

Public awareness and attitudes toward the use of artificial intelligence in pathology research and practice: results from a nationally representative UK survey.

Claire Lewis, Jenny Groarke, Lisa Graham-Wisener, Jacqueline James

Submitted to: Journal of Medical Internet Research
on: April 17, 2024

Disclaimer: © The authors. All rights reserved. This is a privileged document currently under peer-review/community review. Authors have provided JMIR Publications with an exclusive license to publish this preprint on its website for review purposes only. While the final peer-reviewed paper may be licensed under a CC BY license on publication, at this stage authors and publisher expressly prohibit redistribution of this draft paper other than for review purposes.

Table of Contents

Original Manuscript..... 5
Supplementary Files..... 29
..... 29
Multimedia Appendixes 30
Multimedia Appendix 1..... 30

Public awareness and attitudes toward the use of artificial intelligence in pathology research and practice: results from a nationally representative UK survey.

Claire Lewis^{1*} PhD; Jenny Groarke^{2*} PhD; Lisa Graham-Wisener³ PhD; Jacqueline James¹ PhD

¹ School of Medicine Dentistry and Biomedical Sciences Queen's University Belfast Belfast GB

² School of Psychology National University of Ireland Galway Galway IE

³ School of Psychology Queen's University Belfast Belfast GB

*these authors contributed equally

Corresponding Author:

Claire Lewis PhD

School of Medicine Dentistry and Biomedical Sciences
Queen's University Belfast
University Road
Belfast
GB

Abstract

Background: This last decade has witnessed major advances in the development of artificial intelligence (AI) technologies for use in healthcare. One of the most promising areas of research, and potential clinical utility, is in pathology. Whilst the value of using AI in pathology to improve efficiency and accuracy of diagnosis cannot be underestimated, there are several challenges in the development and implementation of such technologies, notably public support for the use of AI to assist in a pathological diagnosis and support for the use of healthcare data and tissues to train pathology algorithms.

Objective: To investigate public awareness and attitudes towards the use of AI in pathology research and practice.

Methods: A sample nationally representative of the UK population was recruited via Prolific (n = 1518) and a cross-sectional online mixed methods survey assessed public awareness and attitudes towards the use of AI in pathology

Results: Quantitative data indicated that awareness was low with only 24% somewhat/moderately aware of AI being developed for use in pathology. Most did not support a diagnosis of cancer (60%) or of biomarkers (46%) being made by AI only. However, the vast majority (97%) supported a diagnosis being made by a pathologist with the assistance of AI. The odds of supporting use of AI in cancer diagnosis and management were higher for men (OR: 1.34). Greater awareness (OR: 1.25), greater trust in data security and privacy protocols (OR: 1.04), and more positive beliefs (OR: 1.27) also increased support, whereas identifying more risks reduced the likelihood of support (OR: 0.80). Three main themes emerged from the qualitative data: Bringing the public alongside; The human in the machine; More hard evidence needed; indicating conditional support for AI in pathology subject to human oversight of AI in decision making; robust oversight measures for data handling and protection; and hard evidence of the benefit and effectiveness of AI.

Conclusions: There was a low level of awareness of the potential use of AI in pathology, yet respondents were positive and indicated a high level of conditional support for its use. Challenges remain in addressing the concerns of certain demographic populations along with apprehension about the access and use of healthcare data by private organisations.

(JMIR Preprints 17/04/2024:59591)

DOI: <https://doi.org/10.2196/preprints.59591>

Preprint Settings

1) Would you like to publish your submitted manuscript as preprint?

Please make my preprint PDF available to anyone at any time (recommended).

Please make my preprint PDF available only to logged-in users; I understand that my title and abstract will remain visible to all users.

Only make the preprint title and abstract visible.

✓ **No, I do not wish to publish my submitted manuscript as a preprint.**

2) If accepted for publication in a JMIR journal, would you like the PDF to be visible to the public?

✓ **Yes, please make my accepted manuscript PDF available to anyone at any time (Recommended).**

Yes, but please make my accepted manuscript PDF available only to logged-in users; I understand that the title and abstract will remain visible.

Yes, but only make the title and abstract visible (see Important note, above). I understand that if I later pay to participate in <http://www.jmir.org/preprint/59591>



Original Manuscript

Original Paper

Public awareness and attitudes toward the use of artificial intelligence in pathology research and practice: results from a nationally representative UK survey.

Dr Claire Lewis*¹ Dr Jenny Groarke*² Dr Lisa Graham-Wisener³ Professor Jacqueline James¹

¹ School of Medicine, Dentistry & Biomedical Sciences, Queen's University Belfast, Belfast, Northern Ireland, BT7 1NN.

² School of Psychology, National University of Ireland Galway, University Road, Galway, Ireland.

³ School of Psychology, Queen's University Belfast, Belfast, Northern Ireland, BT7 1NN.

*These authors contributed equally to this work.

Corresponding author: claire.lewis@qub.ac.uk
School of Medicine, Dentistry & Biomedical Sciences,
Queen's University Belfast,
Belfast,
Northern Ireland,
BT7 1NN.
Tel: +442890972804

Keywords:

Artificial Intelligence, public opinion, pathology, healthcare, public awareness, survey

Abstract

Background: This last decade has witnessed major advances in the development of artificial intelligence (AI) technologies for use in healthcare. One of the most promising areas of research, and potential clinical utility, is in pathology to aid in cancer diagnosis and management. Whilst the value of using AI to improve efficiency and accuracy of diagnosis cannot be underestimated, there are several challenges in the development and implementation of such technologies, notably public support for the use of AI to assist in a pathological diagnosis and support for the use of healthcare data and tissues to train algorithms. The objective of this study was to investigate public awareness and attitudes towards the use of AI in pathology research and practice.

Methods: A nationally representative (n= 1518), cross-sectional, online mixed-methods survey was conducted to assess the UK public's awareness of, and views towards, the use of AI in pathology

research and practice. Respondents were recruited via Prolific, an online research platform, and to be eligible for the study participants had to be over 18, a UK resident, and have the capacity to express their own opinion. Respondents completed a survey which consisted of 30 closed questions and two open questions. Sociodemographic information and previous experience of cancer was collected. Descriptive and inferential statistics were used to analysis the closed question data; thematic analysis was used to analyse the open question data.

Results: Quantitative data indicated that awareness was low with only 24% somewhat/moderately aware of AI being developed for use in pathology. Most did not support a diagnosis of cancer (60%) or of biomarkers (46%) being made by AI only. However, the vast majority (97%) supported a diagnosis being made by a pathologist with the assistance of AI. The odds of supporting use of AI in cancer diagnosis and management were higher for men (OR: 1.34). Greater awareness (OR: 1.25), greater trust in data security and privacy protocols (OR: 1.04), and more positive beliefs (OR: 1.27) also increased support, whereas identifying more risks reduced the likelihood of support (OR: 0.80). Three main themes emerged from the qualitative data: *Bringing the public alongside; The human in the loop; More hard evidence needed*; indicating conditional support for AI in pathology subject to human oversight of AI in decision making; robust oversight measures for data handling and protection; and hard evidence of the benefit and effectiveness of AI.

Conclusions: There was a low level of awareness of the potential use of AI in pathology, yet respondents were positive and indicated a high level of conditional support. Challenges remain in addressing the concerns of women regarding the use of AI in their cancer diagnosis and management. Apprehension remains about the access and use of healthcare data by private organisations

Background

The last decade has witnessed major advances in the development and application of artificial intelligence (AI) technologies. Coined by Professor John McCarthy in 1955, the term AI was originally described as the ‘*science and engineering of making intelligent machines, especially intelligent computer programs*’ (1). It already features in many aspects of modern life, including the use of smart home devices, search engines, and facial recognition software. Indeed, given its potential to improve efficiency and productivity across a range of industries and public sectors, AI has been regarded as one of the most important new technologies of the century for policy makers, governments, and citizens alike (2).

In the context of health, it has been claimed that AI has the potential to revolutionise healthcare by offering improved diagnostic accuracy, reducing costs, and enabling a more personalised approach to medicine (3,4). Currently, there are a limited number of AI applications that have been approved for clinical use in Europe and the United States (US), with most of these being in the field of medical imaging(5). In 2021 the first pathology AI based software was approved by the US Food and Drug Administration to assist with the detection of prostate cancer (6). This milestone was indicative of the transformational shift that has occurred in pathology in the last few decades; a shift that has seen a move away from the traditional microscopic review of a glass slide, toward the use of state-of-the-

art digital scanners to generate a high-resolution image that is wholly representative of the original tissue section and of comparable diagnostic quality (7). This digital approach offers many advantages in terms of improved efficiency and productivity in clinical laboratory workflows, but it is also the availability of complex visual information in these digitally generated images that has provided a rich source of data for the development of novel AI pathology algorithms to potentially aid with diagnostic and analytical procedures (8). Many studies have since used these digitised slide images to train computer algorithms for aspects of pathology practice including automated identification of lymph node metastases (9), prediction of prognosis (10), disease grading and classification (11,12) and identification of clinically actionable targets (biomarkers) for cancer treatment (13), with many studies claiming comparable or superior performance of artificial intelligence when compared to human intelligence (9–12).

