire (SILS)[20] and a digital health literacy screener adapted from eHealth Literacy Scale (eHEALS)[21] (Supplementary material 2).

Prior to data collection, the IBEX BH system was introduced to participants through a presentation given by one of the researchers (RM). This aimed to provide basic insight into the IBEX BH system, with a neutral tone, so that participants could provide their views on the software. Only questions related to understanding the IBEX BH system were allowed, these were not audio recorded. After the presentation, participants were given a short break before the focus group began, allowing them to digest the information presented. RM did not attend the focus group, only participants, FM and AM were present for the focus groups.

Focus groups were run utilising a semi-structured guide (Supplementary material 3) that was created based on the 7 domains of the Theoretical Framework of Acceptability (TFA).[5] Prior to its use, the questions were reviewed by PPI representatives from the Modelling Advisory Group Public Involvement and Engagement (MAGPIE) group. The MAGPIE group is predominantly made up of older people who are semi- or fully retired with a range of backgrounds. The group includes both males and females. Feedback from representatives included simplifying language for greater understanding and clarity. Focus groups were audio-recorded on portable encrypted audio recording devices (Olympus digital voice recorded, WS-811). Recordings were then transcribed verbatim and anonymised.

Analysis

Data analysis began after the first focus group had been completed and continued through the following focus group. Due to the data collection and initial analysis running simultaneously, identified themes and/or gaps could be probed accordingly in the remaining focus group. Data saturation was not an aim of this study, as there are always new theoretical insights to be made as long as data continues to be collected and analysed.[22]

A thematic coding approach was employed to facilitate the development of key themes and codes.[23] The audio recordings were played aloud to increase familiarity and then researcher (AM) undertook open coding in qualitative analysis software NVivo (Release 1.7). Transcripts were then coded in cycles using codes generated by searching for similar ideas or concepts that can be categorised into a theme, and utilising codes identified from literature. Between cycles, the research team (RM, FM and AM) met to discuss the identified themes and further refine the coding. This approach allowed a reflection on overall meaning of data. Once codes were refined, researchers FM and AM aligned these with the seven domains of the TFA. Transcripts and codes were not returned to participants or PPI for checking of interpretation.

Results

Participants

Two focus groups were undertaken on the university campus with a total of 14 participants (Table 1). Seventeen responded to the invitations, 1 decided after their initial response that they were no longer interested in taking part, and two could not make either of the focus group dates. Of those that consented to participate, none withdrew from the study. Participant age ranged from 55 to 80 years. The participants were majority female (78.6%), and less than

Table 1
Focus group Participant Demographics.

Participant number		Total	FG1	FG2
Gender	Female	11 (78.6%)	5	6
	Male	3 (6.7%)	1	2
Age	Range	55–80 yrs	55–80 yrs	68–77 yrs
	Mean ± SD	72.1 ± 6.7 yrs	69.8 ± 9.4 yrs	73.8 ± 3.7 yrs
Ethnicity	White British	11 (78.6%)	5	6
	White Irish	1 (7.1%)	-	1
	White European	1 (7.1%)	1	-
	No answer	1 (7.1%)	-	1
Diagnosis with Osteoporosis	Yes	6 (42.9%)	1	5
	No	8 (57.1%)	5	3
Highest education level	GCSE/High School	2 (14.3%)	-	2
	A level/College	1 (7.1%)	-	1
	Undergraduate	9 (64.3%)	5	4
	Postgraduate	2 (14.3%)	1	1
Health Literacy (SILS)	Never	10 (71.4%)	6	4
	Rarely	3 (21.4%)	-	3
	No answer	1 (7.1%)	-	1
Digital Health literacy	Range	5–12	5–12	8–12
	Mean ± SD	9.6 ± 2.1	9.8 ± 2.8	9.4 ± 1.5

half of the participants had a personal diagnosis of osteoporosis (42.9%). Four participants had taken part in the OFFER1 study.

Despite a range of education levels, health literacy was high, with 13/14 indicating on the SILS they never/rarely need help understanding written health material, 1 participant didn't answer. Digital health literacy showed more variation with a range of 5–12.

