Royal College of General Practitioners

Artificial Intelligence and Primary Care

ARTIFICIAL INTELLIGENCE AND PRIMARY CARE

This report was created to inform GPs of the potential use of artificial intelligence. Work on this topic started in February 2018 following the publication of "The Principles around Artificial Intelligence in Healthcare" paper at RCGP Council. The RCGP participated in workshops with the Academy of Medical Royal Colleges, the Royal College of Physicians and engaged in the Topol Review [1]. In addition, the College held conversations with NHS Digital, NHS England, Health Education England, various industry organisations including IBM and Ada Healthcare, research organisations including, University of Oxford and Imperial College London and frontline GPs. These conversations and workshops combined with desk-based research informed this document. This report is one of a series of reports from the RCGP.

We will continue to engage with GPs, healthcare professionals and patients to explore this topic further to share understanding of the role of artificial intelligence in supporting general practice, a specialty based on relationships and community.

CONTENTS

1. Introduction....4
1.1 No simple universal definition....4
1.2 Origins and renaissance....5
1.3 AI, why now?....5

2. What is AI?....6
2.1 Narrow or General....8
2.2 What do we mean by intelligence?....8

3. The potential of AI in Primary Care....9
Case Study - Wearables:....9
3.1 The opportunity is vast....9
Case Study – Natural Speech....10
3.2 Challenges, risk, regulation and unanswered questions....11
3.2.1 General challenges and risks associated with new approaches....11
Case study – Bias....11
3.2.2 AI specific challenges and risks....11
Case study: ADA....12
3.2.3 Regulation....13
3.2.4 Questions facing AI in general practice....13
4. What does this all mean for me, the practitioner?....14
Case Study – Decision Support....15
4.1 Longer term potential impact for the GP....15
4.1.1 AI supported care approaches....15
4.1.2 Wearables and personalised care....15
4.1.3 Skills and professional development....16
4.2 Changing role of the GP and healthcare professional....16

5. Role of the professional body....16
5.1 Protecting and supporting evolving roles....17
Case Study – Fulfillment Centres....17
5.3 Artificial Intelligence for primary care with people and healthcare at the core....18
5.4 AI silver bullet....18

IN DEPTH: AI Approaches....19
References....21

1. INTRODUCTION

This paper discusses and provides a brief overview of the role and potential impact that artificial intelligence (AI) may have in primary care. It outlines the basic principles of AI, summarising where it may influence primary care and explores the possible role of professional bodies, such as the Royal College of General Practitioners (RCGP), to facilitate change to improve care delivery and patient outcomes.

Primary care has become more complex and requires greater use and integration of new technologies such as AI, diagnostics, medicines and treatments. The recent move to wrap care around the patient should be facilitated by AI to support GPs to deliver person-centred care. Professional bodies such as the RCGP can work with appropriate bodies to facilitate and guide the integration of evidence-based AI. Partnerships can create trust and transparency in AI which is appropriately regulated to ensure safe working to prevent errors and adverse effects.

1.1 No simple universal definition

The question ‘what is AI?’ has no clear or agreed answer. In section two we explore the definition of AI in more detail, but in summary it can include:

1. Any software with decision making capability: in one of its simplest forms consider how an email spam filter functions. When the user marks an email as spam the software checks and removes incoming emails from the same sender or subject line. This is simple decision-making by rule checking – these are known as rule-based systems.

2. Automated software with decision making capability: more sophisticated software that automatically reviews email content, subject, sender, etc. for pre-specified common signs of spam and uses these pre-set rules to automatically decides if an email is spam.

3. Self-learning software with decision-making capability: one step further are algorithms (or lines of code) that adapt so if a user marks an email as spam the characteristics of that email content is used to change what the software categorises as spam in its automated decision-making process.

The RCGP considers any software capable of decision making as AI (more in section two). This includes simple yes or no rule checking, more complex decision trees or even more complex changing and adapting software.

1.2 ORIGINS AND RENAISSANCE

Artificial Intelligence was established as an academic area of research in the 1950's and has since undergone periods of both hype and skepticism as research develops novel findings and encounters challenges. The recent renaissance in AI has been galvanised by new algorithm development and hardware refinements such as improvements in graphics processing units (GPUs), originally used for drawing and displaying images but also well suited for AI software processes. In April 2018, the House of Lords Select Committee on Artificial Intelligence released a report [2] on the potential impact and development needs of the UK. This report presents a comprehensive overview of the broad scope of AI touching on inequality, education, missing and existing skills, Black Box algorithms (software processes that are not transparent) and data.

The application of AI in primary care is a nascent, developing field but is already having influence across health care settings [1,3] and has the potential to influence a wide range of areas and activities within the NHS. The full extent to which AI will change primary care is unknown, nevertheless, there is significant speculation on the potential capabilities and risks of AI, many of which are still emerging [1]. However, there are near and medium-term AI functionalities and applications on the horizon that can be extrapolated from current capabilities (see section 3). For example, there is potential for AI to simplify current workflows and automate certain backend functions through task substitution. In the short term this can release capacity for healthcare professionals. In the longer term there is potential for AI to significantly change existing working patterns, which are explored in more detail in section 3. The longer term changes will impact healthcare professionals (section 4) and require professional bodies to make recommendations to change practice or curtail certain developments to facilitate progress for patient benefit (section 5).