The potential of these AI tools in terms of improved efficiency, cost-effectiveness, and accuracy of diagnosis cannot be underestimated. However, in addition to regulatory considerations, several challenges must be addressed in the development and implementation of such technologies in diagnostic pathology practice. One of these is public support for regulated access to healthcare datasets for AI research. The development of machine learning and deep learning approaches in pathology not only requires access to large numbers of digitised whole slide images (WSIs) but also requires the generation and aggregation of vast amounts of anonymised patient data including, but not limited to, data from healthcare records and investigative tests. The public must therefore have trust and confidence that their data will be used safely, securely, and appropriately (14). While safeguards are in place to govern the sharing of data (15), it is well documented that corporate profiteering, data privacy and security are consistently among the public's top concerns regarding the sharing and use of health data in research (16–18). High-profile cases such as the one involving the AI application Google DeepMind, which was granted 'legally inappropriate' access to National Health Service (NHS) data, have tested public confidence in how the NHS safeguards access to data for secondary use (18). Furthermore, evidence indicates that public support for the use of health data in AI research is conditional upon the potential benefit in return (19). This is important to note given that there appears to be a general lack of public knowledge and awareness of data science and AI (20), which could result in a failure to see the benefit and value of its application in a healthcare setting such as diagnostic pathology.

Secondly, while research in pathology algorithm development uses data in the form of digitised WSIs, the WSI still must be generated from a human tissue sample. In the United Kingdom (UK) the use of human tissue samples for research is governed under the Human Tissue Act of 2004 (21). This provides a regulatory framework that allows deidentified residual clinical material (e.g. formalin-fixed paraffin embedded tissue blocks residing in diagnostic archives and surplus to further clinical requirement) to be used for research purposes without explicit consent so long as the sample is rendered anonymous to the end user (21). This position is in line with public consensus supporting the use of tissue samples in research (22–25) and particularly in cancer research (25). However, we do know that various factors influence public attitudes towards the use of their samples in research. These include socio-demographics, health status, cultural and religious values, awareness, knowledge, past experiences, beliefs about the potential benefits and risks, attitudes towards genetic and medical research, experience with the healthcare system, and trust in government and scientific institutions (22–27). These factors have yet to be explored in the context of the use of tissue and linked data in AI research.

Finally, there needs to be public support for the use of AI in their own healthcare, particularly in disciplines such as pathology where it is predicted that AI will significantly transform practice (28). One UK study surveyed men who had undergone a prostate biopsy (n=1276) and reported that respondents were mostly supportive of AI as a diagnostic companion to professional decision making

(83%, 1058/1276) (29). However, more widely, there have been documented concerns from the public about an over reliance on AI in healthcare at the expense of human involvement (30,31), and uncertainty about the delegation of clinical responsibilities to machines and systems (32,33). A report from The Academy of Medical Royal Colleges recommended early and ongoing public engagement in the development and implementation of AI to maximise impact and ensure that the public has their say when examining the acceptability of such technologies (34). Currently there is a dearth of evidence upon which to draw such conclusions in pathology practice as there has been limited investigation of this to date beyond the male cohort surveyed by Rakovic and others (29). To this end, there is a need to examine the extent of public awareness of AI, and their views on its potential use in diagnostic pathology, to gauge the level of support and identify any concerns, ultimately fostering informed public endorsement for the integration of AI applications in pathology and the anticipated benefits in terms of efficiency and accuracy. The aim of this study was therefore to investigate public awareness and attitudes towards the use of AI in pathology research and practice, with the following objectives:

- I. To assess public awareness and attitudes regarding the *development* of AI technologies in pathology
- II. To assess public awareness and attitudes regarding the *implementation* of AI technologies in pathology
- III. To identify matters of concern and sources of support regarding the design and implementation of AI technologies in pathology.
- IV. To determine whether sociodemographic characteristics, experiences of cancer, awareness, beliefs, and attitudes influence support for the development and implementation of AI in pathology.

Methods

Design

A nationally representative cross-sectional online mixed-methods survey was conducted to 1) assess the UK public's awareness of and views towards the use of AI in diagnostic pathology, and 2) ascertain levels and predictors of support for (i) the use of AI in diagnostic pathology and for (ii) the use of de-identified personal health data and images of tissue in the development of AI technologies for cancer diagnosis and management.

Recruitment

The survey was administered online (30th November 2022), with respondents recruited via an online crowdsourcing platform managed by Prolific Academic Ltd (35) to provide a nationally representative sample of ~1500 UK respondents stratified across three demographics: age, sex, and ethnicity. To be eligible for the study, respondents had to be residing in the UK; over 18 years of age; and have the capacity to express their own opinion.

Survey design and measures.

The survey was created and hosted on Qualtrics, web-based software to assist with survey management. The online survey consisted of 30 closed questions, 2 open questions, 2 attention checks, 2 screener validation questions (age and country of residence) and 1 captcha (see Multimedia Appendix 1: Online Survey Questions). The survey was developed by the research team with input from a Patient and Public Involvement panel and pilot tested with individuals external to the research team (n=5). To ensure the questions were easy to understand, lay terms such ‘cancer diagnosis and management’ were used in place of medical terminology. In the first section of the survey, sociodemographic information and information relating to the respondents’ experience of cancer were collected. The remaining sections of the survey captured both quantitative and qualitative data on public views on the use of AI in cancer diagnosis and management and the use of data (de-identified personal health data and images of tissue) in the development of AI technologies for diagnostic pathology. Unless otherwise stated, responses to the closed questions were rated on a 5-point Likert scale measuring agreement, 1 = strongly disagree to 5 = strongly agree.

To assess *awareness* respondents were asked to rate their level of awareness of AI being developed for use in cancer diagnosis and treatment planning on a 5-point Likert scale (Not at all – Extremely). For *beliefs about potential impact of AI*, respondents rated their level of agreement with the following four statements: AI will help improve the diagnosis of cancer and treatment planning; AI will help reduce the risk of medical error or misdiagnosis; AI will result in less harm for patients; AI will improve efficiency and performance in the NHS. For *Risks and Benefits*, respondents could select any/all that apply from a list of potential risks (harm, error or misdiagnosis, lack of oversight/regulation, lack of accountability, loss of privacy, lack of personal interaction, none) and benefits (more accurate decision making/ more efficiency/money savings for the NHS, less risk of harm, less risk of error or misdiagnosis, more time freed up for staff to work on other tasks, none) of using AI in cancer diagnosis and management.

To measure *Support for implementation of AI in diagnostic pathology*, respondents rated their level of agreement with the following six statements: I support a diagnosis of cancer being made or ruled out by AI only, I support a diagnosis of cancer being made or ruled out by a Pathologist with the assistance of AI, I support a diagnosis of cancer being made or ruled out by a Pathologist only with no AI input, I support the diagnosis of biological ‘markers’ which can inform cancer treatment pathways by AI only, I support the diagnosis of biological ‘markers’ which can inform cancer treatment pathways being made by a Pathologist with the assistance of AI, I support the diagnosis of biological ‘markers’ which can inform cancer treatment pathways being made by a Pathologist only with no AI input.

For *Support for development of data-driven AI technologies for pathology*, respondents rated their level of agreement with the following four statements: I support my de-identified personal health data being used in the development of AI technologies to diagnose and manage cancer by public bodies outside the NHS (e.g., universities), I support my de-identified personal health data being used in the development of AI technologies to diagnose and manage cancer by private commercial research organisations outside the NHS, I support de-identified images of my tissue being used by public bodies outside the NHS (e.g., universities), I support de-identified images of my tissue being used by private commercial research organisations outside the NHS.

To assess *Trust in data security*, respondents rated their level of agreement with the following six statements: I trust that my de-identified personal health data shared with public bodies outside the NHS (e.g., universities) will not be used for purposes other than the development of AI technologies

to diagnose and manage cancer, I trust that my de-identified personal health data shared with private commercial research organisations outside the NHS will not be used for purposes other than the development of AI technologies to diagnose and manage cancer, I trust that the NHS have effective security and privacy protocols for the sharing of personal healthcare data that will protect my anonymity, I trust that de-identified images of my tissue shared with public bodies outside the NHS (e.g., universities) will not be used for purposes other than the development of AI technologies to diagnose and manage cancer, I trust that de-identified images of my tissue shared with private commercial research organisations outside the NHS will not be used for purposes other than the development of AI technologies to diagnose and manage cancer, I trust that the NHS have effective security and privacy protocols for the sharing of image data that will protect my anonymity.

