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REVIEW

Improving colorectal cancer screening - consumer-centred technological interventions to enhance engagement and participation amongst diverse cohorts

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Abstract The current "Gold Standard" colorectal cancer (CRC) screening approach of faecal occult blood test (FOBT) with follow-up colonoscopy has been shown to significantly improve morbidity and mortality, by enabling the early detection of disease. However, its efficacy is predicated on high levels of population participation in screening. Several international studies have shown continued low rates of screening participation, especially amongst highly vulnerable lower socio-economic cohorts, with minimal improvement using current recruitment strategies. Research suggests that a complex of dynamic factors (patient, clinician, and the broader health system) contribute to low citizen engagement. This paper argues that the challenges of screening participation can be better addressed by (1) developing dynamic multifaceted technological interventions collaboratively across stakeholders using human-centered design; (2) integrating consumer-centred artificial intelligence (AI) technologies to maximise ease of use for CRC screening; and (3) tailored strategies that maximise population screening engagement, especially amongst the most vulnerable.

1. Introduction

Colorectal cancer (CRC) is the second leading cause of cancer-related mortality globally and incidence is steadily rising.[1] To perturb the mortality rate, several nations have recommended biennial screening via the faecal occult blood test (FOBT) with follow-up diagnostic assessment via the colonoscopy.[2] While CRC-mortality rates are known to decline in the presence of FOBT screening,[3] the extent of its impact is largely predicated on (a) the degree of population screening coverage (ideally 65-80%),[4] (b) adherence to screening in regular intervals, and (c) adherence to follow-up diagnostic assessment. Unfortunately, many nations fall short of their targets, leading some to suggest that CRC is the "most preventable, yet least prevented" forms of

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cancer.[5] The results from several modelling studies are clear - increase participation rate, reduce mortality rate. In Australia, the current participation rate is ~40% and reduces CRC-related mortality by 15-36%, however, a more significant 59% reduction could be achieved, if participation were to increase to 70%.[6,7] In the European Union (EU), where there exists wide variation in the access and uptake of screening,[8] nations that have a high participation rate of 60-70%, such as the Netherlands and Slovenia, diagnose ~50% of patients at Stage 1,[9,10] while other EU nations with lower participation, diagnose ~15% at Stage 1, and if this were to increase to ~50% broadly, CRC survival rate in the EU would increase to 90% and prevent an additional ~130,000 deaths.[11] Similarly, in the United States, following the National Colorectal Cancer Roundtable (NCCRT) "80% by 2018" initiative, it was argued that increasing the CRC screening rate from ~60% in 2013 to 80% in 2018, would reduce CRC-mortality in 2030 by 33% and avert ~200,000 cancer-related deaths.[12] Collectively, this suggests that internationally, there is a strong medical and economic argument to direct resources and investment into approaches that increase participation in CRC screening.

This paper offers a new philosophical perspective on how to enhance participation in CRC screening. The paper is divided into three parts. Section two first highlights how there are demonstrable disparities in citizen/patient participation in CRC screening programmes across diverse cohorts, which are most pronounced amongst marginalised groups and analyses the reasons for these disparities. It points to a complex of patient, physician, and healthcare system factors that amalgamate to limit participation and highlights how existing issues have been exacerbated by the COVID-19 pandemic. The section culminates with a new position that argues that the conventional generic group-based characterisations of citizens into "cohorts" is problematic, as individuals tend to have multifactorial reasons for nonparticipation, the significance of which is weighted according to a unique blend of psychological, cultural, temporal, and personal circumstances. Therefore, the willingness to participate in CRC screening needs to be observed as a dynamic process that is highly influenced by interactions with current internal personal priorities in life, external cultural, social, and familial circumstances, and wider perceptions and trust in healthcare. Section three proceeds to analyse the current landscape of potential technologies that can be used as an alternative to FOBT-based CRC screening. However, it does not advocate for any "one technology" and instead argues that the dynamic process of participation observed in section two, is arguably incompatible with a singular static "Gold Standard" screening goalpost. It argues that to truly achieve optimal CRC outcomes, the clinical community must move away from perpetual debates around which interventions are most "accurate" and recognise that, an intervention that may be less accurate, but that may be empowering to the consumer to increase their engagement with the health system, is as important as the most accurate system for citizens whose alternative, is simply not to participate. Section four consequently culminates by arguing that a more apt approach for the future is to embrace myriad multi-faceted consumer-driven technological interventions that drive citizens on a journey towards the Gold Standard.

