Does everything cause cancer?

Sonia Paytubi, Yolanda Benavente, Alexandra Montoliu, et al

Objective To evaluate the beliefs about cancer prevention of people professing vaccination scepticism or conspiracy theories.

Design Cross sectional survey.

Setting Data collected mainly from ForoCoches, Reddit, 4Chan, HispaChan, and a website for cancer prevention (mejorsincancer.org) from January to March 2022.

Participants Among 1494 responders, 209 were unvaccinated against covid-19, 112 preferred alternative rather than conventional medicine, and 62 reported flat earth or reptilian beliefs.

Main outcome measures Cancer beliefs assessed using the Cancer Awareness Measure and Cancer Awareness Measure Mythical Causes Scale.

Results The most endorsed mythical causes of cancer were eating food containing additives or sweeteners, feeling stressed, and eating genetically modified food. Awareness of the actual and mythical causes of cancer among the unvaccinated, alternative medicine, and conspiracy groups was lower than among their counterparts. In total, 673 (45.0%) participants agreed with the statement “It seems like everything causes cancer.”

Conclusions The results highlight the difficulty that society encounters in differentiating actual and mythical causes of cancer. They suggest a direct connection between digital misinformation and consequent erroneous health decisions, which may represent a further preventable fraction of cancer.

Introduction

Although social media provide new opportunities to access health information, they also have a pervasive effect. They open a direct avenue of misinformation and disinformation, posing health concerns. Misinformation about cancer can lead to increased disease burden when people do not adopt effective preventive health measures. It can also lead to delays in seeking effective oncological treatment and, consequently, worsen the outcomes in patients with cancer.

Health world views that dismiss scientific knowledge in support of magical thinking were previously associated with vaccination scepticism. However, no data exist on endorsement of conspiracies or vaccination scepticism in relation to individuals’ beliefs about and attitudes to cancer prevention. This study evaluated beliefs and attitudes to cancer prevention among anti-vaxxers, flat earthers, and reptilian conspiracists.

Methods

We collected data anonymously using a cross sectional design, with an online survey distributed on several platforms. Data mainly came from ForoCoches, Reddit, 4Chan, HispaChan, MediaVida, Burbuja Info, and Taringa. The survey was also posted in certain Telegram groups with titles including words such as “anti-vaxxers,” “reptilians,” and “flat earth.” Finally, the survey was distributed on mejorsincancer.org.

Measures

Conspiracy beliefs We asked the participants whether they considered the Earth to be round or flat. We included two questions to assess beliefs about reptilian conspiracies, using the statements “There are many shape shifting lizards taking human forms or turning into reptilian humanoids” and “Presidents of most countries are reptilian humanoids.”

Cancer beliefs We presented participants with risk factor questions on the Cancer Awareness Measure (CAM) and CAM-Mythical Causes Scale (CAM-MYCS). Questions on CAM assess risk perceptions of 11 established risk factors for cancer included in the European Code Against Cancer. CAM-MYCS includes 12 questions on risk perceptions of mythical causes of cancer—non-established causes that are commonly believed to cause cancer without supporting scientific evidence. Finally, we asked about agreement with the statement “It seems like everything causes cancer.” We collected data from January to March 2022 and obtained a sample size of 1494 responses.

Statistical analysis

We did multivariable analyses of CAM, CAM-MYCS, and CAM-total by using quantile regression. We used unconditional logistic regression to do multivariable analyses of binary variables. We introduced missing values into the models as independent categories. All tests were two tailed, with a significance level of 0.05.

WHAT IS ALREADY KNOWN ON THIS TOPIC

- Knowing the established risk factors for cancer is the first step in ensuring adherence to cancer prevention recommendations

WHAT THIS STUDY ADDS

- Awareness of causes of cancer was poor, especially among people who rejected the covid-19 vaccine, preferred alternative medicine, or endorsed flat earth or reptilian conspiracies
- This suggests a direct connection between digital misinformation and potential erroneous health decisions, which may represent a further preventable fraction of cancer
DON’T BELIEVE THE HYPE

Results and discussion

Among full responders, 209 (14.0%) did not receive any covid-19 vaccine and 62 (4.1%) believed Earth was flat or shapeshifting lizards existed. Also, 112 (7.5%) participants preferred alternative to conventional medicine. Awareness of actual and mythical causes of cancer in the unvaccinated and conspiracy groups was lower than in counterparts (figure).