Any new technology has the potential to generate negative and positive impact, in complex systems such as those found in healthcare it is not uncommon for impact to be a combination of both. Risks associated with the use of AI in healthcare are well documented [2,4,5] and encompass unintended harm as a result of reliability, safety, privacy, transparency and inbuilt system biases. In addition, there is potential for intended harm through malicious use of AI and compromised data. Systems need to be appropriately regulated and quality approved to mitigate these risks.

Regulation of AI is currently limited. However, there may be processes set in place similar to medical device regulation. In the near future, AI needs fair and appropriate tests specific to both the application area and as diagnostic aids, to maximise benefits while anticipating and minimising harm. The RCGP aims to support professionals to maximise the benefits that AI brings to patients and care delivery and seeks to engage with regulatory, governing and professional bodies to facilitate adoption and scaling.

1.3 AI, WHY NOW?

Present day AI solutions:

- utilise new hardware to process information faster than the human brain and mimic decision-making capability
- analyse large quantities of data rapidly and repeatedly, far beyond human capabilities
- data-led decision making avoiding the heuristics ("rules of thumb") that form part of human judgement [6].

General practice has evolved to generate, capture and access large quantities of data. The rise in multidisciplinary teams is changing the tasks involved in care provision, introducing an increasingly diverse range of skills and skilled staff into the practice. The pressures on general practice, which include high workload, large quantities of administrative tasks, low GP numbers and increasingly complex cases, are well documented and solutions are required to address these challenges. Furthermore, there is increasing concern about safe working in these circumstances, which AI driven tools could support to address and alleviate.

These benefits in combination with the advances in AI mean we are potentially coming to a point where AI can meaningfully contribute to improving processes, replacing backend administrative tasks and, in the short term, reduce the workload of healthcare professionals to release their time which can be better spent with patients. During this time, regulation, evidence, ethical operation approaches and data structures can be developed and implemented to create AI systems that are patient facing or augment healthcare professional's abilities (i.e. pair people with software to use the innate skills of each to complement each other).

2. WHAT IS AI?

There is no common agreed definition of artificial intelligence. The term is now seen to encompass several software (algorithm) based approaches that replicate one or more “cognitive” (thinking and reasoning) capabilities (see figure 1). Over time, functions previously categorised under the umbrella of AI become part of routine technology and are no longer considered to be AI, which complicates the definition of AI.

Everyday examples of functionality previously considered as AI include voice to text transcription – now available on any smartphone, digitising scanned documents through handwriting recognition or optical character recognition, spam filtering and computer game opponents (Chess, Go etc.).

For our purposes, we adopt the definition for AI found in the Industrial Strategy White Paper [7]:

> “Technologies with the ability to perform tasks that would otherwise require human intelligence"

This definition includes everything from the simplest application of AI, which relies on making decisions based on static predefined rules and parameter checking (e.g. if x then do y), as well as simple yes or no decision trees to the dynamic complex “learning (or evolving)” algorithms that continuously review incoming data, find patterns and adapt existing algorithms (hence learn). As noted above, Figure 1 depicts a range of capabilities that are considered to be AI and Figure 2 depicts potential applications for AI in primary care.