Indeed, the last three decades of technological development in the clinical diagnostic space has shown how a clinician's access to diverse tools such as the conventional optical colonoscopy (CC), CT colonography (CTC), flexible sigmoidoscopy (FS), and capsule-based endoscopy (CCE), as well as various clinical decision support systems (CDSS) has been empowering to both the clinician and the patient, leading to better outcomes. It is time that consumers are empowered in the same way when it comes to screening, where they are provided with a choice in screening interventions that are most suitable to their personal circumstances. However, for this to work, it will require a collective effort between clinicians, policymakers, and the health system to support the view that achieving population-wide "reach" and "engagement" can only occur when individuals are empowered with the *choice* to select the tool most suitable to their individual circumstances. This means that we need to move away from cost-benefit analyses of individual interventions in lieu of other interventions and recognise that improving health outcomes is a dynamic journey, and citizens are more likely to continue down the path of a more invasive and more accurate intervention when they are presented with more options to "start" the journey of engagement.

2. Challenges to Maximising Participation in CRC Screening

One of the challenges in achieving the desired participation rate is the fact that there are demonstrable disparities in the adoption, access, and adherence to CRC screening programmes across diverse cohorts, most significantly amongst marginalised Indigenous, low socio-economic, disabled, or culturally and linguistically diverse groups.[13,14] Qualitative studies that have examined the barriers and facilitators to patient participation in CRC screening suggests that interrelationships between the patient, the physician, and the wider health system, amalgamate in highly personalised ways based on individual circumstances, influencing one's willingness to undertake screening. Generally, factors such as (1) low perception of risk associated with CRC; (2) misunderstanding guidelines around screening, assuming it is only required in the presence of symptoms; (3) low education and awareness of CRC compared to other high-profile cancers; (4) misunderstanding of test kit instructions among culturally and linguistically diverse groups; (5) conflicts between cultural, ethnic, gender, or identity attitudes and CRC screening; (6) reduced access to healthcare services in regional, rural, and remote areas; (7) lack of time or transportation availability to engage with healthcare services; (8) financial affordability when engaging with healthcare services; (9) poor primary care physician endorsement of CRC screening; and (10) poor interoperability between primary physician and national databases to flag patients and follow-up patients in need of screening; have all been implicated as key drivers to poor patient participation in CRC screening.[15–23] Many have argued that the solution to addressing the disparities in screening participation is to (a) increase awareness via mass-media campaigns,[24] (b) increase equity of access by reducing the financial burden

related to screening,[25] (c) improve outreach amongst marginalised under-screened sub-groups who have the lowest participation in screening and the worst CRC outcomes, [26,27] (d) improve primary care physician monitoring and endorsement of screening to eligible participants,[28,29] and (e) simplify the messaging and testing procedure itself and ensure it is sensitive to cultural and linguistic diversity. [30]

While such initiatives undoubtedly play an important role in increasing participation in CRC screening, evidence on the ground suggests that their effectiveness may be limited by the nature of the interventions themselves, particularly as the search for the most cost-effective screening solution has tended to drive the screening strategy, irrespective of whether the approach and/or intervention is relevant to the personalised needs of diverse patients. For example, in the United States, even though the NCCRT did an excellent job at increasing participation rates (65.1% in 2012 to 68.8% in 2018 according to the BRFSS data; and 30.2% in 2012 to 44.1% according to UDS data), it was clear that it fell short of its target and it was apparent that not everyone benefited from the campaign equally.[31] Racial and ethnic communities, low-income communities, rural communities, and even individuals in lower age brackets (50-54 years) experienced significantly lower rates of participation, prompting a new campaign "80% in Every Community".[31] Similarly, in Australia and England, where the cost of CRC screening is alleviated by a national framework, and where investment into large-scale mass media campaigns, targeted education and support programs, and primary care engagement has existed, there remains low rates of participation and significant disparities in participation along socioeconomic lines. [15,27,32,33] In Australia specifically, where addressing the high rate of CRC has been declared a national priority, only marginal improvements in the rate of participation have been observed over the last 5 years (39% in 2014-15, 41% in 2016-17, 42.4% in 2017-18, 43.5% in 2018-2019).[32] Such data suggests that a more nuanced participation strategy is needed; one that balances the need for maximal access, awareness and outreach across diverse communities, with the needs of the patient and their expectations around the nature of the interventions.

