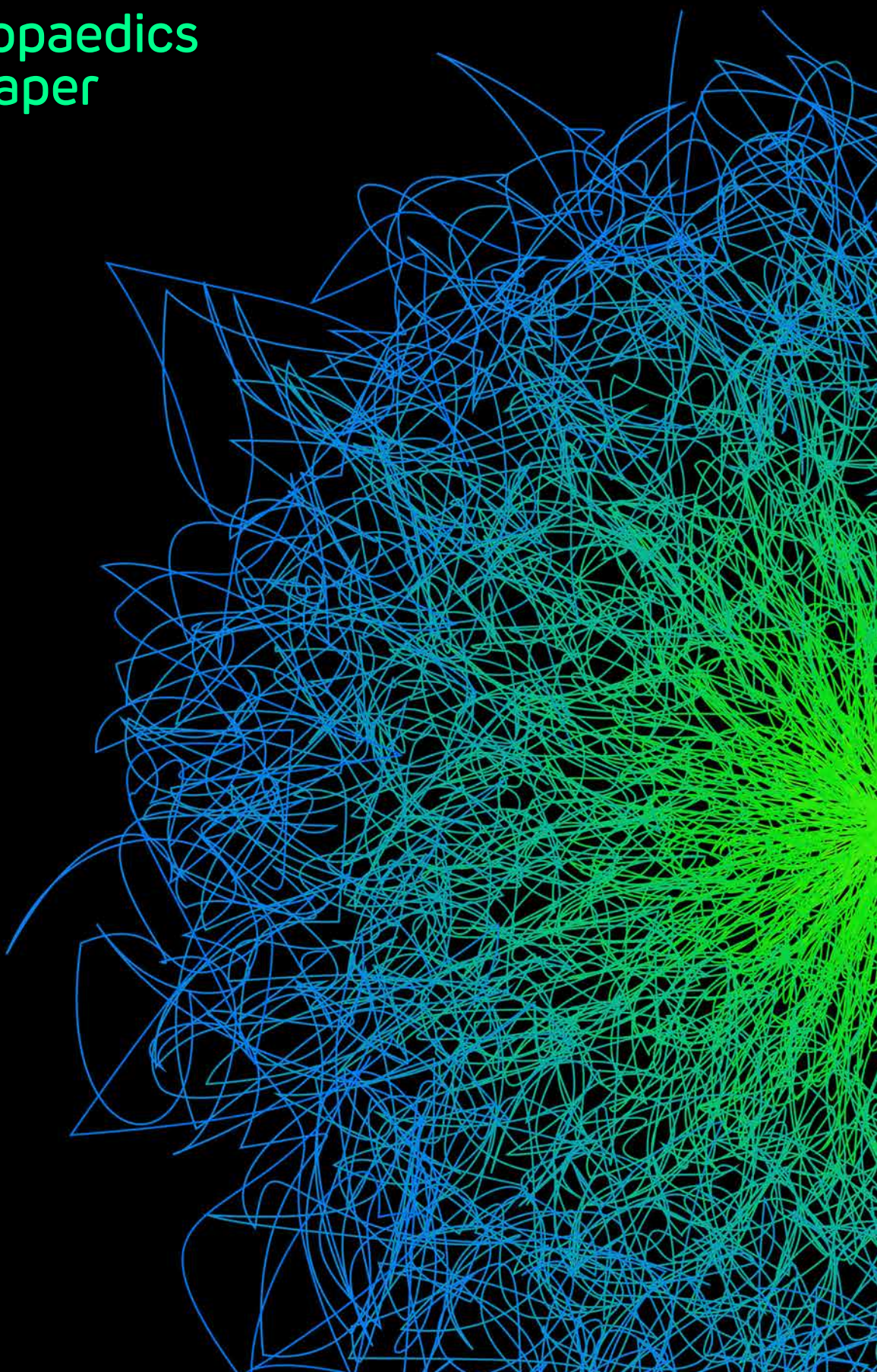
Orthopaedic Research UK

# AI In Orthopaedics – Policy Paper



September 2022

## Orthopaedic Research UK

We are a medical charity dedicated to advancing musculoskeletal (MSK) knowledge and are one of the few significant funders of MSK research in the UK.

Our primary purpose is to use our funding to encourage breakthrough research, education programmes and innovation in bone, joint and muscle wellbeing and thereby reduce the burden of poor musculoskeletal health on individuals, workplaces and our health system.

We aim to achieve this through partnerships with leading academic institutions, charities and commercial organisations and by helping to mobilise the whole MSK community. By working together, this diverse and inclusive community can have a significant impact on the lives of millions of people.

## Executive summary

It is widely recognised that the use of Artificial Intelligence (AI), especially when harnessing the vast amount of available patient data, can play an important role in improving clinical performance and patient outcomes.

This is particularly the case within orthopaedics where AI is transforming the prevention, diagnosis, treatment and management of people with poor MSK health. However, at a time of ever-escalating demand for MSK treatment and support, especially from an ageing population, it is essential that the application of AI technology is broadened and accelerated. Isolated pockets of best practice are not enough; to make a real difference to the lives of millions of people, and deliver significant efficiency and cost savings for a health system under pressure, we need far more investment in AI-based research and education. We also need the support of healthcare leaders to overcome operational barriers inhibiting the more widespread application of AI, especially limitations on the use of patient data.

