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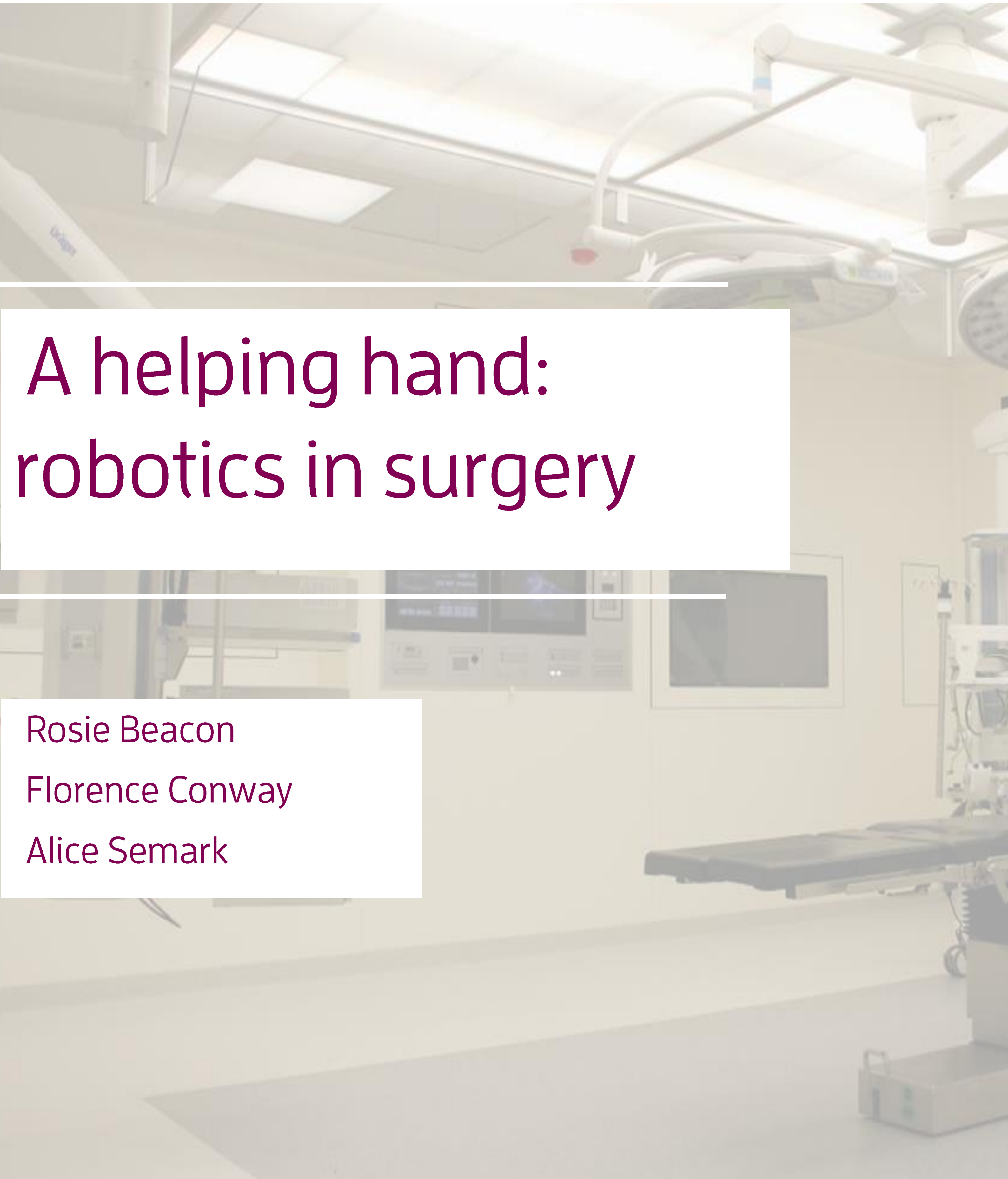

A helping hand: robotics in surgery

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Actions to promote robotic assisted surgery

Action 1: The Department for Health and Social Care should develop a national strategy for robotic assisted surgery. This should include: identification of geographical hot and cold spots for robotic systems, medical domains that gain particular benefit from robotic assisted surgery, the most cost-efficient deployment of robotic systems, and how the business case process can be simplified for innovations that produce benefits across surgical specialities and hospital departments. It should also include assessments of potential workforce changes as a result of changes in clinical workflows.

Action 2: As part of the Ten Year Plan, policymakers should reconsider how cost-effectiveness and efficiency is evaluated in the health system. Particularly in the hospital context, they should seek to develop a measure of patient flow efficiency, rather than the cost efficiency of individual departments. If "what gets measured gets managed",[2] this would support both innovation and efficiency at a departmental and system level.

