How may Artificial Intelligence (AI) affect people living with eye conditions over the next 5 years?

Introduction

Technology is increasingly being integrated across the National Health System (NHS), as it has been recognised that technology has the potential to greatly support healthcare professionals and patients (1). The commitment of the NHS to embracing digitalisation and delivering high-quality healthcare for its patients is further underscored by the recent merger of NHS England, NHS Digital and Health Education England, which was announced earlier this year as the NHS celebrates its 75th anniversary (2).

Artificial Intelligence (AI) is an area of technology that has many potential applications within the healthcare sector. Over recent years, AI has become more embedded within clinical medicine as the technology has been involved in supporting a range of areas, including patient diagnosis as well as administrative aspects associated with operational efficiency and workflow (3).

More specifically, AI has proven to be useful and relevant to the speciality of ophthalmology. For example, AI causal-association networks were integral to the development of a glaucoma consultation program that was previously developed, dating back to the 1970s (4). As AI has become more sophisticated over recent years, owing to advancements in technological development, its potential applications within healthcare have also expanded. Ophthalmology, in particular, is highly data-driven with ophthalmologists having access to a "wealth of digital images" (5), which is in part why the Royal College of Ophthalmologists have recognised that the speciality would be well-positioned to leverage AI.

In fact, the NHS has also publicly shared a favourable outlook in respect of AI and healthcare, as AI has been identified as a key priority for the health system within the NHS Long Term Plan (6). Further support for the greater adoption of AI in healthcare was expressed by Health Education England in the Topol Review (7). Such positive messaging from national reputable healthcare bodies, such as the NHS, Health Education England and the Royal College of Ophthalmologists, is a testament to the fact that AI has the potential to improve the delivery of healthcare in the future.

Although it is undeniable that AI algorithms have become more advanced over the years, with Figure 1 highlighting various domains of AI (8), there is the scope for AI to continue to improve in the years to come. After all, AI algorithms are designed to emulate a human level of intelligence (9), which may eventually be achieved or superseded with sufficient iteration and development.

Against this backdrop, this essay will seek to explore how AI may affect people living with eye conditions over the next five years. Specifically, this essay will consider how AI can help deliver benefits in diagnostic assessment, health equity, and independence for people living with eye conditions. These aspects will be considered alongside issues relating to patient experience, data privacy, and cost which can adversely impact on people living with eye conditions.

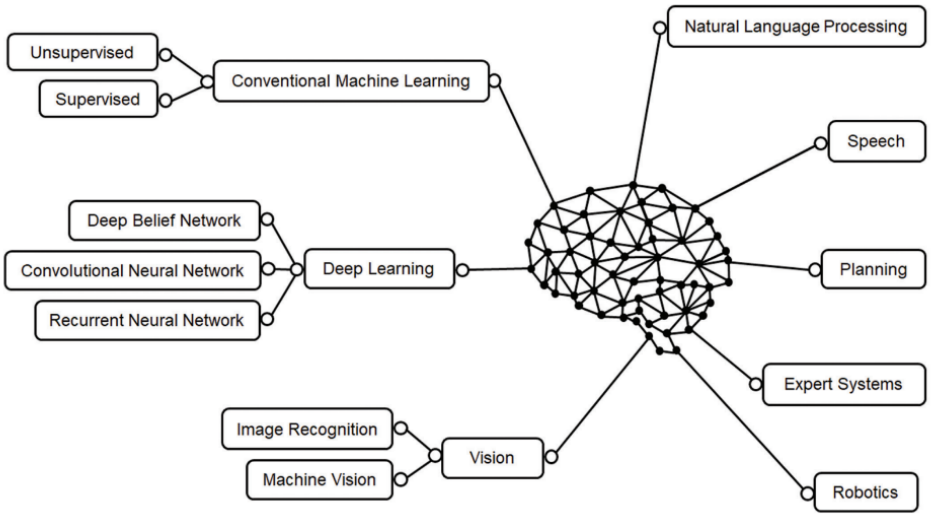

Figure 1: Domains of AI.

How may AI support people living with eye conditions?

Eye conditions can have a substantial impact on the lives of patients, and potentially affect their day-to-day activities. As with other medical conditions, it is imperative that individuals living with eye conditions receive prompt assessment and treatment, and that the appropriate preventative measures are in place to protect patients from any unnecessary deterioration to their condition. At the same time, it is important that any technology and medical devices seek to improve the lives of patients. Fortunately, AI can assist with each of these aspects, and in the coming years, work to continue to improve the quality of life of people living with eye conditions.

<u>More efficient diagnostic assessment</u>

AI has the ability to help support the diagnostic assessment of individuals with eye conditions. Given an appropriately large set of data, AI has the ability to 'learn' from existing data, and subsequently provide better insights based on the additional data that it is 'fed' (8). These principles of machine learning, which is a field of AI, can be applied to diagnostic healthcare imaging.