Overall, 673 (45.0%) participants agreed that “It seems like everything causes cancer.” We observed no significant differences by vaccination status (P=0.96), conspiracy group (P=0.91), or alternative medicine preference (P=0.15) compared with counterparts.

This highlights the difficulty that society encounters in distinguishing actual causes of cancer from mythical causes. In adjusted models, people who believed in conspiracies, rejected covid-19 vaccines, or preferred alternative medicine were more likely to endorse actual causes of cancer. We evaluated beliefs about cancer among flat earthers and reptilian conspiracy theorists, although beliefs may differ substantially among chemtrail believers, global warming deniers, those who believe NASA staged the moon landings in a studio, or even those who believe that birds are drones operated by the US government to spy on citizens.23 24

False information spreads further and deeper than true.31 32 A cognitive paradox has been observed among people who reject covid vaccines—they generally believe less in a range of well established facts and more in fake statements than vaccine supporters26; this is consistent with our results. Interestingly, those preferring alternative medicine were more prone to endorse mythical causes of cancer.

A limitation was potential sampling biases from using an anonymous online survey. We had conversations with an individual who believed in the reptilian conspiracy and learnt about the presence of potentially paranoid features in this group: they may feel spied on by reptilians and would never answer the survey if it was not completely anonymous. This background knowledge implied the use of non-probability sampling wherein response rates and potential duplicate responses could not be evaluated. Our responses to conspiracy beliefs may be affected by fake responses. A detailed characterisation of non-scientific beliefs, using existing scales on conspiracy and magical beliefs,46-50 will help to increase understanding of the effect of the different participant profiles on health.

Endorsement of actual and mythical causes of cancer by covid-19 vaccination, medicine preferences, and conspiracy beliefs
She-Hulk: an incredible case of transfusion associated graft versus host disease

Neil Barrett discusses the haematological implications of Jennifer Walters’ accidental transfusion from a close relative, barriers to future research, and the real heroes in this

Transfusion associated graft versus host disease (TaGVHD) is a rare complication of blood transfusion in which viable lymphocytes within a blood product engraft (survive and proliferate) in a recipient. This process results in an almost always fatal form of graft versus host disease, with donor T cells attacking multiple organs, notably the skin, liver, gastrointestinal tract, and bone marrow.

This paper analyses a high profile case of non-lethal TaGVHD due to inadvertent blood contamination of an open wound after a car accident. While both donor and recipient survived the crash and contamination, the recipient was left with unexpected side effects, namely inheriting the ability of the donor to transform into a huge green rage monster.

The celebrity nature of this case means that the identities of both donor and recipient as well as the details of the incident are already in the public domain. The donor is Bruce Banner MD, PhD, PhD, PhD, otherwise known as the strongest Avenger. The recipient is Jennifer Walters, JD—also known as She-Hulk of high profile law firm Goodman, Lieber, Kurtzberg, and Holliway, the only legal firm in the world representing superhuman clients. Walters recently made headlines after a trademark dispute with Instagrammer Titania, and as such, no details of the case are confidential.

This paper describes risk factors for TaGVHD in this case, discusses other haematological phenomena that might be occurring, and suggests further research aims.

### Risk factors for TaGVHD

#### Shared genetic makeup
The donor has revealed that he and the recipient, his first cousin, share rare combination genetic factors that allow them to synthesise γ radiation. They might also share HLA haplotypes. Among the risk factors for TaGVHD (box, right), one is partial HLA similarity between the donor and host, because HLA similarity could give donor T cells an increased ability to avoid the host immune system and engraft. For this and other reasons, blood donations from one family member to another are discouraged.

We do note that in extremis (noted as an adjective, and not to be confused with EXTREMIS bioelectric nanotechnology developed by Maya Hansen and Aldrich Killian), alternate versions of Banner rampaging around the multiverse, with total disregard to best transfusion practice, carried out a direct donation of his own blood to prevent Ms Walters exsanguinating from a similar accident.

### Instant conditioning

Immunocompromised patients are also at higher risk for TaGVHD, including those who have undergone stem cell transplant conditioning such as with total body irradiation. In this case, the recipient received a lethal dose of γ radiation, which could have weakened her endogenous T lymphocyte response enough to lead to engraftment—in effect, a form of instantaneous transplantation conditioning.