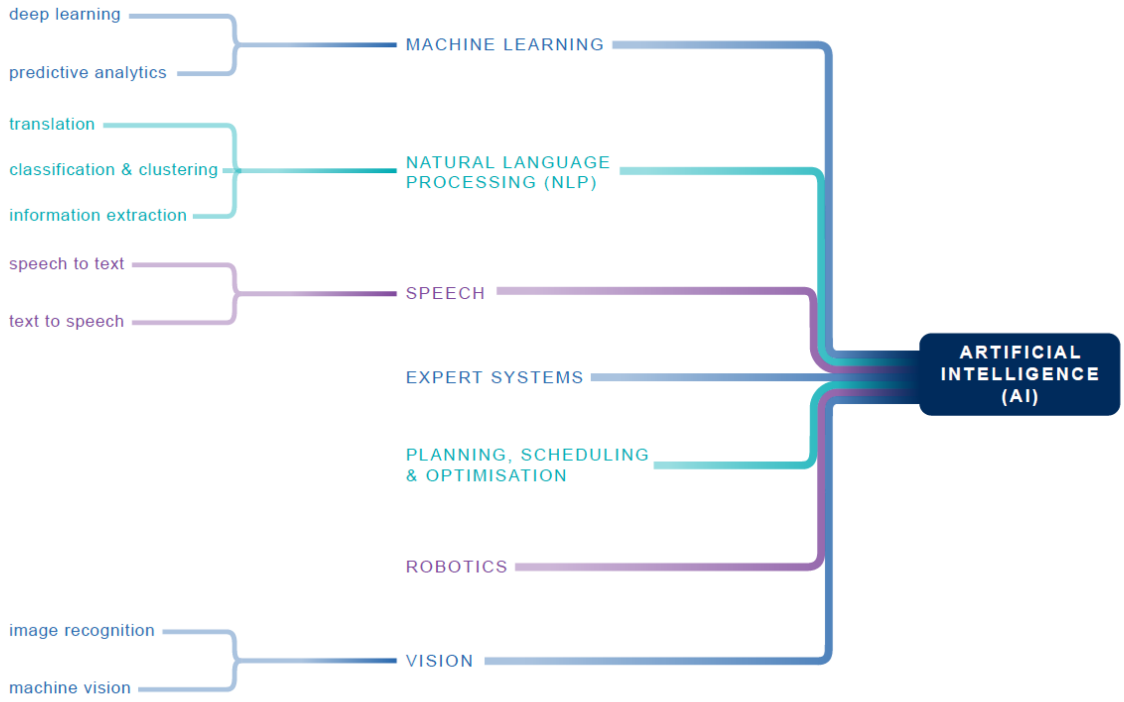

Figure 1: The range of capabilities that are generally accepted as artificial intelligence [8]

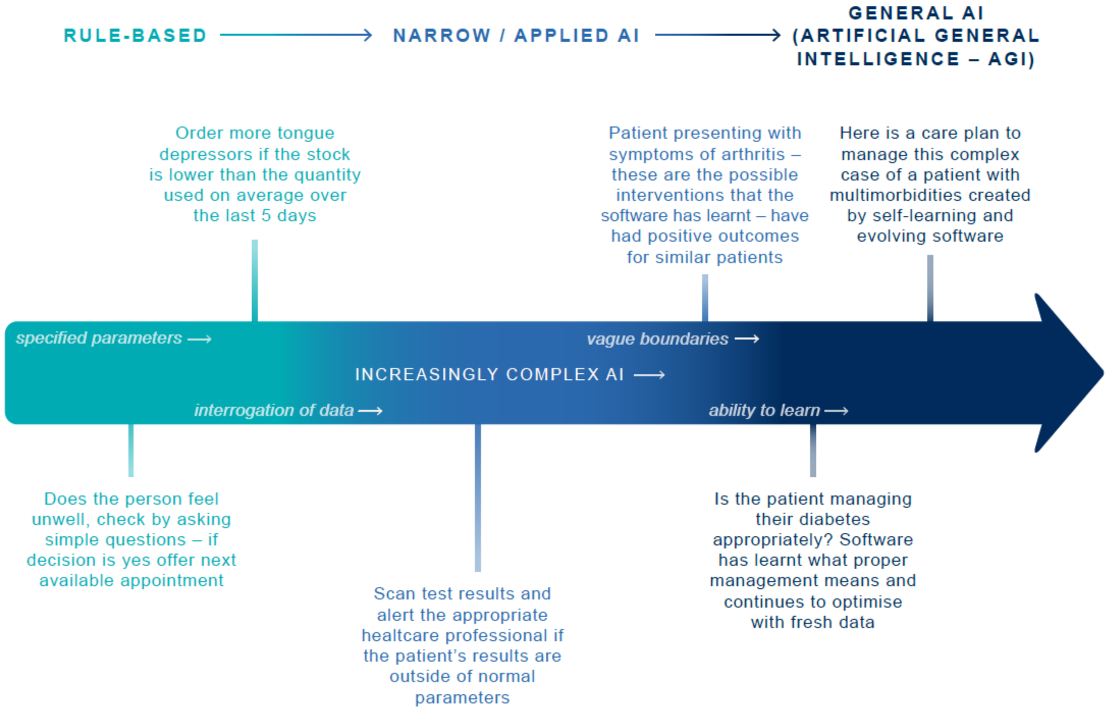

Figure 2: Examples of potential applications for AI in primary care

2.1 NARROW OR GENERAL

To complicate matters further, AI can be narrow (also known as applied AI), where the system has the limited capability of performing a single task, for example filtering spam or translating voice to text, or it can be general. General AI can perform high level decision making, is capable of planning and can incorporate context awareness. These can be applied to a wide range of tasks; general AI is not task-specific. Current real world uses of AI are limited to narrow AI. However, successful applications are often conflated as easily expandable to a wider range of general tasks (general artificial intelligence), this is mainly because contextual awareness is an innate human skill – it feels easy to people, but in reality, is very difficult to replicate in software.

If stripped down to the basics, AI, by its nature of being based in software, is underpinned by:

- algorithms (these may have rule based or learning features)
- availability of large datasets to enable the learning
- powerful computer processing which allows large amounts of data to be processed in short time durations [9].

2.2 WHAT DO WE MEAN BY INTELLIGENCE?

The 'intelligence' aspect of the AI process refers to the software in question demonstrating capabilities that are comparable to aspects of the thinking+analysis+decision combination of humans. For example:

- Decision making
- Learning and then adapting
- Reasoning
- Problem solving
- Contextual awareness
- Natural language understanding [2,10] (being able to understand a normally spoken sentence without requiring the sentence to have specific structure)

AI powered software can do one or several of the above depending on the complexity of the algorithms and the approach taken. These approaches are summarised in the ‘In depth: AI Approaches’ box.