Exacerbating the issues associated with poor participation in FOBT screening, is the fact that patients who receive a positive FOBT, and who are at a higher risk of CRC, require a confirmatory diagnostic colonoscopy to reap the benefit of screening. However, participation in follow-up colonoscopy is equally discouraging at 50-70% across many nations such as Europe, the United States, Canada, Australia, Japan, and Israel.[32,34—36] Unfortunately, this already problematic diagnostic landscape has significantly worsened during the COVID-19 pandemic, where a major global reduction in elective endoscopic procedures combined with a broader unwillingness by patients to engage with healthcare centres due to fear of COVID infection, has challenged the acquired benefits of CRC screening.[37—40] For example, data from the United Kingdom (UK) during the peak phase of the COVID-19 pandemic revealed that total endoscopic activity fell to 5% of normal levels and CRC diagnoses during this time were 72% below expectations,[37,39] with modelling revealing fatalistic implications to the diagnostic delays - an ∼15% increase in CRC-related mortality.[41] Some evidence suggests that there is a greater willingness by some patients to engage in healthcare screening practices when they are accessible from home.[42] Given the way the pandemic has evolved through variant strains and the pertinent possibility of future pandemics arising, it is increasingly important that we consider a paradigm shift in the way we approach delivering patient care - it is likely that diagnostic medical technologies that were once designed for the healthcare setting, will increasingly have patients demand they be delivered from the home.

In the view of the authors, the difficulty with increasing participation rates under the current strategy, is the fact that the issues preventing participation by some individuals, may have less to do with awareness, and more to do with the way that the current intervention interacts and/or conflicts with individual psycho-social and cultural factors. For example, it has been reported that for some individuals issues such as stigma, shame, mistrust, and uneasiness relating to (a) the screening or diagnostic intervention itself (handling of faeces, bowel preparation, or invasiveness of a colonoscopy),[21—23,43] (b) receiving a cancer diagnosis, or (c) engaging with a healthcare practitioner that may lack cultural nuance and be perceived as discriminatory,[44] can be more influential towards non-participation, even in the presence of awareness and education. This view may be supported by the fact that the NCCRT identified that one of the top barriers to CRC screening was an issue of "rationalised avoidance", which described a phenomenon where a patient is knowledgeable, has the financial means for screening, but psychologically diminishes its importance due to multifaceted personal reasons.[45] An important research question to examine, is how do the nature of screening interventions impact on patient non-participation in CRC screening?

3. The Current Landscape of Screening Interventions

It can be argued that some of the human factors preventing participation in CRC screening are tightly coupled with the nature of the FOBT-based screening intervention itself. As a result, some researchers have developed and proposed new modalities that, it is believed may lead to greater citizen acceptability and engagement with CRC screening. These have included plasma DNA testing, colon capsule endoscopy (CCE), urine-based metabolomic tests, and artificial intelligence-based predictive algorithms that utilise diverse data sources. In this section, a socio-technical analysis is provided on the benefits and limitations of these technologies in terms of their potential to enhance patient engagement with CRC screening.

Recent improvements in combinatorial biomarker approaches to plasma DNA testing (sensitivity 88.9% and specificity 92.8%)[49,50] have suggested that it could be considered as an alternative approach to CRC screening with improved participant uptake, particularly as it addresses the issues associated with the handling of faecal matter required by the iFOBT or Faecal DNA test. In a recent qualitative study from Denmark, it was found that 61% of citizens who were unwilling to participate in FOBT-based screening, would reconsider their position, if a blood sampling

intervention was provided.[17] However, importantly, 17% of the non-participants, stood firmly on their unwillingness to engage, even in the presence of a plasma-based screening approach. Interestingly, in a different study, Young et. al. [56] found the opposite to be true: when non-participants were invited to undertake screening, offering an iFOBT in one arm, a plasma-based test in another, or the choice between the two in a third, the number of individuals that participated in screening were 12% for the iFOBT, 13.3% for the plasma-based test, and a significantly higher proportion choosing the iFOBT when given the choice. The dichotomous conclusions presented by these studies highlights the complexity of designing a single universal screening approach for the population. It is important to recognise that there are myriad psycho-social factors that influence nonparticipation, and while plasma-based screening may address *some* of the concerns (e.g., faecal handling), it certainly does not address all of them, for all patients. For example, in the case of attending a venesection, there is a key dependency of direct involvement with the healthcare system, which has been shown to be less favourable by certain non-participating subgroups. Furthermore, neither the iFOBT nor plasma-based test address the other large concern patients may have - the need for a confirmatory diagnostic colonoscopy in the event of a positive result - the knowledge of which may prevent some patients from choosing to be screened to begin with.