As one of the leading research charities for MSK health in the UK, ORUK will play its part in encouraging a greater focus on the application of AI through education, research investment, data standardisation and networking. However, to make the most of the opportunity and respond to the profound challenges facing everyone working within MSK health, we need all elements of what we call 'the MSK community' – clinicians, commissioners, GPs, physiotherapists, nurses, healthcare leaders, academics, clinical researchers, entrepreneurs, engineers, investors and last but not least, politicians – to join us in this endeavour.

Adrian Downing
Chair of the Board of Trustees

Dr Arash Angadji
Chief Executive

# Introduction

The orthopaedic discipline in the UK has been a pioneer when it comes to the collection of patient data. The National Joint Registry has collected information on hip, knee, ankle, elbow and shoulder joint replacement surgery and monitored the performance of joint replacement implants since 2003.[1] It is the largest orthopaedic registry in the world with around 3.5 million records and cited as a 'global exemplar' internationally. Combined with other data sets, including the National Hip Fracture Database, infection data held by the UK Health Security Agency, GP records, hospital data, plus information captured from medical devices, wearable technology and robotics, including that held by private companies, the amount of information available to MSK clinicians and researchers is probably greater than in any other branch of medicine. With the use of AI, including Machine Learning (ML), transforming the ability to link datasets and analyse data (including digital images), this should be a 'golden age' for the application of AI to MSK health.[2] In a survey of the MSK community commissioned for this policy paper, 92% agreed that the use of AI (including ML) and Big Data has the potential to transform the prevention, diagnosis, treatment and management of people suffering poor MSK health.[3]

*'It's an exciting time in health care if you're interested in clinical research, because the ability to integrate large data sets, whether you're using machine learning AI or more traditional techniques, unlocks an opportunity to really accelerate the scope of the work that we do. Orthopaedics is good at this because we've been doing it for a long time. Whenever I talk to anyone about big data sets in clinical research, orthopaedics is always at the vanguard.'*

*Professor Xavier Griffin,*
*Chair Bone & Joint Health, Queen Mary University of London & Barts NHS*

*'I think it essential that we upgrade diagnosis and surgical indications from an art to a digital, data-driven science, because machines may not necessarily replace physicians, but physicians making use of AI will at some point replace those not using it.'*

*Dominique Rothenfluh,*
*Consultant Orthopaedic Surgeon, Oxford University Hospitals*

## Responding to increasing demand

This 'golden age' coincides with an era of unprecedented and escalating demand for bone, joint and muscle care. Poor MSK health places a huge burden on individuals, workplaces and our health system: it is the third largest area of expenditure for the NHS[4] and demand will only grow in an ageing society. The hospital costs of hip fracture alone are estimated at £1.1 billion per year in the UK.[5] Poor MSK health is also linked to rising levels of obesity, anxiety, isolation and depression.

Over 20 million people in the UK (around a third of the population) live with a MSK condition such as arthritis and low back pain.[6] Not surprisingly, MSK conditions account for one in seven of GP consultations[7] and 7.3% of hospital admissions (1.26 million finished admission episodes) in England.[8] There is also a significant impact on the workplace with MSK conditions accounting for 15% of 'working days lost' in 2020.[9]

The size of waiting lists for all hospital procedures, exacerbated by the pandemic, has been well-documented. According to the British Orthopaedic Association, patients awaiting elective Trauma and Orthopaedic (T&O) surgery, including knee and hip replacements, instability and arthritis, fractures and dislocations, account for the largest proportion of people on hospital waiting lists in England; over 700,000 people were waiting for T&O surgery at the end of 2021, the largest total for over a decade. Over 60,000 people had been waiting for over a year – the equivalent figure for January 2020 was only 436.[10]

Unfortunately, even this waiting list data does not reflect the true scale of the problem. The BMA warns of the 'hidden backlog' consisting of patients who require care but have either not yet

1 Data collection was extended to include ankles in 2010 and elbows and shoulders in 2012. The registry includes data from England, Wales and Northern Ireland (not Scotland).

2 For the sake of simplicity, we use the UK Government's definition of Artificial Intelligence, as explained in the DCMS National AI Strategy (September 2021) - "Machines that perform tasks normally requiring human intelligence, especially when the machines learn from data how to do those tasks."

3 ORUK MSK Community survey, July-August 2022. We conducted a self-completion survey among members of MSK community during July-August 2022. The 102 respondents included orthopaedic surgeons, academic scientists, data scientists and allied health professionals. Results from this survey included in the report will be identified as ORUK MSK Community survey, July-August 2022.

4 £5 billion in 2013-14, NHS England (2015)

5 Leal, J., Gray, A. & Javaid, M. (2016). Impact of hip fracture on hospital care costs: a population-based study. Osteoporosis Int. 27, 549-58. DOI: 10.1007/s00198- 015-3277-9.

6 Global Burden of Disease Collaborative Network (2020). Global Burden of Disease Study 2019 (GBD 2019) Results. Institute for Health Metrics and Evaluation (IHME), Seattle.

7 Jordan KP, Kadam UT, Hayward R, Porcheret M, Young C, Croft P. (2010). Annual consultation prevalence of regional musculoskeletal problems in primary care: an observational study. BMC Musculoskeletal Disorders, 11:144. DOI: 10.1186/1471-2474-11-144.