3. THE POTENTIAL OF AI IN PRIMARY CARE

The importance of AI's potential impact has been highlighted in an independent report produced for the UK government summarising its economic and social impact in the UK [1]. The report makes recommendations on how an AI empowered workforce should be developed, including working with industry to utilise AI across all spheres of working including in healthcare. Large companies such as Amazon, Google and Facebook recognise the value and advantages of big data usage, but have yet to identify how to adequately pair this with inherent human strengths (augmenting people).

CASE STUDY

WEARABLES

The use of wearable patient monitoring systems lends itself well to machine learning approaches which can be used to analyse real time clinical data. Examples range from screening programmes, chronic care monitoring using ECGs, in-community rehabilitation, clinical decision support and risk assessment of falls and vascular events in hypertensive patients. Key issues that need addressing when considering these applications include sensors and signal quality; data processing; false positives/negatives, appraising the validity of screening using the Wilson-Junger criteria (see Wilson JMG, Jungner G; Principles and Practice of Screening for Disease, World Health Organization, 1968) and continued patient engagement.

There is on-going work in the area of Personal Health Records on the use and integration of wearable data into clinicians' records. This can include everything from home BP measurement, symptom reporting in chronic inflammatory arthritidies and movement sensor data in Parkinson's disease. At some stage, plans for the effective integration of this data will include AI, which may help to address some of the issues mentioned above, but it is important to ensure the health record continues to be functional and supports those who use it.

3.1 THE OPPORTUNITY IS VAST

The NHS has the potential to harness new technologies to improve practice efficiency, treatments and outcomes for patients. Examples where AI usage could potentially be beneficial include the following:

- Presenting the healthcare professional with a potential combination of treatments or management approaches depending on availability of community activities, app-based tools and pharmacological medicines, while considering the patient's genetic make-up and preferences as well as their health and digital literacy to facilitate clinical decision-making.

- Presenting the healthcare professional with relevant information to ensure comprehensive local health and care records under development are usable [11].
- Using Natural language processing (translating natural speech to text and converting this text into a more formal and standardised structure) to help capture consultation information into the electronic healthcare record. Using these types of AI tools, can potentially improve informational continuity and save clinician time. It is important that the captured information would not need additional editing by healthcare professionals, otherwise this would be task substitution and not a reduction in workload. Additional functionality could include translation to improve care provision to non-native speakers (see Case Study – Natural Speech).
- Bridging the gap between data rich, continuous but lower quality sensors found in consumer wearables and the high quality snapshot data from medical diagnostics (see Case study - Wearables). If evidenced to be possible, this could enable quicker decision making by replacing the current process of establishing trusted baseline information in the first consultation and then having a follow-up consultation.
- AI means we could have systems that adapt to new patient data improving efficacy of these tools, after an appropriate evaluation. Any evaluation only tests a very small percentage of the population, once commissioned the average effectiveness of an intervention drops due to the less common cases. For the first time ever, AI makes it possible to learn from less common cases to continue to improve interventions. To realise this will require regular auditing and testing.

CASE STUDY

NATURAL SPEECH

Natural speech interaction with a clinical decision aid; Beveridge and Fox, J Biomedical Computing (2006) 39, 482-499

Taking patient histories and taking decisions with a standard keyboard and screen is time consuming and distracts from paying attention to the patient. An interface that can interact flexibly with a user through natural conversational speech is a flexible alternative for capturing data and giving advice.

In 2006 a study was undertaken to integrate the PROforma cancer referral application with off-the-shelf speech recognition and production software, this was customised with a conversation manager to ask and answer questions, give recommendations and explanations. Performance was tested against a set of standard linguistic benchmarks adapted for the cancer referral context.

The enhanced PROforma application successfully executed data recording and decision dialogues over 80% of the time and made accurate summaries and decision recommendations in 97% of these dialogues.

3.2 CHALLENGES, RISK, REGULATION AND UNANSWERED QUESTIONS

As with any new technology or approach, there are potential negative impacts that need to be considered. In this section, we summarise the general challenges and risks which need to be considered for any new approach. Following this summary, we conduct a deeper exploration of the challenges and risks most pertinent for AI, on-going work in regulation and, finally, the questions facing primary care.

3.2.1 GENERAL CHALLENGES AND RISKS ASSOCIATED WITH NEW APPROACHES

The risks and weaknesses of any technology applied to healthcare include:

- an increased likelihood for patient harm and insufficient existing safeguards
- an introduction of the risk of systematic errors
- premature implementation without rigorous testing, an evidence base, outcome data or cost-effectiveness
- the potential of over diagnosis [12] (e.g. from increased monitoring and screening) or under diagnoses (e.g. from poor data quality, poor implementation, poor validation/regulation)
- difficulties in integrating into day-to-day practice including interfacing with existing IT and the electronic health record or unanticipated effects on clinical workload, care pathways and payment mechanisms
- successful absorption depends on capacity and infrastructure that is fit for purpose. Frontline services are under pressure and infrastructure capability is variable at best, unknown at worse.