Qualitative data was obtained from responses to the following open-ended questions: 1) AI has the potential to improve the diagnosis and management of cancer, however patients and the public may have concerns about the development and application of AI in this context. What do you think would help yourself or others to support the use of AI technologies in cancer diagnosis and management? Please explain; 2) AI has the potential to improve the diagnosis and management of cancer, however patients and the public may have concerns about the development and application of AI in this context. What do you think would help yourself or others to support the use of de-identified images of tissue and personal health data in the development of AI technologies to diagnose and manage cancer? Please explain.

Data Analysis

Quantitative data analysis

Descriptive statistics were calculated to assess public awareness and attitudes towards the development and implementation of AI in pathology. Absolute numbers and percentages are reported. Unadjusted associations between sociodemographic characteristics, experiences of cancer, awareness, positive beliefs, number of risks and benefits identified, trust in data security and support for the development and the implementation of AI in pathology were assessed by the independent *t*-test for continuous variables (awareness, positive beliefs, number of benefits and number of risks identified) and the chi-square test for categorical variables. For continuous variables and categorical variables with more than 2 levels, unadjusted odds ratios (ORs) were obtained by separately fitting each variable against the binary support classification (univariate analyses). Statistical significance was determined as an alpha level of $p < .05$. Factors that were found to be related to support (using a less conservative threshold of $p \leq 0.10$) were then entered into a multivariable logistic regression model using stepwise backwards selection. Multivariable logistic regression examines the contribution of each variable in distinguishing between groups (those who did and did not support), while controlling for the other variables in the model and was used to assess the relative predictive ability of sociodemographic characteristics, experiences of cancer, awareness, beliefs, and attitudes in explaining support for (i) the use of AI in diagnostic pathology and (ii) the development of data-driven AI technologies for diagnostic pathology.

Defining quantitative variables

Age was recoded into four categories (18-30, 31-45, 46-65, 66+) and gender was collapsed into two categories (man, woman). The simplified ethnicity categories provided by Prolific (White, Black, Asian, Mixed, Other) were used for statistical analyses beyond describing participant characteristics. Personal circumstances related to cancer was collapsed into three categories; those with personal experience (own diagnosis, close person/family member of someone diagnosed with cancer or bereaved close person/family member of someone diagnosed with cancer), professional experience (professional/volunteer working with people diagnosed with cancer), or no direct experience. For the

univariate and multivariable logistic regression analyses composite scores were computed by summing the 6 items measuring trust in data security and the 4 items measuring positive beliefs about AI. New continuous variables were created for the number of potential risks and the number of potential benefits of AI identified by respondents. The outcome variable 'support for implementation of AI in diagnostic pathology' was operationalised as strongly or somewhat agreeing with 4 statements relating to the diagnosis of cancer and of biomarkers by AI only and by a pathologist with the assistance of AI. The outcome variable 'support for development of AI technologies for pathology' was operationalised as strongly or somewhat agreeing with 4 statements relating to the use of de-identified personal health data and images of tissue by public and private research bodies.

Qualitative data analysis

A total of 1472 free text responses were received for the first open-ended question and a total of 1457 were received for the second open-ended question. Reflexive thematic analysis was performed on the data derived from the open-ended questions. The six-stage process described by Braun and Clarke (36) was carried out by CL. The process involved familiarisation with the data through repeated reading of responses, generating initial codes, identifying themes through code grouping, reviewing and refining themes iteratively, and finally defining and naming the themes to construct a coherent narrative that reflects the patterns and meanings within the data. Reflexivity was integral to the rigor of the qualitative analysis, recognising the influence of the research team's backgrounds on interpretation. Thematic analysis was conducted by CL, who has expertise in pathology research and biobanking. The research team also included two health psychologists (JG, LGW) with no professional experience in pathology research or practice. Regular interdisciplinary discussions facilitated critical reflection, helping to enhance the rigour of the analysis and ensure a balanced interpretation of the data. This process resulted in the identification of three themes: 1. Bringing the public alongside; 2. The human in the loop; and 3. More hard evidence needed.

Ethical Considerations

Ethical approval for this study was granted by the Queen's University Belfast Faculty of Medicine, Health, and Life Sciences Research Ethics Committee (Ref: MHLS 22_107). Relevant information such as background of the study, aims and objectives and specific instructions about how to take part in the survey and what would be involved (e.g., length of survey, completion time) was clearly described on the front page of the survey website with a link to a detailed Participant Information Sheet. Respondents were asked to indicate their consent to participate by using a check box. The survey was anonymous, no identifiable information was collected, and all data was released to the research team against a unique ID allocated by Qualtrics. Participants provided an age in full years and all other socio-demographic information was collected at a broad categorical level. A nominal monetary incentive was provided to respondents via Prolific in line with standardised rates (£2.80).

Results

Data Screening

An initial total of 1665 responses were received. One response was removed for not meeting eligibility criteria (i.e., not resident in the UK). Nine were removed for not providing consent. The attrition rate was less than 1% (i.e., fifteen were removed for completing less than 50% of the survey items). The median completion time for this sample was 9.88 minutes. Fifty-one responses were removed for having a completion time less than half the median (i.e., < 4.93 minutes). Thirty-two responses were removed for failing one of two attention checks and 29 were removed for evidencing straight lining behaviour on two matrix questions indicative of low effort responding. The final

number of respondents in the dataset is 1518.

Sample Characteristics

Age ranged from 18 to 82 years ($M = 46.12$, $SD = 15.68$). Fifty one percent of the sample were women (51.3%), 47.6% were men, less than 1% of respondents responded as non-binary/third gender, other (e.g., gender queer), or prefer not to say. Most respondents were White (87.5%), residing in England (85%), educated to graduate level (65.3%), and of no religion (56.3%) or Christian (35.4%). Sample characteristics on all study variables are presented in the first columns of Table 1 and Table 3.

When asked to describe their personal circumstances in relation to cancer, most respondents (58%) selected one response option, and 40% selected between 2 and 4 responses. A large proportion of respondents had experience of a close person or family member being diagnosed with cancer (41%), and 44% had experienced the death of a close person or family member to cancer. Seven percent had been diagnosed with cancer themselves. Five percent of respondents worked with people diagnosed with cancer (on a professional or voluntary basis), and 9% were health and social care professionals, or academics with an interest in the subject of cancer.

Quantitative Results

The UK public's awareness of and views towards the use of AI in diagnostic pathology

Awareness of AI being developed for use in diagnostic pathology was very low with 43% of respondents not at all aware, and only 10% being moderately or extremely aware. The respondents, however, held positive beliefs about the future implementation of AI in cancer diagnosis and management. Most respondents (91%) somewhat or strongly agreed that AI will help improve the diagnosis of cancer and treatment planning, reduce the risk of medical error or misdiagnosis (82%), improve efficiency and performance in the NHS (88%) and result in less harm to patients (61%). Only a minority of respondents (6%), identified no risks of using AI in the diagnosis and management of cancer. There were 1422 respondents who selected at least one risk. Ten percent of respondents identified 5 or 6 risks. Risk of error was the most selected (71%), followed by lack of accountability for decision making (65%), lack of oversight/regulation (52%), and lack of personal interaction (52%). Four percent of respondents identified no benefits of AI in cancer diagnosis and management, and 461 (30%) respondents selected at least one benefit. Approximately one-third (36%) identified four or more benefits. More efficiency/money saving for the NHS were the most common benefit identified (83%), followed by more time freed up for staff (77%) and more accurate decision making (74%).

Support for the use of AI in diagnostic pathology.

Levels of support for the use of AI in diagnostic pathology.

Most respondents (60%) did not support a cancer diagnosis being made or ruled out by AI only. A quarter of the respondents (24%) did. Similarly, most respondents (58%) supported a diagnosis being made by a pathologist only with no AI input, whereas 22% of respondents did not. Relative to cancer, there was slightly more support for diagnosis of biomarkers being made by AI only (37%), however almost half (46%) did not support this. Again, a large proportion of respondents (62%) supported diagnosis of biomarkers being made by a pathologist only with no AI input, whereas 19% did not. However, the vast majority (97%) supported a diagnosis of cancer or of biomarkers (97%) being made by a pathologist with the assistance of AI.