### Most blood processing facilities lack access to infinity gauntlets

#### Whole non-leucodepleted blood
In the present case, whole, unfiltered (non-leucodepleted) blood without exogenous irradiation was introduced from the donor into the recipient. In the UK, universal pre-storage leucodepletion of blood products was introduced in 1999 with the primary intention to reduce transmission risk of variant Creutzfeldt-Jakob disease. However, several other benefits have been observed, including a reduced risk of other infections through transfusion (notably cytomegalovirus) and lower occurrence of TaGVHD. With widespread pre-storage leucodepletion, no cases of TaGVHD involving leucodepleted blood in the UK have been reported in the annual haemovigilance SHOT (serious hazards of transfusion) reports in more than 20 years.

However, adequate leucoreduction depends on statistical sampling of a small proportion of cellular products. This process might fail to achieve desired levels of depletion in all patients, and TaGVHD continues to be reported internationally. While filtration is generally highly efficient, Hulk lymphocytes might be able to “smash” through filters.

#### Irradiation

In the presence of risk factors for TaGVHD, irradiation is used to eliminate engraftment potential of any residual T lymphocytes present after leucodepletion. The British Committee for Standards in Haematology 2020 guideline recommends that irradiation delivers at least 25 Gy of x ray or γ radiation, with strict control of dose and distribution within the product.

Standard dose irradiation of blood component from a Hulk (both made of γ and purportedly resistant to γ radiation), even if donated while in human form, might not be efficacious. While Banner has never specifically mentioned an immunity to the effects of x rays, their lower energy relative to γ rays could be described as “puny” (to paraphrase Banner) and may therefore be insufficient for irradiating Hulk blood.

Banner’s endogenously produced “gamma” does not seem to suppress his T cells to the
Risk factors for TaGVHD and indications for blood product irradiation

<table>
<thead>
<tr>
<th>Immunocompromised host</th>
<th>Product factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Fatal recipients of intrauterine transfusion (IUT) or neonates who received previous IUT</td>
<td>• Presence of lymphocytes (eg, whole blood, granulocyte infusions)§</td>
</tr>
<tr>
<td>• Patients with congenital T lymphocyte immune deficiency (not including HIV/AIDS)</td>
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<tr>
<td>• Patients with history of Hodgkin’s lymphoma</td>
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<tr>
<td>• Patients with previous T cell depletion treatment: anti-thymocyte globulin§, purine analogues, alemtuzumab§</td>
<td></td>
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<tr>
<td>• Recipients of haematopoietic stem cell transplantation from time of conditioning*</td>
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Degree of HLA matching between donor and recipient

<table>
<thead>
<tr>
<th>HLA typed matched products</th>
<th>Coincidental HLA match</th>
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<tbody>
<tr>
<td>Blood donations from related donors‡</td>
<td></td>
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<tr>
<td>Coexistent HLA match</td>
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This case will hopefully encourage normal humans to donate blood - allowing them to be the real heroes

Knowledge of graft versus host disease. In particular, why a green colour rather than red or yellow?

In TaGVHD, infiltration of the skin by engrafted donor T lymphocytes typically produces a diffuse, erythrodermic rash. Red Hulks have been described in case reports, with near global skin effects characterised by intense heat emission, consistent with acute inflammation or indeed hyperfebrile reactions. Alternatively, graft versus host disease of the liver could cause hepatic failure, giving rise to jaundice. Yellow Hulks have also been described in preprints, and intense pruritus might be enraging. Even more notably, advanced graft versus host disease of the liver could produce a prolonged conjugated hyperbilirubinemia and a more classical Hulk green skin as cutaneous bilirubin is oxidised to biliverdin. In the present case, it is not clear whether the discolouration of Walters’ skin results from a genetic trait specific to her family or an attribute of the donor. Given the apparently high tolerance of alcohol observed in Hulks, liver disease is unlikely to be the mechanism.

Second, Ms Walters now also experiences reversible, stress induced muscular hypertrophy of unclear underlying physiological mechanism. One possibility is that the inadvertently transfused peripheral blood contained cells with myogenic potential. Cells in peripheral blood expressing the surface marker CD133 have been shown to have the ability to form muscular satellite cells and myofibres. Since physiological and even psychological stress can cause mobilisation of stem cells of various potentials into peripheral blood, this mechanism could have contributed both to the enrichment of the transfused blood with stem cells (at the time of an accident) and to the subsequent ability of the recipient to transform when she allows her stress to manifest (although in an exceptionally controlled manner).