CASE STUDY

BIAS

Genomic databases may originate from populations that might have not accounted for ethnic diversity as we are aware that ethnic minorities do not engage well with genetic departments for reasons that might be accounted for by cultural factors.

3.2.2 AI SPECIFIC CHALLENGES AND RISKS

There are potentially functional, ethical and economic risks associated with AI. A recent publication by the Wellcome Trust [2] provides a well-documented overview of these AI-specific risks. The risks of particular importance to healthcare are:

- Ensuring patients trust, transparency and privacy underpins the use of their data through Data Trusts [13] (proposed organisations that would hold data to facilitate the ethical sharing of data and prevent the development of data monopolies). Any data repository needs to be able to ensure data security and quality, especially as data is used to not only train AI but also to validate its functionality. Poor data or tampered data may negatively impact outcomes, resulting in serious injury or harm.

- Establishing Data Trusts (see above) or similar principles to define the NHS interface or overlap with commercial organisations contracted by the NHS to provide services. This is essential to mitigate ethical issues including the potential use of publicly funded services and staff for commercial product development, creation of commercially owned assets (e.g. data), the unintentional creation of data monopolies, negative public perception, unclear data ownership and access etc.
- Data quality determines the efficiency of the algorithm which means clinicians, providers and patients need assurance in the quality and regulation of data (see Case Study – Ada).
- Biases can underrepresent patients or ill-inform the AI. For example, underrepresentation of certain patients such as those from poorer socio-economic backgrounds can be crystallised in software processes disadvantaging the care provided to these patients or limited clinician time may impact systematic data capture resulting in only capturing symptoms relevant to the diagnosis which can impact AI performance (see Case Study – Bias).
- Ensuring healthcare professionals have assurance in the AI, including:
    - Transparent processes to incorporate and respect the healthcare professionals opinion (interpretable machine learning systems to mitigate Black Box, or non-transparent AI)
    - Clear understanding of the capability of AI involved in clinical care and the responsibility (including liability and insurance implications) to the healthcare professional
    - Understanding of the safeguards against malfunction, underperformance and erroneous decisions
- Sufficient regulation that is independent of the technology change to ensure it is not quickly outdated, especially as AI is such a fast moving area. For instance, more focus on risk management, safety assurance and how the outcomes of the service users are fulfilled.

CASE STUDY

ADA

Ada is a personal health guide developed by technology company Ada Health. Ada leverages AI to provide personalised symptom assessment and care guidance. It is being piloted by GP practices in South London and used by health systems in several countries including Germany and the USA. UK pilots indicate improvements in patients' health literacy and increases in the levels of self-care – which can impact demand on NHS services. Each time Ada is used to provide personalised guidance, the patient is asked to provide feedback and confirm the impact of the advice. A process involving data analysis and AI (machine learning) uses the new, existing other data and feedback to indicate where and how the system could be further improved. These machine suggestions are reviewed by a team of qualified healthcare professionals. This approach shows how the expertise of healthcare professionals can underpin the functioning of the system to manage the risk of automatically training the system with potentially inaccurate or biased data.

3.2.3 REGULATION

Regulatory frameworks that encompass values and ethics are required to ensure that AI and its applications are implemented safely. Thus, transparency and accountability are important [2]. Work has already started in this area with the Evidence for Effectiveness Working Group [14]. A working group, led by NHS England, including a number of stakeholders representing industry, NHS and academia, that is developing guidance and standards in this area. MHRA and the FDA are looking at regulatory frameworks to understand how they need modifying for digital healthcare interventions that include AI. There is a move for algorithms to be stored in servers on the cloud to help address the issue of data transfer within GDPR, which may eliminate some of the issues discussed such as lack of infrastructure. This is an area the RCGP can help to map out and support to remove further fragmentation - solving some of today's pressing issues.

3.2.4 QUESTIONS FACING AI IN GENERAL PRACTICE

- AI and healthcare professionals in tandem:
    - AI lacks emotion, compassion and presence which is where primary care experts excel over AI. Are clinicians being engaged sufficiently to unlock the potential for working in synergy with the system to continue to provide the soft skills at which healthcare professionals excel?
    - If a system is trained and making decisions based solely on data what about the aspects of a consultation that are undocumented, unmeasurable or rare events? How do visual clues, economic, and social changes get included?
    - How does the AI incorporate personal preference, choice and maintain patient dignity (e.g. those in care homes)?
- Which approach is best for each application area?
    - It is unclear what the requirements of data size, quality and reliability are for each AI approach (see "In depth: AI Approaches" box for overview of the approaches).
- Assurance
    - What is the best approach to checking data for biases and incompleteness and filling in or mitigating their effects on a continued basis?
    - How best to regulate adaptive systems that continually learn in comparison to static versioned systems, especially to unlock the potential for an adaptive system to improve post randomised control trial?
    - How to define and agree the level of trust and autonomy delegated to automated systems and processes?
    - How to define the correct checks that need to be in place to delegated automated systems and processes?