Predictors of support for the use of AI in cancer diagnosis and management

Univariate analyses

As shown in Table 1, there were significant gender differences in the support for use of AI in cancer diagnosis and management. Specifically, being a man increased the probability of supporting implementation (OR: 1.73, 95% CI:1.35, 2.22). There were also age group differences, the odds of supporting implementation were 42% lower for 18–30-year olds (OR: 0.58 95% CI: 0.37, 0.90). Identifying more potential risks of using AI in cancer diagnosis and management reduced the odds of supporting implementation (OR: 0.70 CI: 0.64, 0.77). However, identifying more potential benefits (OR: 1.35 CI: 1.22, 1.48), greater awareness (OR: 1.40, CI: 1.25, 1.57), more positive beliefs (OR: 1.37, CI: 1.29, 1.45) and higher trust (OR: 1.09, CI: 1.06, 1.12) increased likelihood of supporting implementation.

Table 1. Sample characteristics, and support for implementation of AI in cancer diagnosis and management across sociodemographic factors, experience of cancer, awareness, and attitudes towards AI in diagnostic pathology.

	Sample total	Low/no Support	Support	Unadjusted OR (CI)	β	<i>p</i>
N (%)	1518 (100)	1188 (78.3)	330 (21.8)			
SOCIODEMOGRAPHIC FACTORS						
UK nation						.377*
England	85.0	78.3	21.7	Ref (1.00)		
Scotland	8.0	82.0	18.0	0.79 (0.49, 1.29)	-.23	.347
Northern Ireland	2.6	69.2	30.8	1.60 (0.80, 3.21)	.47	.181
Wales	4.3	75.8	24.2	1.15 (0.65, 2.06)	.14	.624
Gender						<.001*
Man	48.1	73.2	26.8	1.73 (1.35, 2.22)	.55	<.001
Woman	51.9	82.5	17.5	Ref (1.00)		
Age Group						.062*
18-30	22.5	82.7	17.3	0.58 (0.37, 0.90)	-.55	.014
31-45	27.2	78.9	21.1	0.74 (0.49, 1.11)	-.31	.146
46-65	38.9	76.6	23.4	0.84 (0.57, 1.24)	-.17	.381
66+	11.4	73.4	26.6	Ref (1.00)		
Educational attainment						.721*
Primary	1.6	76.0	24.0	1.10 (0.44, 2.79)	.10	.838
Secondary	33.0	79.4	20.6	0.90 (0.69, 1.17)	-.10	.447
Graduate	65.3	77.7	22.3	Ref (1.00)		
Experience of Cancer						.395*
personal	43.5	79.6	20.4	0.85 (0.66, 1.09)	-.16	.210
professional	1.2	83.3	16.7	0.67 (0.19, 2.32)	-.41	.523
no direct experience	55.3	76.9	23.1	Ref (1.00)		
Religion						.281*
No religion	57.7	79.6	20.4	Ref (1.00)		

Christian	36.2	75.4	24.6	1.27 (0.99, 1.65)	.24	.064
Buddhist	0.9	78.6	21.4	1.07 (0.29, 3.97)	.07	.921
Hindu	0.6	66.7	33.3	1.96 (0.48, 7.90)	.67	.346
Jewish	0.6	66.7	33.3	1.96 (0.48, 7.90)	.67	.346
Muslim	3.5	82.7	17.3	0.89 (0.39, 1.71)	-.20	.596
Sikh	0.5	100	0	0.00 (0.00, 0.00)	-19.84	.999
Ethnicity						.694*
White	87.9	77.7	22.3	Ref (1.00)		
Mixed	1.3	85.0	15.0	0.61 (0.18, 2.11)	-.49	.441
Asian	6.8	83.3	16.7	0.70 (0.41, 1.19)	-.36	.188
Black	3.1	78.7	21.3	0.94 (0.46, 1.92)	-.06	.870
Other	0.9	76.9	23.1	1.05 (0.29, 3.83)	.05	.946
Awareness	1.92±1.01	1.84±0.97	2.21±1.10	1.40 (1.25, 1.57)	.34	<.001 [^]
Beliefs	16.36±2.64	15.99±2.69	17.71±1.93	1.37 (1.29, 1.45)	.31	<.001 [^]
Trust	21.67±5.76	21.12±5.82	23.65±5.09	1.09 (1.06, 1.12)	.09	<.001 [^]
Number of risks	2.66±1.45	2.81±1.44	2.13±1.33	0.70 (0.64, 0.77)	-.35	<.001 [^]
Number of benefits	3.01±1.34	2.90±1.33	3.42±1.28	1.35 (1.22, 1.48)	.30	<.001 [^]

Multiple Logistic Regression

The 7 variables that were significant at the alpha level $< .10$ in the univariate analyses were entered into multiple logistic regression. The final model with adjusted odds ratios with 95% confidence intervals for the predictors is shown in Table 2. Holding all other predictor variables constant, the odds of supporting the implementation of AI in cancer diagnosis and management were 34% greater for men than for women (95% CI (1.02, 1.75)). The odds of supporting implementation increased by 25% (95% CI (1.10, 1.42)) for every one-unit increase in awareness of AI and by 27% for every one-unit increase in positive beliefs about the potential impact of AI (95% CI (1.20, 1.36)). The likelihood of supporting implementation increased by 4% for every one-unit increase in trust in data security (95% CI (1.01, 1.07)) and decreased by 20% (95% CI (0.73, 0.89)) for a one-unit increase in the number of identified risks.

Table 2. Multivariable logistic regression analysis of factors predicting support for the use of AI in diagnostic pathology

	β	aOR (CI)	<i>p</i>
Constant	-1.27	0.282	<.001
Man	0.29	1.34 (1.02, 1.75)	.036
Age Group			
18-30	-0.11	0.89 (0.55, 1.43)	.634
31-45	-0.13	0.87 (0.56, 1.36)	.553
46-65	0.08	1.08 (0.71, 1.65)	.707
66+		Ref (1.00)	
Awareness	0.22	1.25 (1.10, 1.42)	.001
Beliefs	0.24	1.27 (1.20, 1.36)	<.001
Trust	0.04	1.04 (1.01, 1.07)	.008
Number of risks	-0.22	0.80 (0.73, 0.89)	< .001

Number of benefits	0.06	1.06 (0.95, 1.19)	.299
--------------------	------	-------------------	------

Notes; aOR = adjusted odds ratio; CI = confidence intervals; β = regression coefficient

Support for the use of de-identified personal health data and images of tissue in the development of AI technologies.

Levels of support

There was support (84% agree or strongly agree) for the use of de-identified personal health data and images of tissue (87%) in the development of AI technologies by public bodies outside the NHS e.g., universities. Support was lower for use of de-identified personal health data (57%) and images of tissue (63%) by private commercial research organisations. The difference in support for public versus private bodies was statistically significant for both personal health data ($\chi^2 = 308.35$, $p < .001$) and images of tissue ($\chi^2 = 310.85$, $p < .001$).

Trust in data security

Despite the high levels of support for the development of data-driven AI technologies by public bodies outside the NHS, there were comparatively lower levels of trust that de-identified personal health data (70%) and images of tissue (76%) would not be used for other purposes by such public bodies. There was less trust again that de-identified personal health data (45%) and images of tissue (51%) would not be used for other purposes by commercial organisations. The difference in trust for public versus private bodies was statistically significant for both personal health data ($\chi^2 = 405.09$, $p < .001$) and images of tissue ($\chi^2 = 413.33$, $p < .001$). Nevertheless, there was very high trust that the NHS security and privacy protocols for the sharing of personal healthcare data (70%) and images of tissue (72%) would protect people's anonymity.

Predictors of support for the development of data-driven AI technologies for cancer diagnosis and management.

There were significant age group differences in support for the development of AI in cancer diagnosis and management (see Table 3). The odds of supporting development were significantly lower for 18–30-year old's (OR: 0.45, CI: 0.31, 0.66) and 31–45-year old's (OR: 0.54, CI: 0.38, 0.78). Working with people with cancer reduced the odds of supporting development of AI for diagnostic pathology (OR: 0.35, CI: 0.12, 0.98). There were differences in support based on religious belonging. With respect to those of no religion, odds of supporting development were 40% higher for Christian people (OR: 1.40, CI: 1.12, 1.74) and 61% lower for Muslim people (OR: 0.39, CI: 0.21, 0.72). Compared to White respondents, those of Mixed (OR: 0.43, CI: 0.17, 1.08), Asian (OR: 0.33, CI: 0.21, 0.52), Black (OR: 0.50, CI: 0.27, 0.90) or another ethnicity (OR: 0.15, CI: 0.03, .66) had lower probability of supporting development. Respondents who identified more potential risks of using AI in cancer diagnosis and management had lower odds of supporting development (OR: 0.68, CI: 0.63, 0.74). Those who identified more potential benefits (OR: 1.46, CI: 1.34, 1.58), had more positive beliefs (OR: 1.21, CI: 1.16, 1.27) and more trust in data security (OR: 1.43, CI: 1.36, 1.46) had increased likelihood of supporting development.

Table 3. Sample characteristics, and support for development of data-driven AI in cancer diagnosis and management across sociodemographic factors, experience of cancer, awareness, and attitudes towards AI in diagnostic pathology.