Thematic analysis

The data is presented as aligned with the seven domains of TFA (Fig. 1). Themes and subthemes (In italics in text) are discussed below in relation to their TFA domain, and examples presented in Table 2.

Intervention coherence

Intervention coherence was one of the most prominent domains, however, some of the sense making related to health care and osteoporosis more generally. There did not appear to be any difference in understanding by those who had taken part in the OFFER1 study. One of the discussions in focus group one centred around whether participants saw *osteoporosis as a worthy problem* to require intervention. There was a suggestion that as osteoporosis could not be 'cured', thus intervention, prediction and prevention were not worthwhile. Notably, this first focus group had a lower average age, and fewer participants with osteoporosis, and this may have contributed to such discussions. Focus group two, which had more participants with osteoporosis never questioned the reason

for intervention, potentially suggesting a knowledge gap between the two focus groups.

Participants approached this intervention coherence with their own *experience of predictive software* or lack thereof. Participants used examples of triaging systems such as 111, or risk predictors such as Q score as their understanding of predictive software. However, many participants believed they had never had a known experience of AI or predictive software in their health care. Interestingly, when it came to *understanding AI and predictive software* participants were not generally interested in understanding the details. There was an understanding that harnessing technology would help, and they did not need, or want to understand more than that.

These feelings linked with participants *understanding IBEX BH*, with some suggesting all that they need to know is that someone will look at their bone density when attending for an X-ray. Others had a desire for more information to better understand, such as when the software is run (during or after the X-ray) and what data the software was based upon.

Affective- attitude

Trust of NHS and HCPs was one of the largest themes overall and had impact in other domains. Both focus groups strongly indicated trust in the NHS that if something was introduced to practice, it was tested, worthwhile and worth the cost. This trust also extended to the HCPs employed by the NHS with GPs and consultants being named specifically. Examples of when they had trusted the NHS
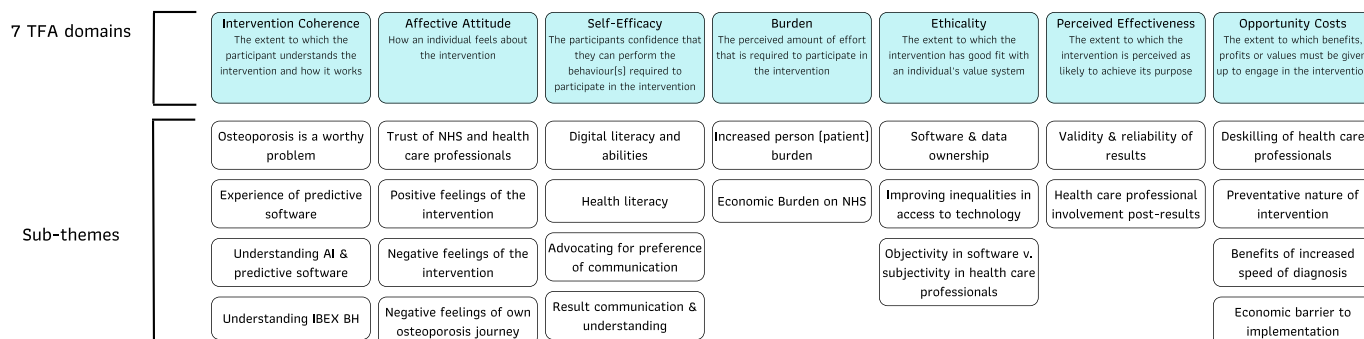
Figure 1. Thematic codes and sub-themes from focus groups, aligned with the seven domains of the TFA. NHS- National health Service, HCP- health care professional.

Table 2

Themes and quotation examples, grouped by domains of the TFA. FG: Focus group (1 or 2), and P: participant (number), OP indicates a participant with a diagnosis of osteoporosis.