Since 2016, AI technology has been found to be successful in analysing optical coherence tomography scans for signs relating to common eye conditions, thereby supporting clinicians to diagnose and monitor glaucoma, age-related macular degeneration, and diabetic retinopathy (10). In fact, a recent review reported that the use of AI may represent a more cost-effective approach to the diagnosis of such conditions, as research has found that AI systems "can consistently match the performance of the experts, sometimes outperforming them" (10).

Faster and more accurate diagnoses, made possible through the usage of such AI systems, would likely be regarded favourably by healthcare professionals and people living with eye conditions, especially since such efficiency could help facilitate more timely intervention to help prevent any avoidable deteriorations to the sight of patients. Furthermore, the diagnostic accuracy of these AI systems is only likely to improve as the machine learning algorithms continue to learn over time.

Hence, it is possible to envisage how ophthalmology could maximise the use of AI through the widespread adoption of this technology, considering the large volume of digital imaging that is accessible to the speciality (5). In considering how AI may impact on the lives of people living with eye conditions, the former Scientific Committee Chair of the Royal College of Ophthalmologists, Professor Andrew Lotery, summarised its impact well when he said: "in the future we will be able to manage patients quicker without compromising accuracy." (5)

Greater support for those who need it the most

It has already been discussed how AI may prevent the progression of common sight-threatening conditions by way of a more efficient AI-driven diagnostic assessment. However, AI technology may be able to also work to address important accessibility issues, and thereby improve health equity, through the use of AI-enhanced assistive devices.

Technology companies, including leading organisations such as Microsoft, are working on such solutions. One project which Microsoft has already launched is the 'Seeing AI' app, which was designed for people with visual impairments and has been provided free of charge (11). By using a smartphone camera, the app provides an audio description of people and objects to the user (11). Although the AI may not be able to restore the sight of the individual, it is able to provide individuals with greater independence in their activities of daily living. This is because AI can be versatile and have many practical applications for individuals, with 'Seeing AI' being capable of assisting with: reading handwritten and printed text; conveying the brightness and colours of the surrounding environment; and identifying friends and loved ones through facial recognition technology (11).

Fortunately, accessibility for patients with visual impairments is only likely to improve with time, especially since the significant investment into such AI tools is likely to result in additional supportive devices being brought to market in the coming years. For example, Microsoft has a dedicated 'AI for Accessibility' programme, which has seen the organisation already commit a substantial eight figure sum to supporting innovative startups and non-profits with the funding needed to help improve accessibility for those living with disabilities (11).

Allowing patients to 'live' with their eye conditions

Having a long-term condition can be a burden for patients, as chronic eye conditions may require regularly scheduled in-person appointments for ongoing monitoring, as well as unplanned visits for concerns that unexpectedly arise. The time and cost associated with travel to and from such appointments could be perceived to be a real inconvenience for some.

Wearable health technology, which is powered by AI technology, may represent a solution to this problem for these individuals, as wearables can help empower patients and detect early-warning signs of some health problems without the need to attend for an in-person appointment (12). For example, smart contact lenses are already available, and these could be worn to collect real-time health metrics from individuals, with AI algorithms analysing this data to detect potential eye-related problems (12). This information could be made available to the user via the companion app that comes with most wearable devices (12), so that the individual could then decide whether to share this data with their doctors.

The use of wearable contact lenses to monitor eye health and detect any signs of deterioration could provide patients with the convenience to monitor their eye health on a more frequent basis over time. This could provide their ophthalmologists with a 'richer' sample of data to consider than would be possible through attending appointments that are less regularly scheduled (12). Given that wearable devices appeal to health-conscious consumers (12), AI-supported wearables could prove useful in health promotion by establishing a larger user base and encouraging these individuals to take a greater interest in their eye health.

How may AI negatively affect people living with eye conditions?

It is evident from the above that AI could prove useful in seeking to provide more effective assessment and preventative options to people living with eye conditions, as well as greater independence for those with sight impairments. Yet, although AI may have the potential to improve the lives of those living with eye conditions in these ways, certain aspects relating to AI could equally have an adverse impact on the lives of these individuals. For this reason, it is important to not only consider the limitations and concerns associated with the usage of AI technology in ophthalmology, but to also reflect on how any potential issues might be overcome.

<u>Less 'patient-friendly' experience</u>

Medical training teaches students the importance of a patient-centred approach, including the need to: build rapport with a patient; develop a trusting doctor-patient relationship; and provide each patient with care that is personalised to their needs, values and preferences (13). However, there is a concern that while the increasing adoption of technology could be beneficial to efficiency, such improvements may be to the detriment of the quality of the patient experience in certain circumstances (14).

For instance, AI has been instrumental to the development of self-imaging technology, such as an optical coherence tomography system which is available to patients (15). Such self-imaging systems may be perceived to be beneficial if used as a screening tool to empower patients to take greater responsibility for their eye care. However, patients could be left unsupported when worrying about any 'bad news' which is reported by such self-imaging tools.