	Sample	Low/no	Support	Unadjusted	OR	β	p
	total	Support		(CI)			
N (%)	1518 (100)	722 (47.6)	796 (52.4)				
SOCIODEMOGRAPHIC FACTORS							
UK nation							.693*
England	85.0	47.1	52.9	Ref (1.00)			
Scotland	8.0	48.4	51.6	0.95 (0.66, 1.38)	-.05		.789
Northern Ireland	2.6	48.7	51.3	0.94 (0.50, 1.77)	-.07		.842
Wales	4.3	54.5	45.5	0.74 (0.45, 1.22)	-.30		.239
Gender							.622*
Man	48.1	46.6	53.4	1.05 (0.89, 1.29)	.05		.622
Woman	51.9	47.9	52.1	Ref (1.00)			
Age Group							<.001*
18-30	22.5	57.8	42.2	0.45 (0.31, 0.66)	-.80		<.001
31-45	27.2	53.3	46.7	0.54 (0.38, 0.78)	-.61		<.001
46-65	38.9	40.4	59.6	0.91 (0.64, 1.29)	-.10		.589
66+	11.4	38.2	61.8	Ref (1.00)			
Educational attainment							.167*
Primary	1.6	40.0	60.0	1.46 (0.65, 3.28)	.38		.361
Secondary	33.0	44.5	55.5	1.21 (0.98, 1.50)	.19		.081
Graduate	65.3	49.3	50.7	Ref (1.00)			
Experience of							.098*
Cancer personal	43.5	46.5	53.5	1.03 (0.84, 1.27)	.03		.758
professional	1.2	72.2	27.8	0.35 (0.12, 0.98)	-1.06		.045
no direct	55.3	47.3	52.7	Ref (1.00)			
experience							
Religion							<.001*
No religion	57.7	49.0	51.0	Ref (1.00)			
Christian	36.2	40.8	59.2	1.40 (1.12, 1.74)	.33		.003
Buddhist	0.9	64.3	35.7	0.53 (0.18, 1.61)	-.63		.264
Hindu	0.6	66.7	33.3	0.48 (0.12, 1.93)	-.73		.302
Jewish	0.6	55.6	44.4	0.77 (0.21, 2.89)	-.26		.697
Muslim	3.5	71.2	28.8	0.39 (0.21, 0.72)	-.94		.003
Sikh	0.5	71.4	28.6	0.38 (0.07, 1.99)	-.96		.255
Ethnicity							<.001*
White	87.9	44.4	55.6	Ref (1.00)			
Mixed	1.3	65.0	35.0	0.43 (0.17, 1.08)	-.85		.073
Asian	6.8	70.6	29.4	0.33 (0.21, 0.52)	-1.10		<.001
Black	3.1	61.7	38.3	0.50 (0.27, 0.90)	-.70		.021
Other	0.9	84.6	15.4	0.15 (0.03, .66)	-1.93		.012
Awareness	1.92±1.01	1.90±1.03	1.94±1.00	1.04 (0.94, 1.15)	.04		.421^
Beliefs	16.36±2.64	15.71±2.68	16.96±2.46	1.21 (1.16, 1.27)	.19		<.001^
Trust	21.67±5.76	17.99±5.1	24.99±3.98	1.43 (1.36, 1.46)	.35		<.001^

7

Number of risks 2.66±1.45 3.05±1.43 2.30±1.37 0.68 (0.63, 0.74) -.38 <.001[^]

Multiple Logistic Regression

The 8 variables that were significant at the alpha level < .10 in the univariate analyses were entered into multiple logistic regression. The final model with adjusted odds ratios with 95% confidence intervals for the predictors is shown in Table 4. Holding all other variables constant, the odds of supporting the development of AI technologies were 59% lower for people of Asian ethnicity (95% CI (0.23, 0.71)) and 86% lower for people of another (non-White, non-Black or not Mixed) ethnicity (95% CI (0.02, 0.79)). The odds of supporting the development of AI technologies increased by 42% for every one-unit increase in trust (95% CI (1.36, 1.47)), and increased by 32% for a one-unit increase in the number of benefits identified (95% CI (1.19, 1.47)).

Table 4. Multivariable logistic regression analysis of factors predicting support for implementation of AI

	β	aOR (CI)	<i>p</i>
Constant	0.12	1.13	.021
Age Group			
18-30	-0.37	0.69 (0.42, 1.14)	.634
31-45	-0.27	0.77 (0.47, 1.90)	.553
46-65	0.18	1.20 (0.75, 1.90)	.707
66+		Ref (1.00)	
Ethnicity			
White		Ref (1.00)	
Mixed	-0.47	0.62 (0.19, 2.04)	.434
Asian	-0.89	0.41 (0.23, 0.71)	.002
Black	-0.41	0.67 (0.29, 1.53)	.339
Other	-1.98	0.14 (0.02, 0.79)	.026
Religion			
No religion		Ref (1.00)	
Christian	-0.04	0.96 (0.71, 1.31)	.810
Buddhist	-0.48	0.62 (0.11, 3.61)	.596
Hindu	-0.63	0.53 (0.07, 3.81)	.530
Jewish	1.12	3.05 (0.41, 22.97)	.279
Muslim	-0.38	0.68 (0.25, 1.85)	.453
Sikh	-1.01	0.37 (0.04, 3.06)	.354
Beliefs	0.01	1.00 (0.94, 1.07)	.957
Trust	0.35	1.42 (1.36, 1.47)	<.001
Number of risks	-0.09	0.92 (0.82, 1.02)	.118
Number of benefits	0.28	1.32 (1.19, 1.47)	<.001

Notes; aOR = adjusted odds ratio; CI = confidence intervals; β = regression coefficient

Qualitative Results

Theme 1: Bringing the public alongside.

Confirming the quantitative findings, when asked about what would help increase support for the use of AI in pathology, respondents frequently cited the need for greater public knowledge about its use. This was emphasised both in relation to increasing basic awareness of what AI is and supporting the public to understand the inner workings of AI in pathology through accessible yet detailed explanation or demonstrations to *see the AI in action* (Man, aged 62).

The general public has been hearing about AI now for many years but I still believe there is a lot of confusion about the genuine benefits that it can bring and still feels like a 'concept' rather than technology that is with us day to day now (Man, aged 42).

I think it needs to be explained and the public made more aware of how it works (Woman, aged 54).

Alongside the discussion on improving public knowledge was an emphasis on the importance of 'transparency' and 'openness', including information on the extent of human oversight within the process, with common concerns around undetected 'glitches' or 'malfunctions' in AI systems. A greater understanding of AI was linked to fostering 'trust' rather than 'fear' of the technology.

Better transparency of the process and how it works, and how much doctors rely on the technology (Man, aged 55).

I think it would need to be better understood what AI could do and how this could help. If people don't understand then they are more likely to be scared (Woman, aged 31).

Risk management-how it will be ensured that we don't rely on AI only to miss fatal diagnoses (Woman, aged 26).

The respondents suggested various ways in which awareness of such technologies could be achieved. These included public awareness raising campaigns via advertising and social media. The benefits of sharing 'real world' patient stories were also discussed to illustrate the individual patient benefits from the use of AI:

By talking about it more through all sorts of different media, especially by commissioning a segment on TV, and a massive social media campaign. Talk people through exactly how it works so that we gain a better understanding of it all (Woman, aged 42).

Case studies demonstrating how the application of artificial intelligence technologies have generated value (Man, aged 24).

Examples of it being used either alone or with human assistance to successfully diagnose and/or manage cancer in a patient (Woman, aged 44).

In response to the open question about support for the use of de-identified tissues and data in the development of AI technologies, the desire for more reassurance was commonly cited by respondents. The potential misuse of de-identified data was the most frequently mentioned barrier for most respondents when it came to support for use of AI. Many respondents expressed a need for

clear communication on how their data is used by AI, to include how their data is managed, stored, and protected.

If the whole process was explained in easy to understand terms from collecting their data to how their data is used, why it's stored, how AI uses this de-identified data to improve its own capabilities (Man, age 22).

A much clearer understanding of what it involves. People don't want to be blinded by science at the time of diagnosis (Woman, aged 62).

Many respondents expressed caution or reticence when it came to support for their data to be shared with commercial entities. Concerns around data protection were nearly entirely focused on commercial entities, with a higher level of trust that the NHS and public bodies (such as universities) would act responsibly and ensure patient benefit from the data.

I personally do not have a problem with these images being shared with the NHS as they are a public body. I do have a problem with this data being shared with private organisations that would then charge the NHS for these services. Being transparent about the use of the data is important to me and others (Man, aged 51).