TFA Domain	Theme	Quote examples
Intervention coherence	Osteoporosis as a worthy problem	'It is just you know the assumption being if we find it, we can cure it which of course we can't so I just … ' FG1 P9 OP
		'got three fractures through sitting on the wrong chair, I got another fracture by a hospital door banging on a stretcher, being moved from department to department, it is so easy to do. But people don't seem to realise that the … information about this, stories about this are around but nobody seems to be able to pick up on it and learn from it' FG2 P8
	Experience of predictive software	'Is the Q score predictive measure of risk of stroke or heart attack for example, which must use a set of data to produce an outcome which in that case might determine whether you use statins for example. If that is an example then yes.' FG1 P4
	Understanding AI and predictive software	'suppose to harness whatever technology is out there and claiming to be accurate but to be honest I don't know enough to know exactly what feelings that … what machine learning …, the more that can be harnessed obviously.' FG1 P10
		'It wouldn't bother me, I don't want to know, I don't need to know, I am anticipating a future where preventative tests are being undertaken'. FG1 P4
	Understanding IBEX BH	'I think I understand the concept that if you're going to … as I had done frequently for X-Rays that if somebody said to me ah and also we have noticed on this that your bone density is looking a bit iffy' FG2 P10
		'I thought it was the piece of equipment looked at the X-Ray not while you were there?' FG2 P6 OP
Affective Attitude	Trust of NHS and HCPs	'You trust it, you trust the professionals, you trust that there is research gone in to it, you trust that actually somebody has done some work in it' FG1 P5
		'so presumably you know the NHS is not going to pay for this unless they have done their trials to say this is value for money and this is the risk this company is taking isn't it?' FG1 P4
	Positive feelings of the intervention	'I would say it is a brilliant idea' FG1 P9
		'[I] am really excited by it' FG2 P4 OP
		'Sort of empowers people do you think?' FG1 P5
	Negative feelings of own osteoporosis diagnosis journey	'I think GP's are very reluctant to send anybody to x-rays and for DXA scans when they are presenting absolutely terrible pain but we haven't broken our wrist or our leg or anything but we have actually got vertebrae fractures and in my case I had nine vertebrae fractures that weren't picked up' FG2 P6 OP
	Negative feelings of the intervention	'So one of the disadvantages is whether or not I am going to say perhaps you know older people maybe, people who are not familiar with erm statistical probability would necessarily feel comfortable with that kind of result. That would be a bit of a down side to it wouldn't it?' FG1 P4
Self-Efficacy	Digital literacy and abilities	'This spreading of information does concern me because the elderly … I have seen patients turn up for clinics that were virtual and they didn't know. They didn't understand, they don't know about texts, they don't get about erm WhatsApp, all of these sorts of things going on and it is incredibly difficult, there is an assumption that everybody knows how to go into the virtual waiting room' FG2 P1
	Health Literacy	'I like to know as much as I possibly can about my health erm but there are a lot of people that just simply don't want to know, they just think well I have got to pay, I will take a pill and off I go and I don't want to know what is going on with my body, well I am not like that. I want to know everything that is available and to improve things, to make things better for me.' FG2 P6 OP
	Advocating for preferences of communication	'And I said I am sorry, but my phone is … well whether it did or not I haven't got a clue how to get Zoom, my daughters do it all, and erm I said oh no I am really sorry I have to see you face to face' FG2 P1
	Result communication and understanding	'But I would expect that these results would be given by a human to another human. I wouldn't have expected them just to be handed a piece of paper and said you have got 89%, rather like with cancer diagnoses there is a consultation and I would not expect it to work without a consultation.' FG1 P8
	Preferences of HCP	'I think I would rather have a consultant. My experience of GP's knowledge of osteoporosis is not good, let alone the nurse. They are brilliant at other things but erm I didn't find them informed and I am very lucky, I am actually under [name] who is one of the top rheumatologists and she did lots of different tests but … ' FG1 P9
Burden	Increased personal (patient) burden	'I mean I find … you find yourself having to remind your doctor a bit you are actually taking something else, or you know you have got osteoporosis you're not supposed to take steroids and that is when is don't like this one-way communication, because I want to be able to ask questions and check on things.' FG1 P9
	Economic burden on NHS	'If you think of the technology having to go on every X Ray machine in the country, it is big numbers … It is expensive' FG1 P9
		'I have the big question, always with medical stuff the price is horrendous. And for some reason the National Health Service swallows it.' FG 1 P8
Ethicality	Software and Data safety	'My view, as soon as AI is mentioned that is going to put a lot of people off I think. You know they have got this paranoia about AI you know the Russians are going to get … find out everything about us' FG2 P9
	Improving inequalities in access to technology	'think it would speed up contact with someone because there is a huge wait for DEXA isn't there and it is geographically a nightmare depending on where you live. Whereas if this gave people a more immediate access, to the beginning of their journey, I think that would be really good.' FG1 P9
	Objectivity in software v. Subjectivity in HCP	'I would say the main advantage of using tech over people is subjectivity, that the tech will always be objective in that within its remit. Whereas a person can be … I mean we all react different to different people and so erm if there is subjective … the subjective element is removed' FG1 P8
		'Yes on that point erm I think it is good when a doctor indicates that he is looking at the whole person rather than just focusing on some mechanistic diagnosis.' FG2 P10
Perceived effectiveness	Validity and reliability of results	'it is the software's interpretation and what they have got to make sure with the software is 100 … fully tested' FG1 P8
		'I am assuming that this wouldn't be developed if the validity of reliability tests had not already been met, is that the case?' FG1 P4