Beyond the physical and practical challenges associated with the FOBT or plasma-based tests, there is a psychological dimension that permeates the concept of screening more broadly - the anxiety associated with the potential of receiving a cancer diagnosis, which may prevent some individuals from choosing to be screened in the first place. It is likely then, that if the goalpost of screening were to shift towards the detection of *precancerous* lesions, the messaging around screening would be significantly more inviting, as it would connote positive attitudes around “disease prevention” rather than negative attitudes around “disease detection” and circumvent some of the psychological inhibitions that prevent the initial uptake and engagement with screening. The issue is that the aforementioned technologies have only ever offered extremely poor sensitivities when isolated for the detection of precancerous polyps, as observed in Table 1: iFOBT (24-56%), faecal DNA testing (17-46%), and plasma DNA testing (12-48%).[46,48,50,57–59] A technology that could detect precancerous polyps and that could be used as a screening intervention with high patient acceptability would have a profound impact on CRC morbidity and mortality outcomes, as it is widely believed that the removal of polyps via polypectomy can reduce CRC incidence by up to 90%, and as a natural consequence of that, reduce associated CRC mortality.[60–63]

CCE technology has been speculated to have the capability to achieve this goalpost and usher in a new era for CRC screening. The view is that CCE technology has the dual benefit of (1) addressing the adverse risks and poor patient acceptability associated with screening, surveillance, and diagnostic colonoscopy,[53] and (2) can lead to an expansion of CRC screening programmes, by enabling for the detection of precancerous polyps through direct visualisation of the bowel wall. The scientific evidence is favourable, where a systematic review on the use of CCE for CRC screening, found that the sensitivities of CCE for polyps $>$ 6mm and $>$ 10mm were 79-96% and 84-97% respectively,[53] and interim results from the largest randomised control trial on the CCE from the Danish Colorectal Cancer Screening Program has also shown a promising high polyp detection rate.[64] Of course, CCE is not without its limitations, there are concerns around capsule retention; variable CCE completion rate (57 - 92%); the need for aggressive bowel preparation; prohibitive costs when used for screening; an inability to biopsy, irrigate, insufflate, and exercise locomotion capabilities; lower image resolution; and a lack of trained video readers.[65–68] Reassuringly, some of these engineering challenges are currently being addressed in the literature and it is expected that many of these issues will be solved in the coming decade.[69–71]

While there is much optimism for CCE technology, it is important to remember that one of its key dependencies is the need for aggressive bowel preparation, which has been shown to be a barrier for some patients. Urine-based metabolomic tests could be used as a more viable and more cost-effective approach to CRC screening, given that preliminary studies have shown promising sensitivities of 80-88.9%.[54] There is some work that has also shown how such an approach could be used for the detection of adenomatous polyps, showing a sensitivity of 82-89%, but poorer specificity of 42-50%.[55,72] However, if this test were to be dependent on the healthcare system, in the same way that plasma-based approaches are, then it too, would succumb to the same problems. This suggests that no “one” technology offers a solution to all citizens, as the dynamic nature of personal and situational context means that interventions that are perceived as problematic for some, are the same technologies that offer solutions to others. Therefore, as a clinical community, a broader strategy to CRC screening that recognises the diversity of the human experience and encourages multiple modalities based on a citizen’s individual circumstances, is more likely to have a more salient effect on participation in screening.

Table 1 Sensitivity and specificity of currently available screening interventions.