The use of this information can only be for the greater good (Man, aged 64)

Many respondents expressed a need for robust oversight measures to be in place to protect their personal information. The potential for misuse of data was frequently linked with the use of data for financial gain, with various high-profile examples given where personal data has been misused. While many respondents referred to data protection legislation, many also requested close monitoring of the use of data and tissues by non-NHS bodies. It was also suggested that organisations should be held accountable if data is misused:

Explain the security measures that are put in place to make sure that the data remains anonymous. Make sure there are independent audits of the security measures (Man, aged 41).

Strict guidelines with respect to data protection. Large fines with appropriate legal actions against bodies that use the images inappropriately (Man, aged 25).

Stronger consequences for organisations that breach data protection policies. Increased transparency and vetting by independent sources with regards to these organisations (Woman, aged 27).

Theme 2: The human in the loop.

Responses to the open question on support for the use of AI in cancer diagnosis and management largely indicated that respondents would be supportive of 'assistance' and 'support' from AI, provided there was human oversight of the technology in the form of checks and balances. There was concern over the potential for undetected errors with use of AI alone, particularly with novel use of AI. Responses included:

Ensuring that there is still a human face to it (Man, aged 32).

In the early days of use, need to use both AI and pathologists - need to check the

validity of diagnosis (Woman, aged 64).

Conversely, respondents also frequently cited the potential for human error in diagnoses, with AI likened to obtaining a second opinion from another clinician. Many respondents highlighted the potential for combined AI and human input to reduce error on both parts:

If it was not used alone, but with human supervision. Both humans and AI can make mistakes- by working together this can be reduced (Woman, aged 23).

There was frequently mentioned concern over the extent to which the use of AI reduces human control over the decision-making process. The respondents emphasised the importance of AI being used as a tool 'by' doctors rather than to 'replace' doctors, with clinical experience ultimately prioritised. The potential for AI to improve the efficiency of the decision-making process was widely recognised:

So long as the final decision is always made by a qualified human, I see no problem in using AI as a shortcut to get to the point where the decision is made (Woman, aged 74).

I think folk's main concern would be the idea of a system making decisions about them in an opaque way they had no input on. If it's explained that the AI is used to support a physician rather than supplant them, I think folk would be considerably reassured (Man, aged 40).

Theme 3: More hard evidence needed.

The respondents recognised the potential for AI to provide efficiency savings for the healthcare system, and the potential for this to directly impact on patient care. However, to enhance public support, respondents also reported a need for 'proof' of the success of AI technologies. There was the overall impression of a lack of research in this area, and the need to build the evidence base.

A fully funded clinical trial, that shows explicitly that AI is effective, even more effective than the current system (Man, aged 22)

Respondents felt that high-quality research to demonstrate the accuracy of AI against human-only input in reducing the number of missed diagnoses, or demonstrating the efficiency of AI, would be the most convincing for public support.

Studies which could demonstrate the effectiveness of AI in improving diagnosis and treatment outcomes when compared with human-only diagnosis and treatment (Man, aged 48).

A series of research studies which showed how effective AI can be to reduce waiting times for diagnosis and treatment (Woman, aged 61).

Overall, the burden of proof is on the part of AI where respondents called for evidence that AI is not only equivalent to a human in performance but surpasses a human in accuracy and reliability of diagnosis. Respondents highlighted a desire for high-level statistics on the overall accuracy of AI.

Success stories where AI has achieved what a human cannot (Woman, aged 32).

If it is totally error free, I would be in favour of AI (Man, aged 32).

Respondents also stated the need for reassurance in the form of evidence that data and tissues would indeed be de-identified prior to transfer outside the NHS, for example through detailing the process through which data would be prepared and handled:

Evidence that data is held and transmitted securely (Man, aged 66)

I would need to understand what the procedure for de-identification actually is, and be convinced that it is effective (Man, aged 67)

Discussion

Principal Findings

This study sought to examine the UK public's awareness of, and attitudes toward, the use of AI in pathology research and practice; and to ascertain predictors of support for its implementation in clinical practice and for the use of health data and tissue images in its development. We found that awareness of AI being developed for use in pathology was low, yet respondents were conditionally supportive of its use in the diagnosis and management of cancer if human oversight was maintained. Respondents were also supportive of their data and tissue images being used in the development of such technologies by public bodies, however there was less support for use by commercial bodies. To our knowledge, this is the only nationally representative study on public opinion of AI in pathology, where AI has been regarded as the 'third revolution' in pathology practice(37).

Comparison to Prior Work

Awareness of AI being developed for use in pathology was very low which was not overly surprising. While awareness of AI in general is increasing, a 2023 nationally representative survey of public attitudes to AI in Britain reported that people were less aware of the use of AI in health compared to other applications such as facial recognition, driverless cars and targeted consumer advertising (31). In the current study, qualitative data indicated a broad appetite for increased awareness and understanding of how AI systems could be used in cancer diagnosis and management. Suggestions from respondents on how to deliver this included social media campaigns and information disseminated via leaflets, videos, and television media using real world examples of how AI can benefit their care. Despite low awareness, the respondents in this study held positive beliefs about the potential of AI to improve patient outcomes and healthcare system efficiency. Accordingly, the most frequently identified benefits of AI in pathology practice were maximisation of NHS resources and more accurate decision-making. However, the most frequently identified risks were error, lack of accountability and lack of oversight. These risks and benefits of AI in pathology are in keeping with those reported in studies investigating the use of AI in other medical specialties such as radiology (38) and dermatology (39). Almost all respondents supported a diagnosis of cancer, or an assessment of biomarkers, being made by a pathologist with the assistance of AI, but there was no widespread support for diagnosis by AI only. This was also evident from the qualitative analysis, with many respondents indicating that some form of human oversight would help increase their support for the use of AI in pathology practice. This position is consistent with previous literature suggesting that the acceptance of AI in healthcare is overwhelmingly based on its use as a tool to support clinician decision making rather than as a replacement (30,40).

There was strong support for the use of de-identified personal health data and images of tissue in the development of AI technologies for pathology by public bodies. This is reassuring given the potential

impact of controversial failed NHS data sharing projects such as Care.Data (41) and the General Practice Data for Planning and Research Programme (42) on public opinion. There was slightly less support for the use of health data and images by private versus public bodies, confirming previous research findings indicating a level of concern among the public when it comes to private or commercial organisations getting access to health data (16,43). Although there were high levels of trust in NHS security and privacy protocols, there was some concern that data would be used for other purposes by both public and commercial organisations, with qualitative analysis highlighting that transparency and openness in how data is shared and governed would help increase support for the use of data in the development of AI health systems. As outlined in a recent UK Government review into the use of healthcare data in research (44), our findings reinforce the need for candid and continuous engagement with the public about data sharing, particularly when this involves commercial organisations.

Identifying more benefits of AI in pathology practice increased the odds of supporting development of AI in pathology research, while identifying more risks decreased the odds of supporting implementation of AI in pathology practice. Greater awareness and more positive beliefs about AI increased the likelihood of supporting implementation, and men were more likely to support the use of AI in cancer diagnosis and management relative to women. This is a finding that is common to the wider AI literature where women appear to be more cautious in their opinions of AI in healthcare than men are. Yakar et al surveyed 2411 members of the public in the Netherlands in 2022 regarding their views on AI in medicine with specific emphasis on dermatology, radiology, and robotic surgery, and reported more trust in AI among their male respondents than among their female respondents(45). Similarly, a large online survey (n=11,004) of Americans' views of AI in health and medicine conducted by the Pew Research Centre in 2022 concluded that men were more open to the use of AI in their healthcare than women (46). Although our data cannot explain why women or people from a non-white background are less likely to support AI in pathology, our findings correspond with the existing evidence of a notable lack of support for AI in healthcare among these populations. Given the evidence of gender inequities in the ability of AI tools to detect liver disease (47) and the concern that datasets used to train AI algorithms will exacerbate ethnic healthcare inequalities if they are ethnically unbalanced or biased (48), it is imperative that those involved in the development and implementation of AI technologies in pathology engage meaningfully with these populations to better understand their concerns.

Fundamentally, AI has the potential to revolutionise healthcare. Although the number of AI systems currently being used in healthcare in the UK remains relatively low, this number will undoubtedly increase within the next decade given the rate of their development along with committed investment from the government to embrace and deploy AI technologies in the NHS (49). However, the acceptability of AI and ultimately its success will depend on public confidence and trust in its development and implementation (50). Whilst the Academy of Medical Royal Colleges recommends early and ongoing public engagement to maximise the impact and acceptability of AI in healthcare (34), our findings suggest aspects of this may have been left wanting to date, particularly in the field of pathology where AI technologies are being developed at such a rapid pace.