Table 2 (*continued*)

TFA Domain	Theme	Quote examples
	HCP involvement post result	*'think if I had an X Ray and they came up with the fact that I needed some sort of medication I would be more comfortable that there was an expert in that field that was doing my analysis'* FG1 P5
Opportunity Costs	Deskilling of HCP	*'My only concern with predominately using AI methods would be what is happening to the doctors inquiring mind really.'* FG2 P4 OP
	Preventative nature of intervention	*'So I think anything predictive that can improve erm possible ways of preventing fractures is a brilliant idea.'* FG2 P4 OP
		'AI if you want to call it that is that it can cope better and the more preventative work we do which is desirable we have all agreed' FG1 P4
	Benefits of increased speed of diagnosis	*'So and if something like AI it should make things faster and erm instead of the you know speed … take steps out of the process.'* FG1 P8
	Economic Barriers to implementation	*'That actual you know software we're looking at just then, what about the actual cost and everything for the NHS these days where we … are they going to stop it in its tracks and say well we can't afford it at the moment and it is not going to happen? That is a bit worrying, it is such a shame if that happens'* FG2 P5 OP

were introduced to reinforce this, such as the COVID-19 vaccination. Trust in AI was not identified as a discrete theme, however, nuances are discussed the domains of ethicality, perceived effectiveness and intervention coherence.

There were many *positive feelings of the intervention* shared by the participants. There was a strong feeling that the intervention was 'great' and a 'really good idea' due to the intervention being preventative, and therefore empowering patients. Among those, participants with osteoporosis thought that the intervention may have a positive impact upon the care journey for people with osteoporosis, compared to their *negative feelings of own osteoporosis diagnosis journey*. One participant's description of 'slipping through the net' after an initial fracture, and other shared examples highlighted the possible impact of IBEX BH and how 'we wish we had this'.

There were some *negative feelings of the intervention shared* too, focussed primarily on the communication of the results of the intervention, and whether patients would be aware/consenting to IBEX BH being integrated into their X-ray. Participants indicated there may be 'shock' and 'horror' if they were informed, they had osteoporosis but maybe didn't want to know. It was also indicated that one could be 'terrified' or 'frightened' if they had only gone for an X-ray for a 'niggle' but had now been diagnosed with osteoporosis.

Self-efficacy

As the TFA defines self-efficacy, this domain related to the participants confidence that they could perform the behaviours required to participate in health care in general and specifically the IBEX BH intervention. Participants discussed how *digital literacy and abilities* varied in older people, and although for some digital access was within their abilities, others were less able to participate in their health care due to the dependence on digital access. Discussions also centred around variations in *health literacy*, with those with higher health literacy feeling more confident in understanding results. Self-efficacy also came into comments around *advocating for preferences of communication*, with those who had lower digital literacy being required to be more insistent on their chosen method of communication than those with higher digital literacy.