8 NHS Digital. (2020). Hospital Admitted Patient Care Activity 2019- 20. Accessed 08 August 2021. https://digital.nhs.uk/data-and-information/publications/statistical/hospital-admitted-patient-care-activity/2019-20

9 Office for National Statistics. (2021). Sickness absence in the UK labour market 2020. Accessed 20 August 2021. https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/labourproductivity/articles/sicknessabsenceinthelabourmarket/2020

10 BOA, T&O waiting list the largest for over a decade, 10th February 2022, based on data released by NHS England and Improvement.

presented, or who have had referrals cancelled due to the impact of Covid-19 on the NHS; patients who, in normal times, would have been referred for treatment, received elective care and attended outpatient appointments, but who for a number of reasons relating to the pandemic have not yet found their way into the health system.'[11]

## Improving performance

The orthopaedic sector has made significant efforts in the past decade to transform clinical performance. In particular, the Getting It Right First Time (GIRFT) programme, headed by Professor Tim Briggs, Consultant Orthopaedic Surgeon at the Royal National Orthopaedic Hospital, has delivered both better quality orthopaedic care and value for money. The programme relies on the sharing of data to highlight excellence and underperformance, thereby encouraging and enabling evidence-based improvement in patient safety, outcomes, efficiency and cost effectiveness. A review of the programme in 2020 highlighted substantial improvements against the key GIRFT metrics, including a reduction in revision rates every year since 2012 (even while total activity and demand grows), a reduction in average lengths of stay by a fifth, releasing over 368k bed-days and delivering recurrent financial opportunities and savings to the NHS of £696 million in the previous five years.[12] The programme has involved a range of measures including the smarter planning of clinical procedures and better service design[13], a focus on more clinically-proven clinical interventions and choice of implant, reduced surgical site infection rates, better training for junior doctors, improved physiotherapy and rehab and smarter procurement. The application of AI to the vast amount of available orthopaedic data represents a further opportunity to deliver better patient outcomes, more efficiently.

## AI is already making a difference

There are many examples of how AI is transforming the prevention, diagnosis, treatment and management of people with poor MSK health. It is delivering better patient outcomes and enhancing the performance and effectiveness of clinical teams. It is improving the accuracy of radiographical image analysis. It is creating 3D orthopaedic templates to provide orthopaedic surgeons with a more detailed view of anatomical structures, enabling them to be more precise in the selection of replacement joints and prosthetics. Healthcare teams armed with AI-enabled data, including images sourced from motion capture, are making better decisions about the scheduling and planning of procedures and identifying patients likely to require higher levels of post operative care and those most at risk of artificial joint failure. Data from wearable technology is being used to monitor patient rehabilitation.

However, isolated pockets of best practice and innovation are insufficient. To make a significant contribution to the health of the majority of patients demanding support, and reduce the costs to the NHS, the application of AI technology must be broadened and accelerated and access to data improved. Scepticism about the use of AI to inform decision making in healthcare among both healthcare professionals and patients must also be countered; in our survey of the MSK community, 86% agree that further work is required to counter scepticism among healthcare professionals about the use of AI to inform decision making in healthcare and 80% agreed that further work is required to counter patient scepticism or concern.[14]

## Elevating the importance of orthopaedics

The most immediate challenge is to elevate the importance of orthopaedics within the wider debate about the application of AI to healthcare. It is noteworthy that the landmark NHSx report on AI does not even mention its use in orthopaedics.[15] The use of AI for cancer and drug development tends to generate most of the headlines and investment. Whilst not questioning the importance of these branches of healthcare, there is a danger of focusing AI expertise and investment on the most complex challenges and potentially most exciting, headline-grabbing breakthroughs.

## Solving routine problems

The technology world tends to focus on novelty and headline-grabbing challenges rather than day-to-day applications. This is an unfortunate propensity given the extraordinary ability of AI to solve routine problems at scale. The treatment of MSK conditions involves a large number of relatively routine problems, such as triage, referrals to primary care and categorising patients in terms of risk. All involve complex decision-making processes that can be streamlined, accelerated and delivered with a high degree of accuracy and consistency through the use of AI. Patients experience more personalised treatment and better outcomes and the healthcare system benefits from huge scale economies and cost savings.

11 BMA NHS Backlog Data Analysis, 19th July 2022

12 Getting It Right in Orthopaedics, Reflecting on success and reinforcing improvement, GIRFT is delivered in partnership with the Royal National Orthopaedic Hospital NHS Trust, NHS England and NHS Improvement

13 For example, acting on evidence that operations delivered by surgeons who perform higher volumes of that surgery type are associated with reduced lengths of stay, complications and cost.

14 ORUK MSK Community survey, July-August 2022.

15 https://www.nhsx.nhs.uk/media/documents/NHSX_AI_report.pdf

*Orthopaedics is fertile ground for adoption of technological innovations, including artificial intelligence, where small gains in the treatment of one condition can lead to improved outcomes for some of the largest patient populations in medicine. Orthopaedics is well suited to innovation and the application of AI as it has clear pathways for common diseases and is a highly technical field with constant technical innovation.*

*Artificial Intelligence in Trauma and Orthopedics, Roshana Mehdian & Matthew Howard*[16]

## Overcoming barriers

In common with healthcare in general, the use of AI in orthopaedics is constrained by difficulties in accessing and using patient data at scale. Aggregating and processing data held by different entities is frustratingly complicated. The NHSx report on AI describes 'the lack of coordination between regulators and statutory bodies along the innovation pathway. In addition, the absence of a guidance and regulation navigator makes it difficult for people to figure out what they need to do and with whom they need to interact with at each stage of the process.'[17]