Presently, the UK lacks specific legislation governing the use of AI, opting instead for a “proportionate and light touch” framework that will provide a set of principles for regulatory authorities to interpret and implement according to the requirements of their own sector(51). This approach, deemed pro-innovative, aligns with the rapidly evolving AI landscape. However, our research underscores that public support for the use of AI in pathology is contingent on maintaining human oversight in clinical decision-making, therefore regulatory bodies and stakeholders who govern the application of AI technologies, not only in pathology but also in the wider healthcare

milieu, recognise that any shift from this position may undermine public confidence and trust. To ensure support for the use of AI in pathology, stakeholders should prioritise initiatives fostering awareness and promoting positive beliefs about AI. Awareness campaigns should adopt a balanced perspective that acknowledges potential risks while concurrently emphasising the benefits. Stakeholders must inform the public of the evidence supporting the use of AI in healthcare while reassuring the public regarding robust data security measures in place in their development. Simultaneously, efforts should be made to bridge gender disparities in support, and specific strategies should be developed to address the lower support among individuals from diverse backgrounds, ensuring inclusivity in AI discussions and decision-making. Through a balanced approach, encompassing transparency, engagement, and targeted education, policy makers can cultivate a supportive and informed public stance towards the responsible implementation and development of AI in healthcare, aligning with the evolving regulatory landscape.

Strengths and Limitations

This study was novel in that it was the first to examine public awareness and opinions of the use of AI in pathology research and practice with a nationally representative UK sample. However, there were several limitations to acknowledge. First, selection bias was a possible limitation in this study due to the online nature of the survey as this restricted access to those without an internet connection and/or some level of digital literacy. Second, a known limitation of using a panel survey is the risk to data integrity due to inattentive responses (52). Although this risk was mitigated in this study by using attention checks, screener validation questions, and a captcha along with removal of responses indicative of low effort responding, there remains potential for low quality responses due to the uncontrolled nature of the survey. Third, it was also noted that a large proportion (65.3%) of the respondents in the survey were educated to graduate level; this may have implications for the findings given claims that attitudes on societal and political issues change incrementally with educational levels(53). Lastly, the survey questions used in this study were developed by the research team, based on the study objectives and the existing literature. However, to the best of our knowledge, no validated standardised questionnaire on the development and implementation of AI in pathology, or even healthcare, was available when this study was conducted.

Future Directions

Future work to validate a tool to longitudinally assess public knowledge and trust of AI in healthcare would be of value, in line with AI being implemented more widely in many aspects of healthcare delivery. There is also a need to further explore the gender and ethnic disparities that were uncovered in this study to recognise the specific concerns of women and those from a non-white background. Given the suggested variances between countries in their level of trust in AI in general(54), further research representative of wider geographical areas would be of merit.

Conclusions

Our findings showed a low level of awareness of the use of AI in cancer diagnosis and management. Respondents were positive about the potential of AI and indicated a high level of support for its use, albeit conditional on the fact that human oversight of the process is maintained. Analysis of qualitative data on support for AI reinforced the need for transparency and regulation regarding the use of images and personal healthcare data for research purposes. It also largely indicated that respondents would be supportive of 'assistance' from AI in their cancer diagnosis and management, provided there was human oversight of the process and evidence of its ability. Notably, our findings demonstrated that challenges remain in addressing the concerns specifically of women, and apprehension remains about the access and use of healthcare data by commercial organisations.

The findings of this study have important implications for all stakeholders involved in the development and implementation of AI in pathology research and practice. They indicate the need for a balanced approach to the process; one which comprises openness, engagement, and education to cultivate a supportive and informed public. It is imperative that AI developers, researchers, and organisations deploying AI applications take these into account to align with the expectations and concerns of the public regarding such technologies.

Acknowledgements

The authors would like to thank the members of the Northern Ireland Cancer Research Consumer Forum who kindly reviewed the survey questions, and the respondents who completed the survey.

Conflicts of Interest

None declared.

Abbreviations

AI: Artificial Intelligence

CI: Confidence interval

NHS: National Health Service

OR: Odds ratio

UK: United Kingdom

US: United States

WSI: Whole Slide Image

Availability of data and materials

Datasets generated under this study are not publicly available and may be available from the corresponding author on reasonable request.

Authors' contributions

Conceptualization: C.L., J.J., L.G. and J.G.; Formal analysis: C.L. and J.G.; Investigation: C.L. and J.G.; Methodology: C.L., J.J., L.G. and J.G.; Project administration: C.L.; Visualization: C.L. and J.G.; Writing – original draft: C.L. and J.G.; Writing - review & editing: C.L., J.J., L.G. and J.G.

Additional Files

Multimedia Appendix 1: Online Survey Questions (PDF)

References

1. Hamet P, Tremblay J. Artificial intelligence in medicine. *Metabolism*. 2017 Apr;69:S36–40.
2. Misuraca G, Van Noordt C. AI Watch - Artificial Intelligence in public services [Internet]. [cited 2024 Apr 8]. Available from: <https://publications.jrc.ec.europa.eu/repository/handle/JRC120399>
3. Alowais SA, Alghamdi SS, Alsuhebany N, Alqahtani T, Alshaya AI, Almohareb SN, et al. Revolutionizing healthcare: the role of artificial intelligence in clinical practice. *BMC Med Educ*. 2023 Sep 22;23(1):689.
4. Lekadir K, Quaglio G, Tselioudis A, Gallin C. Artificial Intelligence in Healthcare. Applications, risks, and ethical and societal impacts. . 2022.

5. Muehlematter UJ, Daniore P, Vokinger KN. Approval of artificial intelligence and machine learning-based medical devices in the USA and Europe (2015–20): a comparative analysis. *Lancet Digit Health*. 2021 Mar 1;3(3):e195–203.
6. da Silva LM, Pereira EM, Salles PG, Godrich R, Ceballos R, Kunz JD, et al. Independent real-world application of a clinical-grade automated prostate cancer detection system. *J Pathol*. 2021 Jun;254(2):147–58.
7. Parwani A V. Next generation diagnostic pathology: use of digital pathology and artificial intelligence tools to augment a pathological diagnosis. *Diagn Pathol*. 2019 Dec 27;14(1):138.
8. Cui M, Zhang DY. Artificial intelligence and computational pathology. *Laboratory Investigation*. 2021 Apr;101(4):412–22.
9. Ehteshami Bejnordi B, Veta M, Johannes van Diest P, van Ginneken B, Karssemeijer N, Litjens G, et al. Diagnostic Assessment of Deep Learning Algorithms for Detection of Lymph Node Metastases in Women With Breast Cancer. *JAMA*. 2017 Dec 12;318(22):2199.
10. Yu KH, Zhang C, Berry GJ, Altman RB, Ré C, Rubin DL, et al. Predicting non-small cell lung cancer prognosis by fully automated microscopic pathology image features. *Nat Commun*. 2016 Aug 16;7(1):12474.
11. Nagpal K, Foote D, Tan F, Liu Y, Chen PHC, Steiner DF, et al. Development and Validation of a Deep Learning Algorithm for Gleason Grading of Prostate Cancer From Biopsy Specimens. *JAMA Oncol*. 2020 Sep 1;6(9):1372.
12. Coudray N, Ocampo PS, Sakellaropoulos T, Narula N, Snuderl M, Fenyö D, et al. Classification and mutation prediction from non-small cell lung cancer histopathology images using deep learning. *Nat Med*. 2018 Oct 17;24(10):1559–67.
13. Kather JN, Pearson AT, Halama N, Jäger D, Krause J, Loosen SH, et al. Deep learning can predict microsatellite instability directly from histology in gastrointestinal cancer. *Nat Med*. 2019 Jul 3;25(7):1054–6.
14. Murphy K, Di Ruggiero E, Upshur R, Willison DJ, Malhotra N, Cai JC, et al. Artificial intelligence for good health: a scoping review of the ethics literature. *BMC Med Ethics*. 2021 Dec 15;22(1):14.
15. Data Protection Act 2018 [Internet]. 2018. Available from: <https://www.legislation.gov.uk/ukpga/2018/12/contents>
16. Aitken M, de St. Jorre J, Pagliari C, Jepson R, Cunningham-Burley S. Public responses to the sharing and linkage of health data for research purposes: a systematic review and thematic synthesis of qualitative studies. *BMC Med Ethics*. 2016 Dec 10;17(1):73.
17. Kalkman S, van Delden J, Banerjee A, Tyl B, Mostert M, van Thiel G. Patients' and public views and attitudes towards the sharing of health data for research: a narrative review of the empirical evidence. *J Med Ethics*. 2022 Jan;48(1):3–13.
18. Horn R, Kerasidou A. Sharing whilst caring: solidarity and public trust in a data-driven healthcare system. *BMC Med Ethics*. 2020 Dec 3;21(1):110.
19. McCradden MD, Sarker T, Paprica PA. Conditionally positive: a qualitative study of public perceptions about using health data for artificial intelligence research. *BMJ Open*. 2020 Oct 28;10(10):e039798.
20. Castell S, Robinson L, Ashford H. Future data-driven technologies and the implications for use of patient data. *Dialogue with public, patients and healthcare professionals* [Internet]. 2018 [cited 2024 Mar 13]. Available from: <https://acmedsci.ac.uk/file-download/6616969>
21. Human Tissue Act 2004 [Internet]. 2004. Available from: <https://www.legislation.gov.uk/ukpga/2004/30/contents>
22. Goodson ML. A study of public opinion on the use of tissue samples from living subjects for clinical research. *J Clin Pathol*. 2004 Feb 1;57(2):135–8.
23. Bossert S, Kahrass H, Strehl D. The Public's Awareness of and Attitude Toward Research Biobanks – A Regional German Survey. *Front Genet*. 2018 May 24;9.
24. Gaskell G, Gottweis H, Starkbaum J, Gerber MM, Broerse J, Gottweis U, et al. Publics and