Method	Sensitivity (CRC)	Sensitivity (Adenoma)	Specificity
iFOBT[46,47]	79%	24 - 56%	94%
Multitarget Stool DNA Test[48]	92%	17 - 46%	90%
Plasma DNA Test[49,50]	89%	12 - 48%	93%
Computed Tomography Colonography[51,52]	84%	57 - 84%	88%
Colon Capsule Endoscopy[53]	93%	79 - 97%	66 - 97%
Urine Metabolomic Test[54,55]	80 - 89%	82 - 89%	80%

The incumbent artificial intelligence (AI) and machine learning (ML) revolution has also provided much needed optimism for the future by expanding the potential ways that future onset of CRC can be predicted accessibly through software-based implementations using a range of different data inputs. Wan et al.[73] predicted the early onset of CRC with a mean Area Under the Curve (AUC) of 0.92 and sensitivity and specificity of 85% using whole-genome sequencing of plasma cell-free DNA; Chan et al.[74] predicted recurrence of CRC using historical genomic data with sensitivities ranging 80-91.67% (depending on nationality), and Nartowt et al.[75] classified citizens into low, medium and high CRC-risk groups using various personal and lifestyle factors captured from the National Health Interview Survey (NHIS) dataset and the Prostate, Lung, Colorectal, Ovarian Cancer Screening dataset (PLCO). However, as with all technologies, the current implementation of AI has its own set of limitations. Representational biases in datasets used to train ML models combined with AI model constraints that tend to inadequately disentangle citizen context, can in some cases exacerbate healthcare inequities and further marginalise individuals that are already the least supported by the current healthcare system.[76—79] This is of particular concern when developing AI methods to increase participation among nonparticipants, as the healthcare datasets that algorithms depend on are often skewed in favour of a participating population, only to be productionised on a general population that includes a large proportion of nonparticipants who potentially carry different predispositions of disease. Therefore, AI optimism needs to be moderated by a more nuanced approach to the design, development, implementation, and evaluation of AI systems that considers the implications for the patient, the physician, and the wider healthcare system. Assuming researchers are cognisant of these challenges in the development of AI systems, the important next question becomes, what interventions and/or experience can be developed to maximally engage marginalised nonparticipants into the process of screening? While we can posit varying concepts such as (1) an autonomous monitoring device that analyses faecal matter without the need of additional steps by the patient; or (2) a computer-vision based mobile application that analyses pictures of stools; or (3) a predictive model that uses diverse, but ubiquitous multi-modal data points combining the patient's health record with external lifestyle data inputs; it is important to consider that a more effective way of imparting maximal benefits to marginalised users, is to adopt a user-centred design philosophy and engage nonparticipants as active co-designers of new interventions. Otherwise, there is a risk that future solutions presented by AI do little to improve patient outcomes, due to ineffective adoption by the target population.

4. Moving Forward with Technology for CRC Screening and Participation

In the analysis of section three, it was noted that what is perceived as a "problem" to *one* consumer, is not the same for *all* consumers. For instance, a patient that denigrates their belief in the accuracy of a positive FOBT due to an unwillingness to undertake an invasive diagnostic colonoscopy, may be more inclined to perform a conventional colonoscopy, after first receiving a confirmatory diagnosis with images in a CCE. Similarly, a citizen that does not participate in any screening presently due to fear of a cancer diagnosis, may find greater utility in a CCE that is capable of screening precancerous lesions. This will not be the case for all consumers, as some may find bowel preparation itself as the main inhibitory factor irrespective of CC or CCE, and therefore, may opt out of both modalities in their entirety. Alternatively, a patient whose primary issue is the handling of faecal matter via stool-based tests may find greater utility from a plasma-based or urine-based test; but for a different patient, where access to a healthcare facility is the most significant hindrance or where time is an imposition or simply where systemic distrust of healthcare practitioners permeates, an AI-based risk stratification tool may have a greater role in engaging the participant to revisit their relationship with the health system. Ultimately, the list of potential citizen characterisations is boundless once it is recognised that the way a consumer engages with healthcare is a dynamic, context-dependent interaction, and the decision to use one intervention over another is individually balanced against the multifactorial reasons for nonparticipation. This leads us to the central thesis of this paper - a consumer's individual situational context, rather than their generic cohort characterisation, will ultimately dictate the relative significance of the purported modality's strengths and limitations.