Finally, there is one somewhat related report of a failed attempt to transfer superhuman capabilities via bone marrow transplantation. Owning to the recourse donor’s history of orthopaedic surgery, harvesting bone marrow from his bone claws - a non-traditional harvest site - would require adamanantium (or vibrium) collection needles, or, indeed, a gigantic adamanium samurai exosuit and remains purely theoretical.

Discussion

In this incredible case of non-lethal TaGVHD, whole blood transfusion from donor to recipient with multiple risk factors for TaGVHD seems to have merely transferred superhuman abilities. Several extraordinary factors could have safeguarded against disaster. While wildly speculative, the endogenous γ production unique to Walters’ genetic makeup could have modulated engrafted cell activity, specifically preventing fatal TaGVHD; therefore, the outcome of this transfusion might not be readily reproducible.

While attempts have since been made to gain access to samples from Walters, replication studies are unlikely. Banner has strongly refused any attempts to replicate the findings, going so far as to destroy all known samples of Walters’ blood (we are told it is inadvisable to make him angry). Furthermore, ethics committees are unlikely to approve further research under the rules of the Helsinki declaration, or indeed under the Sokovia accords (although New York based attorney Matt Murdock confirmed during a recent public court proceeding that the Sokovia accords have been repealed).

While HLA disparities between Hulk blood and human recipients could reduce the risk of TaGVHD, transfusion of blood from Hulks remains highly inadvisable on safety grounds, even with leucodepletion and irradiation. Given unpredictable outcomes, any history of so-called Hulk-ing out or turning into an enormous green rage monster should be added to the exclusion criteria for blood donation in pre-donation screening questionnaires.

Several other manifestations of TaGVHD in this case warrant further discussion. First, the verdant hue of the recipient raises several questions based on our nascent understanding of Hulk physiology and point he has recurrent infections. However, “gamma” produced in Walters’ post-transfusion blood could be modulating donor T cells, thus preventing fatal effects of GVHD. Her ability to produce “gamma” is different (better) from her cousin’s and could provide engrafted cells with “just the right amount of rage.”

Hulks can have prolonged side effects from very high levels of γ radiation, including after exposure to infinity stones. However, because most blood processing facilities lack access to infinity gauntlets, achieving this level of γ dosage is impossible for most blood centres.

Conclusion

While superheroes as blood and bone marrow donors capture the imagination, the safety of engaging superpowered individuals as donors is far from established. However, this case will hopefully encourage normal humans to donate blood—allowing them to become the real heroes. The campaign by NHS Blood and Transplant and the Wakandan government, “Not Family, but Blood” (#inourblood), highlights the urgent need for blood donors of Black African or Black Caribbean heritage, owing to the increased diversity of red blood cell antigens and the rising incidence of blood disorders such as sickle cell disease within this population. Real heroes rising from superpowered tales would be truly incredible.

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Can artificial intelligence pass the Fellowship of the Royal College of Radiologists examination?

S C Shelmerdine, H Martin, K Shirodkar, S Shamshuddin, J R Weir-McCall; on behalf of the FRCR-AI Study collaborators

Original Research

Multi-reader diagnostic accuracy study

Objective To determine whether an artificial intelligence (AI) candidate could pass the rapid (radiographic) reporting component of the Fellowship of the Royal College of Radiologists (FRCR) examination.

Design Prospective multi-reader diagnostic accuracy study.

Setting United Kingdom.

Participants One AI candidate (Smarturgences, Milvue) and 26 radiologists who had passed the FRCR examination in the preceding 12 months.

Main outcome measures Accuracy and pass rate of the AI compared with radiologists across 10 mock FRCR rapid reporting examinations (each examination containing 30 radiographs, requiring 90% accuracy rate to pass).

Results When non-interpretable images were excluded from the analysis, the AI candidate achieved an average overall accuracy of 79.5% (95% confidence interval 74.1% to 84.3%) and passed two of 10 mock FRCR examinations. For the same radiographs, the average radiologist achieved an accuracy of 84.8% (range 76.1-91.9%) and passed four of 10 mock examinations. The sensitivity for the AI was 83.6% (95% confidence interval 76.2% to 89.4%) and the specificity was 87.3% (85.0% to 89.3%).