*Most healthcare data remains uncaptured or unutilised. Currently, we have unstructured, heterogeneous data available in silos not ready to be used meaningfully. Organising and cleaning data is a labour-intensive, immensely costly, and time-consuming task.*

*Mr Thomas Harte MBChB MRCS (Eng)*

*We don't have a standardised method of collecting data that is consistent, resilient and robust and to which everyone adheres. This leaves gaps in our data knowledge and everyone works in silos which makes it challenging to share information.*

*Dr Justin Green, Orthopaedic Registrar, ORUK/BHS Research Fellow 2022*

Variations in the interpretation of data protection legislation across the system, especially consent processes, can be problematic. In our survey of the MSK community, 76% agreed that it is difficult to access and use patient data at scale because of the ways in which data protection regulations are interpreted and applied.[18]

The problems appear particularly acute when using long-running datasets for multiple research studies; do consents captured for the initial study cover subsequent research studies or do they need to be renewed? In a recent case, the organisers of an important MSK research study using an existing dataset were advised to seek updated consent in writing from every patient, the costs of which made the research study unviable – according to one of the researchers, 'We were writing to people, who had already provided generic consent, to get their permission to use their anonymized data.'[19]

The challenge of accessing high quality data at scale is not unique to the NHS; according to consultants Deloitte it is a common problem for all healthcare organisations, which are 'challenged by siloed, unstructured, and at times, incomplete and inaccurate data. To add to this, patient-level data is sensitive and highly regulated, which makes it more difficult for AI applications to gain access to it. Lack of access to clean, integrated datasets hinders the ability to train high-performance AI models and deploy them at scale.'[20]

*Data protection legislation generally works well in allowing for data to be used in a safe way, that protects people's rights and privacy. Where we experience situations in which people advise researchers that they don't have the right consent to use specific datasets, in my experience it is usually because they have misapplied and misinterpreted the law.*

*Taj Sallamuddin, Data Protection and Information Lawyer*

Even the most sophisticated AI cannot function without high quality data. At a ground truth level this means the accurate labelling or tagging of orthopaedic images. AI can be used to compensate for human error – identifying images that have been mislabelled – but there is still a need to *highlight to everyone involved in data collection* how every x-ray or scan represents an important part of the AI jigsaw that will open-up new discoveries, improve patient safety and clinical effectiveness.

16 Mehdian, R., Howard, M. (2022). Artificial Intelligence in Trauma and Orthopedics. In: Lidströmer, N., Ashrafian, H. (eds) Artificial Intelligence in Medicine. Springer, Cham. https://doi.org/10.1007/978-3-030-64573-1_256

17 https://www.nhsx.nhs.uk/media/documents/NHSX_AI_report.pdf

18 ORUK MSK Community survey, July-August 2022

19 Mr. Vipin Asopa PhD FRCS (Tr&Orth), Big Data and Artificial Intelligence in Orthopaedics... A meeting of Minds. Tuesday 10 May 2022

20 Health care's quest for an enterprise wide AI strategy, Deloitte Insights, 27th June 2022

# How AI is already transforming orthopaedics

## Better analysis and forecasting

Predictive modelling is being used to identify patients most likely to benefit from an orthopaedic procedure, forecast likely post-operative complications and develop tailored rehabilitation programmes. This aid to decision making enables clinical teams to work more efficiently, maximise the use of surgery time and deliver better, safer and more personalised outcomes for patients. It can also be helpful in removing biases (conscious or unconscious) from clinical decision-making processes.

**CASE STUDY:**

### Using Machine Learning to assess post-operative risk

Surgeons at Northumbria Healthcare NHS Foundation Trust are using AI to develop post operative risk profiles that predict whether patients are more or less likely to have complications after hip or knee operations. The team led by Professor Mike Reed and Dr. Justin Green is applying data science and machine learning to historical data on surgical outcomes to produce individualised patient risk profiles. This information is used to inform the allocation of patients to the most appropriate operation facilities – higher risk patients are allocated to high intensity units with specialist 24-hour cover, including cardiology teams and organ support. Lower risk patients, likely to have less complex post operative needs, can be allocated to more local facilities and discharged faster, which is better for the patient and more cost effective as a whole.

According to Dr Green, *'When we compare our approach using AI to the standard routine practice of the clinical teams it is proven to be four times more accurate at identifying patients at higher risk of developing complications.'*

**CASE STUDY:**

### Applying data analysis to the prediction of trauma patient outcomes

Becca Stoner, a PhD student from Queen Mary University of London, was the recipient of the 2021 Joint Orthopaedic Research Fellowship, co-funded by Orthopaedic Research UK and The Royal College of Surgeons of Edinburgh. An Orthopaedic Registrar by training, she is researching the use of statistical modelling to help better predict trauma patient outcomes. Becca describes how her project is designed for scenarios where there are several patients who require urgent treatment:
*'In a mass casualty incident, to save as many lives as possible you need to know in what order to treat people. There are existing scoring systems to predict mortality, but they tend to be rather simplistic. By harnessing the power of AI, we can analyse the information we have about trauma patients, for example how their heart rate is changing over time and what's happening to their blood pressure, to make better decisions.'*

Better forecasting, using AI to analyse vast amounts of healthcare data, also helps improve use of equipment and medical products in a clinical setting and reduce waste, delivering a significant sustainability benefit.