These discussions on digital and health literacy linked with participants view on how IBEX BH *result communication and understanding* could be enhanced. Participants wanted to know the results of tests done, even if there was not a specific issue identified as this was important in reassuring participants. There was a strong desire for human involvement in the review and delivery of results primarily to facilitate discussions and for patients to be able to ask

questions. There was also a desire for written communication with the aim of facilitating memory and providing evidence. However, even within the desire for written communication, the preferences varied between participants, with those with higher digital literacy happier to receive texts and emails.

Also, in relation to the communication of results, participants expressed *preferences of HCP type* or qualifications of HCPs who reviewed and/or delivered the results. GPs were seen as knowing the participants, providing continuity of care and understanding them holistically, however, they were seen as lacking knowledge relating to osteoporosis specifically. This led to some indicating the preference for an expert in osteoporosis.

Burden

Burden, the perceived amount of effort that is required to participate in an intervention, was one of the least prominent domains, with the majority of quotes relating to the potential for *economic burden on the NHS*. Participants were concerned that the cost of this intervention may be too great for the NHS to shoulder and that this may prevent its implementation. Others worried about the role of private companies pushing the NHS to spend more money would increase the burden. Some, however, did think that this intervention could result in a reduced economic burden to the NHS, suggesting that screening and prevention would help in the long term. Some participants with higher education levels were even aware of cost benefit analysis and questioned whether these had been done.

Increased personal burden brought up by participants was not specifically related to IBEX BH, rather in relation to results of tests in general. Participants described having to chase GPs for results or remind them that they have osteoporosis when it came to issues of polypharmacy and comorbidities. This increased burden also links with the ideas of advocacy discussed in the self-efficacy domain.

Ethicality

Software and data safety concerned some of the participants, specifically in terms of who can access or 'hack' into the data. This was considered on a specific IBEX BH level, whether the NHS or the IBEX company would have data ownership, as well as on a more global scale with worries about 'Russians'. However as seen in the affective attitude domain, trust in the NHS was seen as reassurance that data would be safe.

IBEX BH was viewed by participants as having the potential to *improve inequalities in access to technology*, namely DXA scans. This theme came out more strongly from who had been through the process of seeking an osteoporosis diagnosis. The perceived ease of

access to X-rays (and therefore IBEX BH) v. DXA ('*geographically a nightmare depending on where you live*'), was seen as to be a positive.

Lastly, in the domain of ethicality, themes were identified on the topic of *objectivity in software v. subjectivity in HCPs*. Some participants saw objectivity as more ethical, as it removes preconception, focuses on the logic and removes reactions to different types of people. The implication being that subjective measure can reduce inequality of treatment based on perceptions. However, other participants worried that by removing subjectivity, the individual is lost, making objectivity less ethical. They indicated how HCPs can see a whole person, include value factors, and solely focus on mechanistic diagnosis. Interestingly, these views were not consistent even within the same participants. One participant indicated both preference for objectivity and subjectivity within a few minutes of each other.

Perceived effectiveness

As this study was a prospective look at the IBEX BH intervention, all views on perceived effectiveness were anticipatory, rather than concurrent or retrospective. Therefore, the perceived *validity and reliability of results* was a key theme. Participants wanted reassurance of the accuracy of the software so as not to misinform people, however, how participants viewed reliability was varied. Education level appeared to play a key role in this interpretation of validity and reliability and the process to understand such measures. Further the role IBEX BH plays, some participants indicated they would be happy with lower reliability since it was not a drug. Participants generally indicated that they would like to know the reliability of the software if it was being used in their health care, and the reliability may impact how they perceive the results. Specifically in relation to IBEX BH, one participant wanted to know whether there was another test to confirm the IBEX BH result, indicating a lack of confidence in its effectiveness.

This confidence or lack thereof in the results of the IBEX BH software were also reflected in the desire for *HCP involvement post result.* Specifically in relation to clinical decision making on the basis of the results, participants felt they did not trust the software enough to take medications based on its result.