Conclusions When special dispensation for the AI candidate was provided (that is, exclusion of non-interpretable images), the AI candidate was able to pass two of 10 mock examinations. Potential exists for the AI candidate to improve its radiographic interpretation skills by focusing on musculoskeletal cases and learning to interpret radiographs of the axial skeleton and abdomen that are currently considered “non-interpretable.”

Introduction

Radiologists in the UK are required to pass the Fellowship of the Royal College of Radiologists (FRCR) examination before completion of training. One component of this is the “rapid reporting” examination, in which candidates interpret 30 radiographs within 35 minutes and need at least 27 (90%) correct to pass. This examination tests radiologists’ speed and accuracy—areas in which artificial intelligence (AI) has been purported to excel. Imagine the examination is today. The “AI candidate” has received extensive training and, alongside its human peers, we test whether it can pass the FRCR examination.

Methods

The performance of 26 radiologists who recently passed the FRCR examination was compared with one “AI candidate” across 10 FRCR mock rapid reporting examinations. The AI candidate, a commercial tool, was trained on almost one million radiographs, and, although it was not certified to analyse those of the axial skeleton or abdomen, we included these to maintain fairness across participants.

We calculated the pooled results for summation of diagnostic accuracy across each of the 10 examinations for all radiologists using a bivariate binomial random effects meta-analysis. The diagnostic accuracy of the AI candidate was scored in different ways—scoring only the radiographs the AI candidate could interpret, and analysing all images provided but not awarding a mark for non-interpretable (“wrong”) ones.

Results

When we excluded non-interpretable images, the AI candidate passed 2/10 mock examinations (fig 1) with overall sensitivity of 83.6% (95% confidence interval 76.2% to 89.4%), specificity of 75.2% (66.7% to 82.5%), and accuracy of 79.5% (74.1% to 84.3%). The average radiologist passed 4/10 mock examinations with a summary estimate sensitivity of 84.1% (81.0% to 87.0%), specificity of 87.3% (85.0% to 89.3%), and average accuracy of 84.8% (range 76.1-91.9%) for the same radiographs (fig 2). The AI candidate was ranked as the highest performing candidate in one mock examination but came second to last overall (rank 26/27).

What is already known on this topic

- A large number of approved commercial artificial intelligence (AI) products are available, many of which are suited for “narrow” (ie, specific) AI tasks
- For acute chest and musculoskeletal radiographic interpretation, AI has shown high diagnostic accuracy, with sensitivity rates of 86% and 89%, respectively

What this study adds

- The AI candidate passed 2/10 mock examinations, compared with an average of four by trainees who had recently passed the examination
- Overall sensitivity, specificity, and accuracy rates were high for images that the AI candidate could interpret, at 83.6%, 75.2%, and 79.5%, respectively
- For the same radiographs, summary estimates across 26 radiologists were 84.1%, 87.3%, and 84.8%, respectively
When all images were taken into consideration (the strictest marking criteria), the overall sensitivity for the AI candidate was 75.2% (67.4% to 81.9%), specificity was 62.3% (54.0% to 70.0%), and accuracy was 68.7% (63.1% to 73.9%) compared with radiologists’ summary estimates of sensitivity of 84.0% (80.8% to 86.7%), specificity of 87.5% (84.8% to 89.8%), and average accuracy of 85.2% (75.0-91.7%). In this scenario, the AI candidate did not pass any of the mock examinations and ranked last in overall performance.

Discussion

With special dispensation, taking account of the AI candidate’s lack of experience in certain radiographs, a pass mark would have been achieved by the AI candidate in two of the 10 mock examinations. However, if dispensation was not granted, the AI candidate would not pass any of the examinations. The AI candidate can take solace in the fact that this was a particularly challenging set of examinations, with the average radiologist passing only four mock examinations. If these marks were moderated to account for the difficulty, as in the real FRCR examination, the pass rates may have been higher.
Although the AI candidate did not outperform most radiologists, its accuracy was relatively high considering the imaging case mix and complexity. Nonetheless, the AI candidate would still need further training to achieve the same level of performance, particularly in identification of subtle musculoskeletal abnormalities (which made up most of the pitfalls) and in interpretation of abdominal, skull, and spine radiographs, which it has no training in analysing.

The promise of AI as a diagnostic adjunct in clinical practice remains high as the AI came close to radiologist level performance when we consider the cases it could interpret. This could potentially bring near radiologist level accuracy to non-radiologists in the clinical environment and where immediate radiographic opinion is not available.