*'As clinicians we're not so good in assessing and predicting risks and also predicting outcome. [For example] the conclusion from one study of knee arthroscopy procedures was that surgeons' criteria for deciding that surgery is indicated in a sample of patients with degenerative meniscal tears resulted in a prediction as accurate as a coin toss. And that's essentially where we are with clinical decision making. It is quite arbitrary... Our decision making is very much influenced by our most recent experiences'.*

*Dominique Rothenfluh,*
*Consultant Orthopaedic Surgeon,*
*Oxford University Hospitals*

*'Computer vision enables clinicians and researchers to capture much greater information from the available data; computers are better than people at recognising patterns. This presents substantial research and clinical opportunities but to take this forward we need good interactions between the people who understand the science and the people who have the clinical questions and are able to clinically interpret that science.'*

*Professor Mark Wilkinson,*
*Professor of Orthopaedics,*
*University of Sheffield*

Machine Learning and predictive modelling is also being used to identify hip replacements at risk of failure. The machine is able to spot changes in the bone and joint interface that cannot be detected by the human eye and the predictive model has proven to be more accurate than even experienced clinicians. Not only does this help identify problems early, but it has the potential to save tens of millions of pounds for the NHS by reducing the need for regular screening of hip replacement joints that are highly unlikely to fail in the near future.

CASE STUDY:

## Using Machine Learning to classify hip fractures

A team from the University of Bath has recently completed a study demonstrating that Machine Learning outperforms clinicians in the classification of hip fractures.[21] There are around 76,000 hip fractures each year in the UK[22] and their treatment represents one of most significant items in the NHS budget; cost estimates range from £1-2 billion per year.[23] Patients who sustain a hip fracture have a reported 30-day mortality of 8.3%, with 30% dying over the course of the first year[24], twice the age-specific mortality rate of the general population. This is why the improvement of hip fracture management and its impact on mortality and healthcare costs is such a high priority.

The swift and accurate classification of fractures prior to surgery is crucial in helping clinicians select the right interventions to treat a fracture and restore mobility. However, there isn't a standardised way of making this classification. Radiology departments also struggle to deal with the increasing volume of radiographs (including x-rays), which means that they cannot always report results in a timely manner; it is estimated that in the UK more than 300,000 radiographs remain unreported for over 30 days.[25]

By creating a Machine Learning algorithm, the University of Bath team was able to identify and classify hip fractures from X-rays with a 19% greater degree of accuracy and confidence than hospital-based clinicians.

Professor Richie Gill, Co-Director of the University of Bath Centre for Therapeutic Innovation, says: *'The AI-enabled process we've developed has the potential to provide greater accuracy and speed up diagnosis. From a clinical perspective it potentially shortens the decision-making pathway. If a hip fracture is suspected it will be flagged automatically for radiographic review, regardless of what time or day the patient arrives at the hospital.'*

*The project was not without its challenges, not least the difficulty of accessing accurate data at scale. It took the team almost 18 months to get their hands on the x-rays. They then had to be classified by clinical experts to provide ground truth data to train the Machine Learning model. However, the success of this project has encouraged the team to seek investment to fund a larger study.*

## Better planning and templating

The combination of 3D scanning and AI is transforming orthopaedic templating – the use of imaging data to help clinicians estimate the correct size of implants based on the anatomy of individual patients.

CASE STUDY:

## Using AI to design better-fitting prosthetics

ORUK has taken an equity stake in Radii Devices, a start-up company that uses state-of-the-art AI and biomechanical modelling to help clinicians design better fitting prosthetic sockets for people with limb loss or limb difference. The company was founded by University of Southampton postgraduate, Dr Josh Steer, who says that designers of prosthetic limbs 'should have access to the same technology as Formula 1 or NASA engineers'.

The socket between the patient's limb and a prosthetic is often a source of pain and discomfort and can sometimes even prevent the user from walking. Every patient is unique, so the sockets have to be custom made to each individual and the external shape of the patient's limb often changes over time, making the fitting of prosthetics a time-consuming process. Following amputation, up to nine clinical visits are required before a comfortable fit is achieved. Radii Devices helps clinicians design more comfortable prosthetic sockets, more efficiently, by providing them with analytical data from 3D scans of thousands of procedures.

ORUK's investment is matched by funding provided by Innovate UK's Biomedical Catalyst programme. This investment will fund a multi-centre clinical trial of the company's software in several clinics across the UK, to evaluate how well the software works and the quantifiable improvements that have been made.

21 Murphy, E.A., Ehrhardt, B., Gregson, C.L. et al. Machine learning outperforms clinical experts in classification of hip fractures. Sci Rep 12, 2058 (2022). https://doi.org/10.1038/s41598-022-06018-9

22 Healthcare Quality Improvement Partnership

23 National Institute for Health and Care Excellence. Hip fracture in adults NICE quality standard, https://www.nice.org.uk/guidance/qs16/documents/draft-quality-standard-2 (2016).

24 National Hip Fracture Database. NHFD 2020 Annual Report. (2021). Data for England and Wales.

25 Annarumma, M. et al. Automated triaging of adult chest radiographs with deep artificial neural networks. Radiology 291, 180921–180921 (2019)

Around 8,000 lower limb prosthetic procedures are undertaken every year in the UK and demand is growing, largely because of the rise in diabetes. Radii Devices has ambitious plans to expand into new territories, such as North America (where there is an enormous demand for prosthetics), and also into new areas of medicine. The company believes that its biomechanical modelling can be applied to other areas of medicine in which external medical devices are attached to the skin, including orthotics and the fitting of respiratory masks.