Opportunity costs

IBEX BH was seen as both providing opportunity and costing opportunity by participants. Costs were primarily discussed in relation to HCPs and the health care system. *Deskilling of HCP* was a concern of some participants, suggesting that increased reliance on AI and predictive software may have a negative impact on 'doctors inquiring mind'. However, both the *preventative nature of intervention* and the *benefits of increased speed of diagnosis* were seen as providing opportunity to patients. The preventative aspects were seen as being able to reduce the potential of pain and fractures, resulting in better life outcomes for patients. Speed was seen as opportunity for the patient- 'easier', 'less steps', 'faster diagnosis'- as well as for the NHS as it would make better uses of limited resources.

That said*, economic barriers to implementation* were also seen as a potential for costing opportunity to patients. It was feared that positive advances and interventions such as IBEX BH would be prevented from being implemented due to the lack of funds in the NHS.

Discussion

This study aimed to explore public perceptions and acceptability of predictive software, specifically the IBEX BH software and its integration into healthcare, using the lens of acceptability. To the best of our knowledge this is the first paper to gather public views on predictive software in osteoporosis diagnosis and management. Focus group participants generally viewed predictive technology positively, as it was seen to reduce burden and increase the speed of diagnosis and prevention. Trust in the NHS and HCPs was identified as crucial to participants' perceptions of effectiveness, reliability, cost-effectiveness, and integration into the healthcare system. Communication of intervention expectations, clinical decision-making, and post-results communication were highlighted as important factors that could influence the acceptability of IBEX BH to patients.

Literature on diagnostic imaging and radiography as a wider field has been undertaken with many similarities arising in themes. For example, Haan et al.,[11] identified domains of 'proof of technology' and 'competence' which map to similar themes in this study. Another of their domains, 'personal interaction' was also seen strongly in our data, crossing domains of 'affective attitude', 'self-efficacy' and 'perceived effectiveness'.[11] One domain identified in Haan's work that was not seen in our study data was the idea of accountability.[11] Haan identified that patients saw practitioners as accountable for their mistakes, and there was wonder as to who can be held accountable for software errors. A similar theme was identified in Yang et al.'s systematic review on stakeholders views, where medico-legality was a strong theme identified.[9] Themes of reliability, validity and effectiveness were raised in this study, however, the prospective nature of the questions, and the specific application of the IBEX BH software may explain the differences in themes arising.

Trust participants placed in the NHS and HCPs was a theme in this study that was not present in previous acceptability studies, likely due to the differences in healthcare provision across the world. Trust in the NHS is not a new phenomenon, it has been described previously at a micro level, between patient and clinician, as well as at a macro level in which the collective patient and public trust the joint healthcare organisation or healthcare system.[24] Both micro and macro levels of trust were evident in this study with participants citing trust in their specific GP or consultant as well as general trust in the decisions of NICE and NHS bodies. Considering the average age of participants in this study (72.5 yrs), many will remember the NHS in its infancy which may impact on their high levels of trust and belief in the reliability of the healthcare system for patient benefits.[25] Even participants who described challenging osteoporosis diagnosis journeys and high burden displayed trust in the wider system. This trust extended to ethical issues such as software and data protection where some fears were expressed about access from perceived enemies ('Russia') but fears being overridden by trust in NHS integrity.

The potential integration of predictive software and AI within healthcare was a major theme in this study, and it heavily impacted the acceptability of IBEX BH. While this software was indicated to evoke positive emotions by empowering patients, unclear communication of results and a lack of opportunity for questions raised feelings of fear and worry. These themes have been seen in other research seeking patient perspectives both in radiography and in wider healthcare.[9,11,14] Although preference for communication methods appeared to be impacted by digital literacy in this

study, the unambiguity of the need for HCP interaction was evident as with previous work.[11] Focus group participants cited result consultation as an important time to be able to gain deeper understanding of the results, especially presented numerically and to converse about treatment and lifestyle options.