4. WHAT DOES THIS ALL MEAN FOR ME, THE PRACTITIONER?

This short publication represents a brief overview of what Artificial Intelligence might mean for primary care. The potential is huge, but like any innovation, it requires careful thought around implementation and regulation.

The potential near-term benefit of AI to primary care is in its application to administrative tasks and freeing healthcare professional's time. Potentially in the near-term, is task replacement in the consultation - identifying where AI can directly replace specific activities in the consultation, for example, automating the display of information on medication (e.g. the BNF) or pathways, therefore supporting clinicians to deliver care by ensuring relevant information is available in the consultation. Near-term solutions, such as the ones outlined above, need to be identified with healthcare professionals to create solutions and processes that work to reduce workload, reduce (or not add to) cognitive load, addresses the real current needs and release healthcare professional time.

CASE STUDY

DECISION SUPPORT

Diagnosis and management of patients with acute stroke; Ranta et al Neurology 2015 14; 84(15), 1545-51

Strokes are a common cause of adult disability and mortality worldwide. Transient ischaemic attacks (TIA) are associated with a high risk of subsequent stroke. A 2015 trial aimed to test whether a decision support tool in primary care can safely improve guideline adherence and reduce recurrent stroke/vascular event rates. The trial in New Zealand found that primary care use of the TIA or stroke electronic decision support tool improves guideline adherence, safely reduces treatment cost, achieves positive user feedback, and may reduce cerebrovascular and vascular event risk following TIA/stroke. GP feedback on the usefulness and acceptability of the tool was high.

4.1 LONGER TERM POTENTIAL IMPACT FOR THE GP

Over the longer term, new approaches need to be considered that become possible with AI, which previously may not have been possible.

4.1.1 AI SUPPORTED CARE APPROACHES

Artificial Intelligence is very good at generating lists of all possible combinations from within a large data set. This strength could be used to provide clinicians with a list of all potential treatment and management approaches combining medication, physical activity, therapy, community activity and apps for a specific patient. The GP would be essential to help the patient reach a decision (shared decision making) to select an approach and support the patient through the chosen intervention combination.

4.1.2 WEARABLES AND PERSONALISED CARE

Wearables generate vast quantities of personal data and when combined with analytics they have the potential to contribute to health, preventative care and aid management of ongoing conditions. In theory, personal analytics enables the wearer to improve awareness of their health and wearables represent a potential source of untapped and continuous information. However, their use in improving individual awareness and medical decision making is yet to be robustly evidenced. Diagnostics used in the surgery are expensive, under-utilised and only provide a snapshot, but the data is trusted and of high quality. In comparison, wearables have unknown variability in data quality and precision due to i) different sensor types [15], ii) rate of data collection [16] iii) data aggregation [14], iv) calibration [14], v) connectivity [17], vi) contact/fit, vii) noise/interference and viii) measurement error [18]. However, AI may enable the two to be reconciled and to support wearable data to be used to inform healthcare professionals of health conditions longitudinally.

As mentioned previously, one of the strengths of AI is to rapidly process and generate possible answers from large amounts of data combining a variety of sources. For example, coupled with wearables this could provide personalised health prompts. It also opens the doors for a personalised screening process however screening is an area with high potential for overdiagnosis and overtreatment with ineffective outcomes and would need to undergo appropriate validation.

4.1.3 SKILLS AND PROFESSIONAL DEVELOPMENT

In both the near- and long-term an agile approach to identifying the developing and changing skillset needs of healthcare professionals will support the use of new AI driven tools. Such an approach can facilitate achieving the maximum impact from AI tools for improving patient care. As these tools are developed and tested it is essential that patients, GPs and healthcare professionals are engaged to co-develop, or are given the opportunity to lead the development of these tools to ensure they are suitable for the working environment and preferences of the users.

4.2 CHANGING ROLE OF THE GP AND HEALTHCARE PROFESSIONAL

The role of the GP and practice staff will continue to evolve as AI has a greater impact on services and care provision. It is possible in the long-term there will be a need to redefine the responsibilities of each member of the primary care team to fully unlock the potential of AI to benefit patient care and the system. It is especially important to consider how responsibilities may change and be redistributed to take advantage of the natural strengths of machines and humans.

5. ROLE OF THE PROFESSIONAL BODY

Professional bodies have a key role to play in supporting healthcare professionals to:

- Establish trust:
    - Maintain awareness on where AI is established and evidenced, where it is emerging and where it is speculated to have application.
    - Minimise false perceptions around the value of AI or its potential to lead to social inequities, discrimination or unethical behaviours.
    - Demystify AI to guide and facilitate the uptake of AI that is 1) evidenced, regulated and improves patient care, 2) supports care delivery, saving time and reducing workload.
    - Play a custodian role, support regulatory bodies to ensure suitable evidence and standards are met, ensure ethical provision of care and flag negative impacts to care provision to the disadvantaged.
- Facilitating the development of AI driven solutions
    - Coordination of GPs, healthcare professionals and patients with other stakeholders to identify the unmet needs where AI can improve general practice.