- biobanks: Pan-European diversity and the challenge of responsible innovation. *European Journal of Human Genetics*. 2013 Jan 6;21(1):14–20.
25. Lewis C, Clotworthy M, Hilton S, Magee C, Robertson MJ, Stubbins LJ, et al. Public views on the donation and use of human biological samples in biomedical research: a mixed methods study. *BMJ Open*. 2013 Aug;3(8):e003056.
 26. Domaradzki, Pawlikowski. Public Attitudes toward Biobanking of Human Biological Material for Research Purposes: A Literature Review. *Int J Environ Res Public Health*. 2019 Jun 21;16(12):2209.
 27. Merdad L, Aldakhil L, Gadi R, Assidi M, Saddick SY, Abuzenadah A, et al. Assessment of knowledge about biobanking among healthcare students and their willingness to donate biospecimens. *BMC Med Ethics*. 2017 Dec 2;18(1):32.
 28. Berbís MA, McClintock DS, Bychkov A, Van der Laak J, Pantanowitz L, Lennerz JK, et al. Computational pathology in 2030: a Delphi study forecasting the role of AI in pathology within the next decade. *EBioMedicine*. 2023 Feb;88:104427.
 29. Rakovic K, Colling R, Browning L, Dolton M, Horton MR, Protheroe A, et al. The Use of Digital Pathology and Artificial Intelligence in Histopathological Diagnostic Assessment of Prostate Cancer: A Survey of Prostate Cancer UK Supporters. *Diagnostics*. 2022 May 13;12(5):1225.
 30. Palmisciano P, Jamjoom AAB, Taylor D, Stoyanov D, Marcus HJ. Attitudes of Patients and Their Relatives Toward Artificial Intelligence in Neurosurgery. *World Neurosurg*. 2020 Jun;138:e627–33.
 31. Ada Lovelace Institute and The Alan Turing Institute. How do people feel about AI? A nationally representative survey of public attitudes to artificial intelligence in Britain (2023) . [Internet]. 2023 [cited 2024 Mar 28]. Available from: https://www.turing.ac.uk/sites/default/files/2023-06/how_do_people_feel_about_ai_-_ada_turing.pdf
 32. Esmaeilzadeh P. Use of AI-based tools for healthcare purposes: a survey study from consumers' perspectives. *BMC Med Inform Decis Mak*. 2020 Dec 22;20(1):170.
 33. Young AT, Amara D, Bhattacharya A, Wei ML. Patient and general public attitudes towards clinical artificial intelligence: a mixed methods systematic review. *Lancet Digit Health* [Internet]. 2021 Sep;3(9):e599–611. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S2589750021001321>
 34. Artificial Intelligence in Healthcare [Internet]. 2019 [cited 2024 Mar 13]. Available from: https://www.aomrc.org.uk/wp-content/uploads/2019/01/Artificial_intelligence_in_healthcare_0119.pdf
 35. Prolific [Internet]. [cited 2024 Mar 13]. Available from: <https://www.prolific.com/>
 36. Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol*. 2006 Jan;3(2):77–101.
 37. Salto-Tellez M, Maxwell P, Hamilton P. Artificial intelligence-the third revolution in pathology. *Histopathology*. 2019 Feb;74(3):372–6.
 38. Hemphill S, Jackson K, Bradley S, Bhartia B. The implementation of artificial intelligence in radiology: a narrative review of patient perspectives. *Future Healthc J*. 2023 Mar 31;10(1):63–8.
 39. Nelson CA, Pérez-Chada LM, Creadore A, Li SJ, Lo K, Manjaly P, et al. Patient Perspectives on the Use of Artificial Intelligence for Skin Cancer Screening. *JAMA Dermatol*. 2020 May 1;156(5):501.
 40. Fritsch SJ, Blankenheim A, Wahl A, Hetfeld P, Maassen O, Deffge S, et al. Attitudes and perception of artificial intelligence in healthcare: A cross-sectional survey among patients. *Digit Health*. 2022 Jan 8;8:205520762211167.
 41. Carter P, Laurie GT, Dixon-Woods M. The social licence for research: why *care.data* ran into trouble. *J Med Ethics*. 2015 May;41(5):404–9.
 42. General Practice Data for Planning and Research revocation letter [Internet]. 2021 [cited 2024 Mar 13]. Available from: <https://digital.nhs.uk/about-nhs-digital/corporate-information-and-documents/directions-and-data-provision-notices/secretary-of-state-directions/general-practice-data-for-planning-and-research-revocation-letter#legal-basis>
 43. Kim J, Kim H, Bell E, Bath T, Paul P, Pham A, et al. Patient Perspectives About Decisions to Share Medical Data and Biospecimens for Research. *JAMA Netw Open*. 2019 Aug 21;2(8):e199550.
 44. Goldacre B, Morley J. Better, Broader, Safer: Using Health Data for Research and Analysis. A

- review commissioned by the Secretary of State for Health and Social Care. [Internet]. 2022 [cited 2024 Mar 13]. Available from: <https://www.gov.uk/government/publications/better-broader-safer-using-health-data-for-research-and-analysis>
45. Yakar D, Ongena YP, Kwee TC, Haan M. Do People Favor Artificial Intelligence Over Physicians? A Survey Among the General Population and Their View on Artificial Intelligence in Medicine. *Value in Health*. 2022 Mar 1;25(3):374–81.
 46. Funk C, Tyson A, Nolan H. 60% of Americans Would be Uncomfortable With Provider Relying on AI in Their Own Healthcare [Internet]. 2023 [cited 2024 Mar 13]. Available from: [file:///C:/Users/2622856/Downloads/PS_2023.02.22_AI-health_REPORT%20\(1\).pdf](file:///C:/Users/2622856/Downloads/PS_2023.02.22_AI-health_REPORT%20(1).pdf)
 47. Straw I, Wu H. Investigating for bias in healthcare algorithms: a sex-stratified analysis of supervised machine learning models in liver disease prediction. *BMJ Health Care Inform*. 2022 Apr;29(1):e100457.
 48. Owens K, Walker A. Those designing healthcare algorithms must become actively anti-racist. *Nat Med*. 2020 Sep;26(9):1327–8.
 49. £21 million to roll out artificial intelligence across the NHS [Internet]. 2023 [cited 2024 Mar 13]. Available from: <https://www.gov.uk/government/news/21-million-to-roll-out-artificial-intelligence-across-the-nhs>
 50. Harwich E, Laycock K. Thinking on its own: AI in the NHS [Internet]. 2018 [cited 2024 Mar 13]. Available from: https://reform.uk/wp-content/uploads/2018/11/AI-in-Healthcare-report_WEB.pdf
 51. A pro-innovation approach to AI regulation [Internet]. 2023 [cited 2024 Mar 13]. Available from: <https://assets.publishing.service.gov.uk/media/64cb71a547915a00142a91c4/a-pro-innovation-approach-to-ai-regulation-amended-web-ready.pdf>
 52. Greszki R, Meyer M, Schoen H. The impact of speeding on data quality in nonprobability and freshly recruited probability-based online panels. In: *Online Panel Research*. Wiley; 2014. p. 238–62.
 53. Brennan J, Chanfreau J, Finnegan J, Griggs J, Kiss Z, Park A. The effect of Higher Education on graduates' attitudes: Secondary Analysis of the British Social Attitudes Survey. London; 2015.
 54. Gillespie N, Lockey S, Curtis C, Pool J, Ali Akbari. Trust in Artificial Intelligence: A global study. 2023 Feb.

Supplementary Files

Untitled.

URL: <http://asset.jmir.pub/assets/2cae692d3e3e9cfad505e69cc3adc19b.docx>

Multimedia Appendixes

Online Survey Questions.

URL: <http://asset.jmir.pub/assets/0cf29e05ac373ea5a3190e2537ecddf8.pdf>