Deploying AI to improve planning, forecasting, screening and monitoring of orthopaedic procedures enables clinicians and other healthcare professionals to deliver better patient outcomes more efficiently, identify patients at risk before they experience serious and expensive complications and focus precious resources on those with the greatest need. For example, it has been suggested that AI methods such as Deep Learning have the potential to reduce the time radiologists spend reviewing images by 20%.[26]

Quantifying the true impact of these improvements, including cost savings or cost efficiencies, is challenging and further health econometric studies are required. The reporting of AI studies also needs standardisation.

## Wearables and patient apps

The use of digital health tools, including wearable devices, is an important element of The NHS Long Term Plan[27] and the government's Integration White Paper.[28] Within MSK health, wearable devices such as GetUBetter[29] and Good Boost[30] harness AI to enable patients to better manage their conditions by providing personalised behaviour change information and therapy sessions, tailored to their specific needs. The evidence suggests that these self-management platforms lead to fewer GP appointments, physio referrals and medication prescribing, whilst giving clinicians the data they require to provide evidence-based, tailored support.[31] In our survey among the MSK community, 91% agreed that using technology for passive and continuous monitoring/data collection could help the post treatment recovery of MSK patients and facilitate more targeted management and intervention.[32]

AI is also powering a new generation of virtual assistants, such as Versus Arthritis' AVA chatbot.[33] This assistant, which was developed using the IBM® Watson® Assistant service on the IBM Cloud™ platform, answers patient queries on a diverse range of self-management topics, including exercise and medication.

# The role for ORUK

Orthopaedic Research UK (ORUK) can play an important role in encouraging further development of AI within MSK health through:

**1. Education**

As part of the Topol Review into *Preparing the healthcare workforce to deliver the digital future*, the AI and Robotics Panel recommended that 'Educational resources should be developed to educate and train all healthcare professionals in health data provenance, curation, integration and governance; the ethics of AI and autonomous systems/tools; critical appraisal and interpretation of AI and robotics technologies.'[34]

We are a leading provider of education to the MSK community. Our research indicates that there is no formal AI and Big Data training course (or certification model) specifically for those working within MSK. There is no lack of existing online content on AI and related topics, from video tutorials and self-learning modules to interactive quizzes. What is needed is a structured programme, tailored to the specific needs and interests of MSK professionals and facilitated by experienced trainers.

Our survey highlighted self-acknowledged gaps among members of the MSK community:[35]

- 75% agreed that MSK professionals in general lack the knowledge to apply AI and Big Data to their work.
- only 42% claimed to have a good understanding of the application of AI and Big Data to MSK health.

According to our survey, members of the MSK community are most interested in learning more about the following aspects of AI and Big Data:

26 H. Harvey, Clinical Director at Kheiron Medical Technologies; Royal College of Radiologists Committee for Medical Imaging Informatics. Co-Chair of the Topol Review Artificial Intelligence and Robotics workstream. [Expert opinion email] December 2018.

27 NHS England, NHS Long Term Plan. Last accessed December 2021. Available at: https://www.longtermplan.nhs.uk/online-version/chapter-5-digitally-enabled-care-will-go-mainstream-across-the-nhs/

28 NHS Confederation (2022), The integration white paper: what you need to know. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1055687/joining-up-care-for-people-places-and-populations-web-accessible.pdf

29 https://www.getubetter.com

30 https://www.goodboost.org

31 Research provided by https://www.getubetter.com

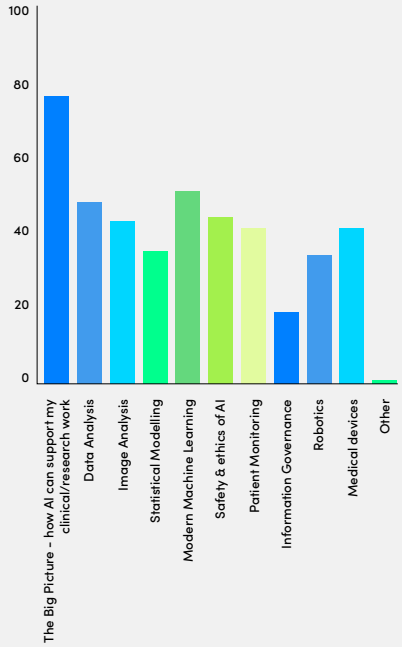
32 ORUK MSK Community survey, July-August 2022

33 https://www.versusarthritis.org/get-help/arthritis-virtual-assistant/

34 The Top Review, Preparing the healthcare workforce to deliver the digital future, An independent report on behalf of the Secretary of State for Health and Social Care, February 2019

35 ORUK MSK Community survey, July-August 2022 – Strongly agree or agree

**Which of the following aspects of AI and Big Data are you most interested in learning more about?**




We are therefore working with some of the world's leading technology companies, with a proven track record in providing practical education in all things related to AI, to develop a comprehensive training programme for MSK professionals. This will blend online and face-to-face learning and combine self-learning with trainer-led tutorials and workshops.