    - Support cross discipline working to develop AI that augments the healthcare professional, co-developed with patients, GPs and healthcare professionals.
    - Provide GPs with the opportunity to develop their own solutions.
    - Map practice processes and highlight key areas needing support.
    - Provide example care pathways and highlight key areas where AI could help.
    - Collaborate across organisations to ensure emerging infrastructure and approaches are fit for purpose, enable interoperability and avoid fragmentation.
- Provide and support new skills development
    - Professional development opportunities addressing current and future needs.
    - Identify future skills and ensure they are represented in training.
    - Review training approaches to be agile and flexible to match the rapid pace of technology change.
- Identify the need for resources and support for primary care
    - The vast majority of the focus and funding is on secondary care and AI for imaging with little resource allocated to primary care.
    - Primary care is at risk of not being able to benefit from the new and existing AI powered digital tools, which needs to be brought to the forefront of discussions.
    - Application of AI to backend systems and routine tasks may not be headline grabbing but AI in such "routine" processes would provide support to an overloaded general practice and could be realised in the near term.

5.1 PROTECTING AND SUPPORTING EVOLVING ROLES

AI is a technology that has potential to change role responsibilities. As AI empowered clinical tools become available, professional bodies will be essential in ensuring healthcare professionals have access to appropriate professional development to be able to maximise the effectiveness of AI tools available and trust AI handling tasks that are more appropriate for such tools.

Professional bodies will also need to support the development of new workflows that maximise and match the complementary strengths of innate human skills and computational capabilities for improved patient care. If implemented and developed correctly, AI has the potential to significantly augment healthcare professionals. However, it is important to not be blindsided by the discussion of AI taking jobs when there are documented instances of AI tools leading to new use cases that require more skilled staff (see Case Study – Fulfilment Centres). The role of a professional body is to also support the profession and protect from additional burdens by keeping patient at the centre.

CASE STUDY

FULFILLMENT CENTRES

Amazon robotics from 2014-2016 increased the numbers of robots used to automate picking from 1,400 to 45,000 during same time frame the number of full time employees increased by 200,000 with the majority of these in the highly automated fulfilment centres. Robots allow more products packed into the same warehouse footprint. The shift to using robots made the process of picking more productive by augmenting the workers - workers formerly doing simple pick and lift now coordinate multiple robots. This enabled Amazon to do more of the same thing and serve more customers but also do new things like next day delivery, which in turn increased the need for more workers.

5.3 ARTIFICIAL INTELLIGENCE FOR PRIMARY CARE WITH PEOPLE AND HEALTHCARE AT THE CORE

It is important to ensure this revolution in primary care offers:

- patients and their carers timely access, continuity of care, comprehensiveness and co-ordination of care
- supports care delivery to be person centred
- supports GPs and healthcare professionals to meet the needs of each person
- engagement and co-development with stakeholders ensure integration of AI into long standing systems with established practices and norms in the short term and establishing new workflows maximising the strengths of humans and computational systems in the longer term.

5.4 AI SILVER BULLET

AI has the potential to bring significant changes to healthcare, but it needs to be properly designed, evaluated and adopted to improve patient outcomes. AI has significant amounts of hype associated with it, but it is not a silver bullet and will have both negative and positive impacts. If AI solutions can be developed for the more routine aspects of care provision and backend activities, this may be the most significant contribution from AI to improving care provision and improving the perception of AI to enable wide scale adoption in the near-term. There are opportunities to improve general practice with the use of AI, however there is a need for:

- Mapping of practice processes and care pathways against AI capabilities to roadmap the near-term, medium-term and long-term potential tools addressing real needs of general practice
- Bespoke solutions developed for general practice use cases facilitated by funding and collaborations across academia, business and healthcare professionals
- Infrastructure and technical development nationally and within practices to deploy tools (e.g. data trusts, interoperability etc.)
- Education, training and capacity for GPs and healthcare professionals to deploy and use the tools

AI is no panacea for all the problems in healthcare. However, properly designed, it has the potential to create efficiencies and improvements. To do this, it needs to have humans at the centre.

IN DEPTH: AI APPROACHES

This box provides an overview of the various approaches included under the term artificial intelligence.

Basic logic: A basic reasoning approach e.g. if the patient is an otherwise healthy adult but has a fever, then they may have influenza.

Rule based (and decision tree): A basic approach which follows a process of checking simple parameters and classifying, e.g. does the patient have a temperature of 38C or above? If yes, they are classified as having fever and you can move on to checking the next pre-identified parameter. If no, the patient is classified as not having a fever and you can move on to checking the next pre-identified parameter (which may be a different parameter to the yes branch).

Bayesian inference (more general approach) which is commonly implemented in chatbot triage systems: The software has a pre-populated list of illnesses and the bot interface asks the patient questions on their symptoms to adjust the list so the most probable illnesses move to the top of the list. For example, when the chatbot asks the patients temperature if the patient has a fever, there is an increased probability they have influenza (or another illness that demonstrate symptoms of fever); influenza then goes up the list of most probable illnesses.