In particular, the technology may adopt a singular approach to sharing medical results as it may not be capable of replicating the personality of a doctor, communicating with empathy, or adopting a holistic perspective when considering the patient that presents before them. These are all values and skills which patients value in their healthcare professionals, and which positively develop the doctor-patient relationship (16). However, if AI were to be used in direct communications to patients, its delivery of information may not be expressed in the

same emotionally sensitive manner by which a trained healthcare professional might convey such information. Using AI in this way could result in patients feeling anxious and in need of support, as any patient communications may lack a much needed 'human touch'. This may pose a greater problem for those living with chronic eye conditions who value the personal connection that they have with their doctor.

Hence, in order to help preserve the doctor-patient relationship and continue to deliver a personalised experience to patients living with eye conditions, the use of AI may need to be limited to the support of healthcare professionals. Specifically, it may be deemed appropriate for AI to only be used in supporting staff with administrative work, imaging analysis, and tasks which would not involve the AI directly engaging or communicating with patients. Over time, patients will also need to be introduced to any technology that is used, as this may make them more likely to accept the role of AI in their future eye care (17).

Data privacy and security

Data privacy is a major concern which relates to AI, especially since health data is often targeted in data breaches so may be compromised as a result (14). Hence, patient concerns regarding data security may be further justified by the fact that the training of AI algorithms is a relatively data-intensive process, which relies on a large pool of data to improve the accuracy of the AI.

The complexity of data privacy, as an issue relating to the usage of AI in the healthcare sector, is discussed in detail within a report published by the World Health Organization on the 'Ethics and Governance of Artificial Intelligence for Health' (18). The report highlights the global nature of the data privacy implications associated with AI technology, and notably, the need for appropriate regulatory oversight to ensure that any data is used with the consent of patients (18). In the context of ophthalmology and AI imaging systems, it will therefore be important to involve patients with eye conditions, and inform them of the implications, benefits and risks associated with providing access to their data. This would be particularly prudent given that health data is sensitive and classified as 'special category data' by the Information Commissioner's Office under the UK General Data Protection Regulation (19).

Although having the necessary regulatory procedures in place may seem to be relatively straightforward, it is worth noting that the AI regulatory landscape is anything but simple, as legislation relating to AI continues to change (20). In addition, regulation gives rise to a challenge associated with implementing the appropriate safeguards without overly restricting the volume of data that is accessible to AI systems, as many AI systems require an abundance of data (14).

Nevertheless, with the increasing adoption of digital technology in healthcare, many people living with eye conditions will likely seek reassurance from healthcare systems that their data is held securely. Consequently, it may become more commonplace to have open discussions with patients relating to their data and AI systems, especially since certain patients may need to be educated about the use of AI in ophthalmology.

Cost precluding access

Cost is another contentious issue which often arises in discussions relating to technology, and cost is certainly relevant to this discussion of AI and its potential future impact on people living with eye conditions.

One of the benefits discussed earlier referred to how AI could help improve accessibility, especially for disabled individuals living with eye conditions. However, it is important to also consider the potential for AI to work counterproductively and worsen health inequalities.

Due to the scale of small and medium-sized enterprises, most do not have the necessary funding to provide technological solutions at no cost to users as Microsoft has (11). For this reason, organisations may need to implement pricing strategies in order to help recoup their investments in the research and development of their technologies. If businesses choose to pass on these costs to consumers or healthcare providers, it may result in people living with eye conditions being unable to access technology that would be beneficial for them. In such circumstances, cost may represent a barrier to accessing technology for those with lower incomes.

This is clearly a difficult issue to reconcile, as ideally the pricing of any AI technology should not be too cost prohibitive to patients in need of it, but equally, many companies are run for

profit so may be incentivised by the prospect of getting a good return on their investment in the technology. For this reason, it may be necessary for the NHS to subsidise any AI technology that is deemed to be beneficial for patients with specific eye conditions, so that the technology is accessible to individuals who would likely benefit from its use. Though, such spending would obviously represent an opportunity cost for the NHS that would likely need to be justified.

Conclusion

AI is likely to have a substantial impact on people living with eye conditions over the coming years, both in the short-term and long-term. In particular, AI may help support clinicians by providing a more efficient assessment of patients, so that people living with eye conditions can benefit from improved outcomes and a reduced likelihood of developing complications due to earlier intervention. In addition, the quality of life of individuals could be further improved through AI-supported technology, including assistive devices for patients with visual impairments, and smart contact lenses that allow individuals to monitor their eye health independently. Furthermore, the benefits provided by AI for people living with eye conditions are likely to increase in time, especially in light of the anticipated future advancements in AI that are expected with quantum computing.

However, with the increasing integration of technology in the healthcare sector, it has become apparent that a proactive approach needs to be taken to pre-empt and mitigate any undesirable issues associated with any technology. AI is no exception to this; as any technology will likely have important considerations in respect of patient experience, data privacy and security, and pricing which must be carefully assessed. If not managed appropriately, such issues might limit the potential impact and success of any AI interventions. Therefore, a unified approach must be taken, with clear and transparent messaging, in order for healthcare providers, clinicians and patients to appreciate the role of AI in the future of ophthalmology.

Provided that the technology is used in a responsible and ethical manner, the future impact of AI on people living with eye conditions could be truly transformative.

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