This theme of HCP involvement in result communication should be especially noted in the case of osteoporosis diagnosis and management. The osteoporosis treatment gap notes a large proportion of those who need and can be prescribed anti-osteoporotic medications are not taking or taking medications incorrectly.[26,27] The osteoporosis treatment gap is evidently multifaceted in its causes,[27] however, some research indicates that increased patient understanding of osteoporosis, anti-osteoporotic medications and involvement in their healthcare decisions, increases uptake and adherence to treatment.[28,29] In fact a paper by Ralston et al., postulates that it is not a 'treatment gap' that is the problem but rather a 'care gap' when it comes to osteoporosis.[29] This aligns with calls for increased shared decision making and patient centred care within osteoporosis diagnosis and management. Therefore, as with any new intervention, the implementation within a healthcare setting needs to be carefully addressed to have positive impacts and be acceptable to patients. Merely the integration of a new diagnostic system without clear guidelines on communication will be unlikely to create any meaningful change for future osteoporosis patients.

When it came to the communication of results, the type of HCP appeared less important than their knowledge on osteoporosis and trust participants place in them. In this study some participants expressed concern of the amount of knowledge GPs and nurses held on the topic of osteoporosis. Research indicates that many GP's see osteoporosis as far less important than other chronic diseases and lack confidence in the interpretation of diagnostic BMD examinations.[30] There is further evidence that some GPs and other HCPs could be unfamiliar with osteoporosis related guidelines on anti-osteoporotic drug therapies which may result in poor clinical decision making.[31–34] Participants in this study indicated preference for a results communication from those they perceived as experts, either in osteoporosis, related subjects e.g. rheumatology or technical specialists. However, there was discussion that expertise was only a priority when being diagnosed with osteoporosis, results of 'normal' had fewer preferences. Participants who indicated preference for GP communication of results, related this to their desire for a trusted HCP. Participants mentioned preference for continuity of care or a practitioner who had known them for a long time, although there was a recognition that this is becoming less plausible with the lack of GPs and high demand from patients.[35] Previous literature support this, with patients reporting their preference to wait longer to see a familiar medical practitioner, specifically in cases where they had a problem causing uncertainty or new symptoms.[36]

Our study has limitations that should be considered. Participants were recruited from the local area resulting in a solely white population, who had higher average education levels than the general population. This is likely to have impacted the perceptions of participants and acceptability of the IBEX BH software. Further, while we aimed to employ purposively sampled to gain a range of health and digital literacy, the low response rate and acceptance of all who expressed interest resulted in the majority of participant being skilled in these areas and therefore future work may benefit form a focus on those digitally limited and excluded in current health care.

Future work

The development of IBEX BH is in its infancy with its first clinical trials currently being reported. Therefore, there is more research required into the reliability and validity of the technology prior to its implementation into clinical settings. This paper highlights key aspects of implementation from the perspectives of public and patients, however, future research should focus on perceptions of primary care and secondary care practitioners, their acceptability and views on implementation. Further, given the importance raised on result communication, future work could focus on co-production of result reporting guidance for IBEX BH outcomes.

Conclusion

This study utilised the lens of acceptability to understand public perceptions and acceptability of predictive software's in general, the IBEX BH software and IBEX BH integration into health care. Participants were generally positive about the possibility of new AI and predictive software's entering the healthcare system. Specifically in relation to IBEX BH participants with osteoporosis saw that this type of predictive software could speed up diagnosis and reduce the potential pain and decrease quality of life that occurs with osteoporosis. Participants were very clear that the way such technologies are integrated into the healthcare system greatly impacts the acceptability of such interventions specifically in relation to results communications.

Author contributions

Fay Manning: Conceptualisation, methodology, funding acquisition, investigation, writing- original draft, writing-review and editing and visualisation. *Aseel Mahmoud*: Investigation, data curation, writing-review and editing and project administration. *Rob Meertens*: Conceptualisation, methodology, funding acquisition, writing-review and editing and supervision.

Conflict of interest statement

Authors FM and RM have worked on the clinical trial initial clinical trial of the IBEX BH Software. This study received no funding from, nor had any involvement from IBEX Innovations or any of their employees. No other competing interests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.radi.2023.08.011.

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