Nearest-neighbour: Asks the patient questions about them and their symptoms, then examines an existing dataset (training data) for relevant factors (symptoms, temperature etc.) that mostly match the patient reported information. Once all the nearest matches have been found, it finds the percentage of these matching cases which corresponds to each different illness (e.g. 10% diagnosed as influenza, 40% diagnosed as common cold, 5% diagnosed as pneumonia etc). This percentage is used to inform the probability that the presenting patient has a particular diagnosis such as influenza.

Machine Learning (or Deep Learning) a pattern identification and software adjustment approach: A process which starts with analysis of existing data (training data) using software capable of finding patterns across the data. The software is pre-programmed (or trained) to analyse features specific to its intended use case – all (or a subset of) the symptoms a patient may present with. The software goes through the data to find patterns. This allows the algorithm to find illnesses and the correlate symptoms to then adjust the way the algorithm links these symptoms and illnesses. This means through the pattern identification process (training), algorithms learn how to categorise symptoms.

For example, with a million training data sets of consultations on patients who were diagnosed with influenza, the machine learning process looks for patterns and can identify if there are differences in age, sex, ethnicity, height, weight, etc. but commonalities in certain symptoms such as fever, cough, muscle aches etc. Through the training process the software changes the importance it gives to these symptoms that have high correlation to the specific diagnosis.

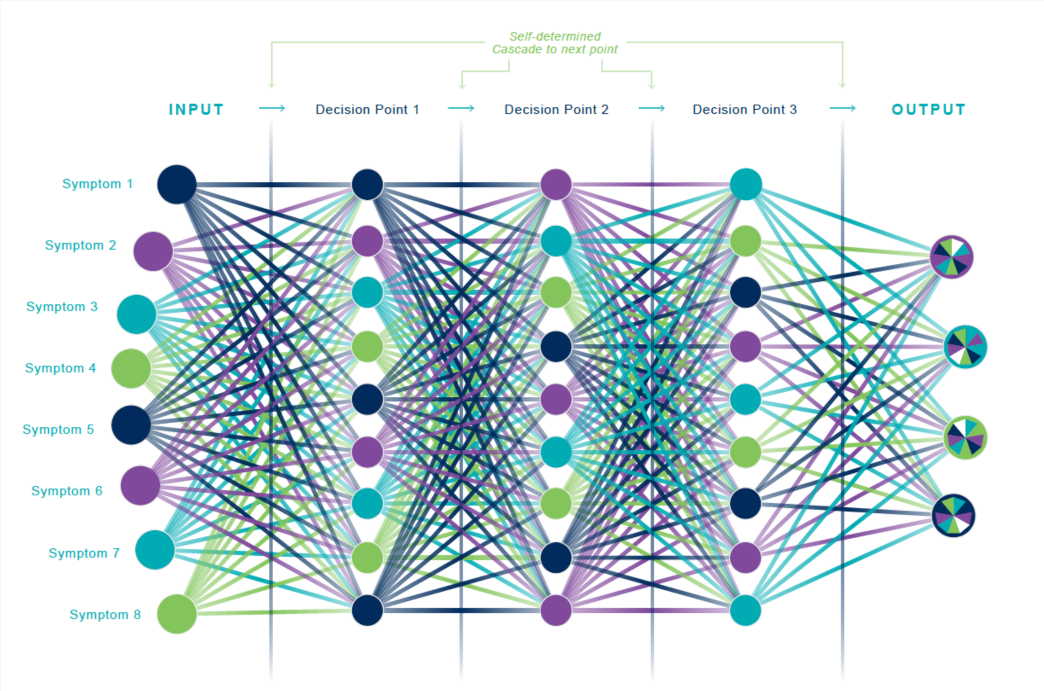

Figure 3: Depicts the complexity of the propagation of symptoms put into an AI system with each coloured dot on the left-hand side indicating a specific symptom and each layer cascading the decision to the next layer

A popular implementation of machine learning is through an artificial neural network (see depiction in figure 3). The artificial neural network approach uses layers, each layer is made up of collections of algorithms. Each layer could be dedicated to one patient characteristic (age, sex, weight etc.) or symptom (fever, cough, aches etc.).

Each layer consists of algorithms that check for specific characteristics or symptoms to help the software make a decision on what to check next. There is a process of check-classify-pass on to next layer, this way each layer propagates the decision making to the next layer. This propagation to the next layer is self defined by the software and learned through the pattern matching enabled software adaption discussed above. Training is the process of using large amounts of data to allow the algorithms to look for patterns which are then used to determine the pathways from one layer to the next.

These neural networks are complex with large numbers of layers and connections with unknown linkages between them. These systems are called “Black Box systems” because they make decisions that cannot be explained, meaning they make decisions that have not been hard coded but the algorithms learn through the data. Deep learning is a subset of machine learning, but has more classification capability and so starts from a more generalised level with less narrow application.

Machine learning, deep learning and artificial neural networks are driving the recent progress in AI application.

Note: rule-based systems are often considered to be the simplest but can comprise of hundreds of parameters making them difficult to understand or explain this is a type of non-transparent AI (Black Box).

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