The difficulty in translating this philosophical view into a broader actionable system-wide CRC screening strategy, is the fact that there are implementation challenges associated with scaling personalised care that cannot go ignored, such as the issue of cost effectiveness. For example, if a screening intervention increased participation, but did so in a way that dramatically increased the number of unnecessary colonoscopies that needed to be performed, is the intervention perceived as a success or failure? What residual effect does this then also have on patient outcomes, if their engagement with the health system changes over time in response to having undertaken an unnecessary procedure? Or alternatively, if the intervention itself is costly to develop and manufacture, can it be equitably adopted across global health systems, and be disseminated to the patients who need it most? Indeed, the authors acknowledge this limitation, but also note that one of the hallmarks of modern technology is its ability to achieve greater cost-effectiveness and scalability over time, particularly when there is a public interest in adopting the technology. For example, sequencing the human genome 20 years ago was inaccessible to most of the population, costing $100 million per human genome, but today, that cost has reduced significantly to less than $1000.[80]

Consequently, it is critical that more qualitative work is performed that captures data around the nature of the context-dependent interactions that influence choices around interventions so that the right technologies that users are willing to adopt are developed. Furthermore, design, development, deployment, and evaluation methodologies need to be enhanced for the AI-era so that the development of novel technologies address the human factor-based issues associated with dichotomous human experiences that currently prevent a large proportion of the population from

participating in CRC screening. The hypothesis is that there is a need for interventions that are sensitive to calls for: (a) home-based delivery of patient care, particularly in a COVID context, (b) fewer steps in the screening process, (c) lower barrier to initial entry (e.g., not requiring a stool sample), (d) fear and anxiety around procedural requirements, and (e) a shifted goalpost to not only screen for disease, but precancerous lesions to promote a positive narrative around prevention. However, the solution should not be one approach and instead should entail myriad technologies to meet the expectations associated with diverse consumer lived experiences. Technologies in the current landscape may already address some of these issues, however, where it is believed that a significant gap in current research remains is in how to better utilise AI technologies for the purpose of screening in a way that is accessible, equitable, safe, and adoptable by under-screened groups. Empowering these patients to drive the agenda around what could be developed, may be one way to achieve that goal.

The dogma of AI development, to date, has focused predominantly on accentuating accuracy through big data collection. While this approach has been advocated as the best method to training highly accurate AI systems, it is likely that this approach alone in practice, will not be robust enough to solve all the challenges of participation. Prior evidence suggests that marginalised individuals that do not currently participate in screening, and who would potentially benefit the most from an AI-based intervention, tend to be the same individuals that AI systems consistently misclassify, due to the systemic biases that are engrained in AI training datasets.[81] Furthermore, the data-driven, accuracy-first approach of AI development, tends to assume that the patient, clinician, or health system, will be willing or capable to provide all the data required of an intervention. This leads to what we call, a problematic *"data displacement dogma"*, where AI model development comes first, interrogation of the veracity of data comes second, and end-users come last. The methodology to AI development in the CRC screening space needs to be reversed to favour a consumer-centred approach if we are to achieve the tangible impact desired by the community on CRC mortality rates. Otherwise, theoretically interesting ideas, such as a recently proposed personalised AI-based health monitoring device that analyses excreta from a Smart Toilet in real-time, identifying the user through a biometric photograph of their anus, [82] stays just that - theory - with little benefit to CRC outcomes, as very few end-users choose to use the system, data collection subsequently becomes skewed to a minority group, and ultimately AI models fail to generalise when operationalised in the real world.

5. Conclusion

Participation rates in CRC screening have plateaued globally and initiatives to increase screening participation by marginalised patients have tended to not achieve their targets. This paper argues that the issue with screening has less to do with the strategies used to increase engagement and awareness, and more to do with whether the interventions that are being advocated for, meet the expectations that diverse consumers have of the interventions. In analysing the different interventions that currently exist for screening, such as the iFOBT, plasma-based test, CCE, or urine metabolomic test, a recurring theme emerged: each technology offered various experiential trade-offs, the significance of which is often context-dependent according to the unique circumstances and values of the patient. For example, it was observed that plasma-based tests, widely perceived as a tentative solution to the problem of faecal handling with the iFOBT, returned conflicting results across different studies, with one suggesting a significant effect on screening uptake, and the other showing the opposite to be true. Such evidence reinforced the position of this paper, which advocated for a more flexible screening strategy; one that acknowledges the different needs of diverse patients. In adopting this view, an opportunity to leverage emerging technologies and design new interventions to meet those needs was identified. To that end, AI may play a central role in reimagining new possibilities. However, it is critical that AI development is approached in a nuanced way, to (1) mitigate against the risk of representational biases that exacerbate the health divide, and (2) results in systems that benefit the population that needs it most. The methodology that may be best positioned to achieve that, is user-centred design, where end-users who have thus far, been let down by technology, are invited to reimagine and design a system that meets their needs. This will form the basis of our ongoing research.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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