We envisage that this will be of particular interest to the new generation of clinicians and researchers entering the MSK discipline who are operating at the intersection of medical and data science. They have seen how AI when applied to data analysis and image interpretation, is transforming the prevention, diagnosis, treatment and management of people with poor MSK health. In the words of a PhD student who has recently received one of our fellowship grants to research the use of statistical modelling to help better predict patient outcomes, *'I am part of that generation that has grown up with computers, so it feels natural to ask how we can we exploit this technology. We are all getting more on board with the idea of smart technology and wearable devices and questioning why we are not applying these technologies to our patients.'*

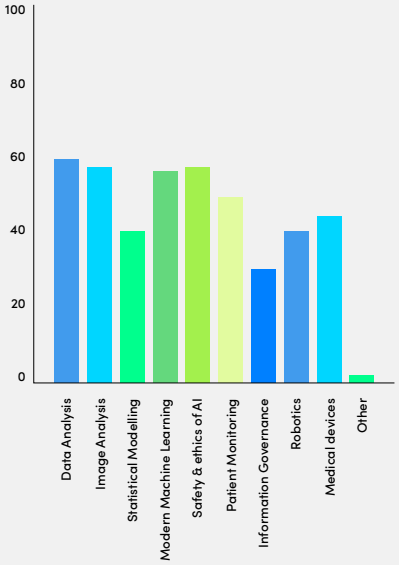
Dr Justin Green, Orthopaedic Registrar at Northumbria Healthcare Trust agrees with this focus on improving knowledge whilst respecting the role of data science specialists: *'We need to develop our technical capabilities. A lot of clinicians like myself are interested in data science – I have spent the past three years developing my knowledge - but we also need to involve genuine data scientists in healthcare. They can bring a level of understanding and skills that clinicians, no matter how tech-savvy, cannot replicate. It is not enough for data science to be a hobby. To make the most of the opportunity, beyond low code, automated AI systems, we need dedicated expertise from people trained in data science.'*

### 2. Research Investment

We aim to fill the most important gaps in research funding in bone, joint and muscle well-being. We fund innovative research projects in the UK that expand knowledge, improve patient outcomes and pioneer new forms of diagnosis and treatment.

Our research indicates that relatively few MSK researchers utilise advanced AI and ML to deliver their research projects. According to our survey conducted among our MSK community 71% agreed that there is a lack of investment in research in the application of AI and Big Data to MSK health. In the same survey, respondents were invited to rank aspects of AI in terms of the need for further research investment:[36]

**Which of the following aspects of AI (including machine learning) and Big Data require further investments in research in their application to MSK health?**




We will collaborate with leading academic institutions, charities and technology providers to co-fund research fellowships to support the brightest and best academic talents to explore the application of AI to MSK health. The focus will be on innovative research proposals that address patients' unmet needs by using AI and ML models to reduce MSK pain, improve function, decrease healthcare costs, and improve quality of life.

We hope that by highlighting the importance of AI within MSK health, and the availability of proven technologies and processes that can be scaled-up to meet patient demand, we can encourage significant increases in research funding from government, third sector and private companies.

We also want to encourage entrepreneurs seeking to harness the power of AI to improve outcomes for MSK patients. In particular we will make the most of our involvement in the NHS Clinical Entrepreneur Programme

36 ORUK MSK Community survey, July-August 2022

to encourage AI-based solutions devised by MSK clinicians. We know that clinicians are not only well placed to identify key problems and potential solutions, but many have the entrepreneurial ambition to bring their ideas to life. MSK specialists are already well represented among the clinicians attending the Programme.

**3. Data standardisation**

We support ongoing initiatives, such as NHS Transformation Directorate's efforts to address common issues such as information governance (IG), data access and protection. We also welcome the publication of the Goldacre Review (commissioned by the Secretary State for Health and Social Care) with the aim of achieving better, broader, and safer use of health data for research and analysis, and HEE's Data Driven Healthcare report.[37]

Alongside the major structural changes to the use of health data identified by the Goldacre Review, we have identified the following operational improvements that can make a real difference to the application of AI to MSK health – what might be described as quick wins:

**a. Championing better data standards for everyone involved in MSK research.**

An important area for data standardisation is in the reporting of AI-based research projects. The main issues were identified in a recent review of the literature on the accuracy of AI when applied to image analysis in hip and knee arthroplasty.[38] Although the reviewers noted that the research studies reported 'good precision and accuracy' there was a clear lack of standardisation in terms of reporting. The deficiencies identified in the review included:

- failing to include or mention all the eligibility criteria for the X-rays that they used, which introduces the possibility of selection bias.
- not assigning ground truth level data, which is the baseline comparative used to train an AI system.
- failing to provide adequate information about the dataset distribution so they didn't say how much data they use to train or validate and test their models.
- failing to describe the AI models that they used in full detail, making it impossible to critically analyse the paper and to be able to replicate and validate it for future application.
- not using external data to test their models.
- relying on very small sample sizes rather than sufficiently large datasets.
- failing to use clinical data to improve the prediction model of the AI systems.

According to one of the researchers involved in the review, Binay Gurung, Junior Clinical Research Fellow, South West London Elective Orthopaedic Centre, *'The review indicated that we can perform implant identification, measurement, positioning and detect loosening under test conditions. However, in the absence of external validation of these studies, the real world clinical use of these studies is unknown. It is evident that we need to improve the reporting of the AI studies.'*

It is also important to counter biases derived from narrow data sources that fail to reflect a diverse population. Algorithms need to be trained on an appropriately diverse dataset.