With respect to radiology training, if the performance of AI continues to increase and is widely adopted in routine clinical practice, a greater focus on learning how to evaluate radiographs for which AI yields less accurate or uninterpretable results may be needed (the college could potentially use AI to select out such cases for rapid reporting examinations).

Nevertheless, on this occasion, the AI candidate was unable to pass any of the 10 mock examinations when marked against similar criteria to radiologists. With further training and revision, it may be possible to improve the AI candidate’s chances of passing the FRCR examination.

**COMMENTARY**  
AI may facilitate workflows, but human input is crucial

In 2017 a robot called Xiaoyi (“little doctor”) attempted China’s medical licensing examination.1 In its first practice examination, the robot scored 100/600 points; after studying 400 000 articles and millions of patient records, it scored 456, substantially higher than the passing score of 360. Although Xiaoyi excelled at questions based on memorisation, it did not do as well dealing with patient cases.2 The company that developed the robot is clear that it is not meant to replace doctors,3 but other people have been less restrained about the effect of artificial intelligence (AI) systems on human doctors, particularly in areas requiring speed, accuracy, and radiographs.4

Consequently, radiology—a specialty that uses imaging technology for diagnostics and interventions—has long been predicted to become extinct as a result of AI. Geoffrey Hinton, a computer scientist sometimes called the father of deep learning, stated in 2016 that: “We should stop training radiologists now.”5 After Hinton’s pronouncement, several deep learning algorithms showed promising results compared with human radiologists.6 Now, Susan Shelmerdine and UK based coauthors have asked whether an AI candidate could pass the Fellowship of the Royal College of Radiologists (FRCR) examination, which allows radiology candidates to obtain the diploma for the licence to practise.9

### A dose of realism

This article joins others that aim to provide a dose of realism to the hype surrounding the outsourcing of radiology to AI.10 Shelmerdine and colleagues found that when given 300 radiographs, the AI tool—a commercial product already used in 10 European institutions—ranked last among its 26 human peers, all of whom had passed the FRCR examination the previous year. Nevertheless, the AI candidate did not outperform the radiologists, it was more accurate than some of them, some of the time. Interestingly, human radiologists thought that the AI system would perform better than it did, which suggests a cognitive bias towards AI and casts doubt on their own ability to assess the risks and limitations of these technologies.11

The authors note that the AI candidate—unlike the Chinese robot—was never trained to compete mock radiology examinations, let alone act independently in clinical practice. Their conclusion is therefore that the potential of AI remains large and that additional training could further boost the performance of AI.

But what specific design decisions should be made by engineers so that AI can genuinely augment the capabilities of human radiologists? And what are the social realities influencing both radiology as a specialty and the functioning and deployment of these systems?

### The human factor

Presumably, answering these questions requires an agreement about which aspects of the encounter between human patient and human radiologist are desirable. Firstly, we must acknowledge the key tasks of radiologists beyond interpretation of images. Radiologists “protocol” cases. They determine priority, imaging modality and sequences, and whether a contrast agent is needed to glean clinically meaningful information from an imaging study, taking into account the clinical history of each patient. Although some people have argued that natural language processing based machine learning can complete “protocolling” at a human specialist level,12,13 it cannot replace discussions between human radiologists and referring doctors for complex clinical scenarios in which uncertainty abounds. Furthermore, radiologists participate in multidisciplinary rounds with other specialists—for example, during postoperative oncology rounds—when human radiologists’ input is crucial for comparing and interpreting images to inform the clinical impression of a cancer, its response to treatment, and whether further treatment should be undertaken. The higher level synthesis of clinical expertise and the ability of human radiologists to understand a patient’s illness in context maintain their comparative advantage over AI.

AI is already being explored and even implemented as a tool to facilitate workflow, such as with image acquisition and interpretation.14 Tasking AI with these aspects of radiology could free up human radiologists’ time for higher level, complex, interdisciplinary discussions and other aspects of care. Using AI has untapped potential to facilitate efficiency and diagnostic accuracy to meet an array of healthcare demands. Doing so appropriately implies educating doctors and the public better about the limitations of AI and making these more transparent.

It also begets the discussion of how, given the open ended improvement potential of AI systems for some tasks, the expectations of patients and doctors of radiology are being shaped. The research in this subject is buzzing, and the study reported by Shelmerdine and colleagues highlights that one foundational aspect of radiology practice—passing the FRCR examination necessary for the licence to practise—still benefits from the human touch.

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