**b. Encouraging greater consistency in the application of IG and specifically consent processes.**

Misunderstanding or misinterpretation of the existing regulations can be countered by working more closely with IG teams at an individual Trust level and highlighting best practice throughout the patient pathway.

**c. Improved training and support across the healthcare system to ensure the accurate labelling/ tagging of images.**

It is axiomatic that AI needs good data with which to work. We recognise that radiography departments are under huge pressure, but improvements in ways in which digital image data is labelled will make a real difference to the effective application of AI within orthopaedics. Greater accuracy will also help reduce the amount of time spent by researchers to clean up datasets. Technology may be able to help through the automation of some processes.

**4. Networking**

We will facilitate the sharing of information, intelligence and funding opportunities among clinicians, commissioners, researchers, innovators and entrepreneurs and highlight the importance of AI to the future of orthopaedics to those in government and other decision makers. It is only by mobilising the wider MSK community that we can deliver the full benefits of AI to the tens of thousands of patients in need of care and support. We are planning a series of events, such as seminars and conferences, to bring together the wider community and facilitate knowledge sharing.

37 Data Driven Healthcare in 2030: Transformation Requirements of the NHS Digital Technology and Health Informatics Workforce, HEE Digital Readiness Programme, March 2021

38 AI-based image analysis in Hip & Knee arthroplasty. B Gurung, P Liu, PDR Harris, A Sagi, RE Field, DH Sochart, K Tucker, V Asopa

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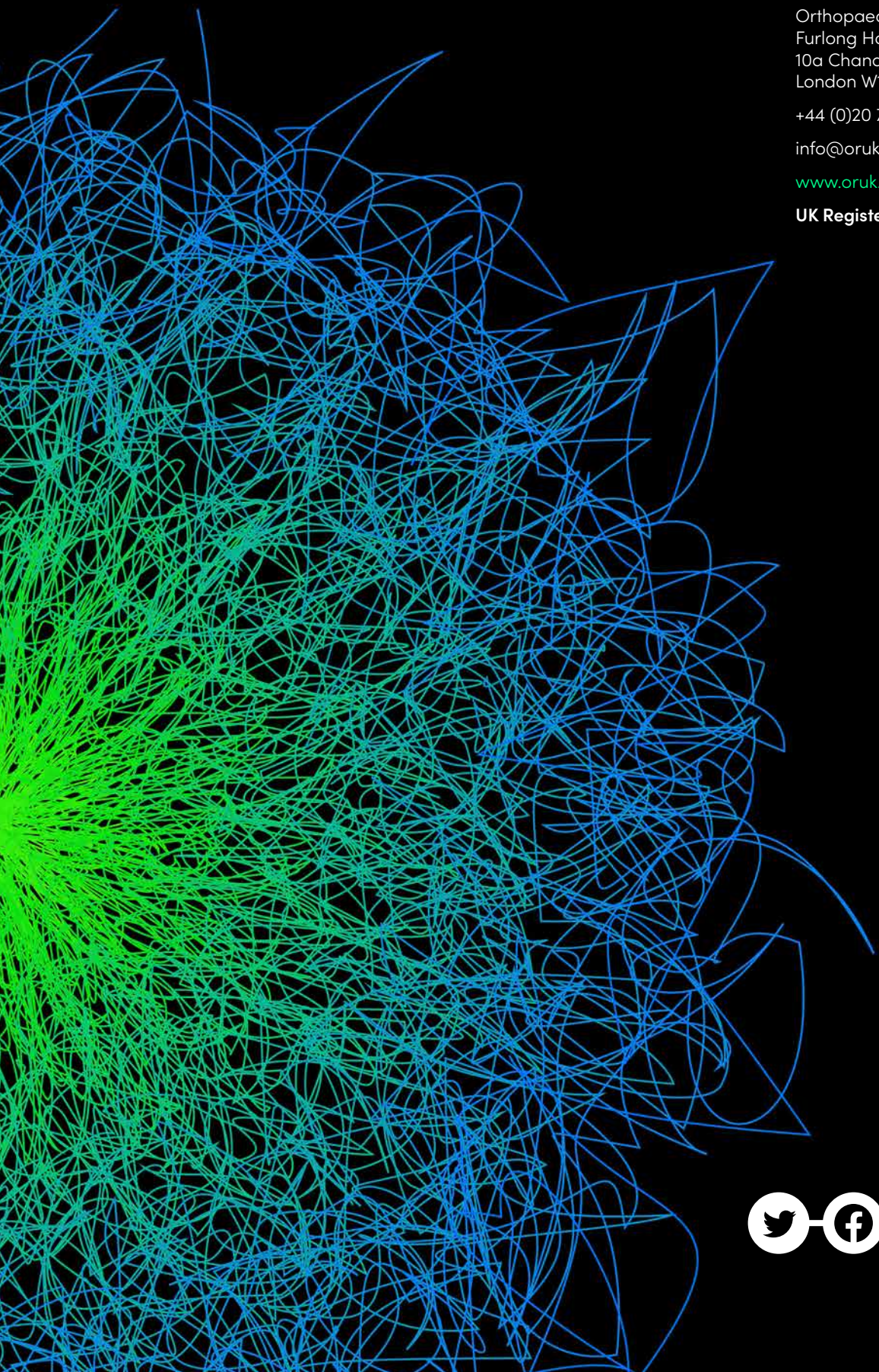

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