Action 3: NHS England should collaborate with the Royal College of Surgeons, among other specialist bodies, to develop a standardised training and regulatory programme for robotic assisted surgery that can be integrated within the surgical training programme, either as part of core surgical training or specialty training.

[2] Ara Darzi, *Independent Investigation of the NHS in England* (Department for Health and Social Care, 2024).

1. Introduction

In 1985 the first surgical robotic system, the PUMA 560, was used for a brain biopsy procedure.[3] A procedure previously subject to errors from hand tremors, robotics instead enabled surgeons to guide the robotic system to insert a needle into the brain. In the decades since, robotic assisted surgery (RAS) has advanced in terms of use, capabilities, and outcomes. Indeed, robotic surgical systems have transformed the way surgeons can conduct specific procedures and brought about "a next level of surgery".[4]

Often thought to be the domain of science fiction, robotic systems are not uncommon and are well documented to offer significant advantages in surgery. From less invasive procedures to shortened recovery times, they improve the patient experience while reducing the amount of resource needed for surgery.[5]

Surgical innovation has long transformed health outcomes. The introduction of laparoscopy— a surgical procedure that allows a surgeon to operate using a camera and small incisions — revolutionised surgery and marked a fundamental change in the evolution of medicine. For example, between 1970 and 1975 uptake of female sterilisations more than tripled from 185,000 to 670,000 procedures per year due to advances in laparoscopy.[6] Procedures that were once inconceivable are practiced widely today.

Much of robotics assisted surgery builds on the laparoscopy revolution by providing greater precision and a range of motion that is difficult to achieve with human hands. And for patients, less invasive surgery is universally preferable as it dramatically improves the patient recovery and leaves smaller scars.

Meaningful productivity advantages are derived from improving the patient experience. If the surgery is less lengthy, invasive, and painful, it substantially shortens the patient's recovery time. If their recovery is improved, they require less hospital resources in bed capacity and staffing, in turn freeing up capacity for other patients who do need it. It is a mutually beneficial innovation both for the patient and the system. As hospitals reach crisis point, the need for productivity-enhancing innovations grows more pressing by the day.

But, despite this, their use remains niche. Robotic systems are commonly found in the hospitals that can afford them, rather than as a mainstream feature of the modern surgical theatre. As this paper will explore, this slow adoption is misguided. This briefing paper sets out the policy context within hospitals, the advantages of RAS and the major policy obstacles to scaling them across the health system.

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[3] The Surgical Clinic, 'The History of Robot-Assisted Surgery', 15 July 2024.
[4] NHS East Sussex Healthcare, 'Da Vinci XI Robotic-Assisted Surgical System Arrives at Conquest Hospital', 3 May 2023.
[5] Rocco Ricciardi et al., 'The COMPARE Study: Comparing Perioperative Outcomes of Oncologic Minimally Invasive Laparoscopic, Da Vinci Robotic, and Open Procedures: A Systematic Review and Meta-Analysis of The Evidence', *Annals of Surgery*, 22 October 2024, https://doi.org/10.1097/SLA.0000000000006572.
[6] Bhide et al, 'Case Histories of Transformation Advances: Laparoscopy - Minimally Invasive Surgery', *Harvard Business School* Working Paper 20-008 (2024).

2. The current state of hospital care

There are well established challenges facing hospitals – in both emergency and elective care – that need addressing urgently.

As of August 2024, the NHS waiting list for consultant-led elective care stood at 7.64 million.[7] In Accident and Emergency (A&E) performance, the long-standing target that 95 per cent of A&E patients are admitted, transferred or discharged within four hours has been missed every month since July 2015.[8]

Fixing these problems is not straightforward. Hospitals are highly interdependent systems – more akin to a factory – with the efficiency of many functions relying on other processes in the hospital. These functions include, but are not limited to, surgery, diagnostics, A&E, and laboratories.

The elective wait list, for example, corresponds to a variety of different services and appointment type. This includes diagnostic scans and non-surgical treatment, which do not always take place in the hospital and do not always result in surgery. The collapse in A&E performance meanwhile, is related to poor patient throughput in hospitals and delays to discharge.[9]

Figure 1 below outlines a simplified overview of the 'patient flow' within a hospital. 'Patient flow' is a term used within healthcare management to describe how patients literally flow through the system. The starting point is a patient's first contact with a hospital department, and the flow finishes when the patient is discharged home or an alternative care setting.

Given that patients will have highly divergent clinical needs, patient flows from one patient to the next can look very different. But like any system dependent on multiple functions, a blockage in one part of the hospital can have ramifications for the rest. Indeed, poor patient flow is well established as a driver of the current crisis in hospitals – efficiency within and between hospital functions is therefore essential in reducing both elective and emergency waiting times.

But as illustrated below, improving the efficiency of discreet functions within the hospital, such as surgery, can have a substantial impact in reducing congestion in the patient flow.

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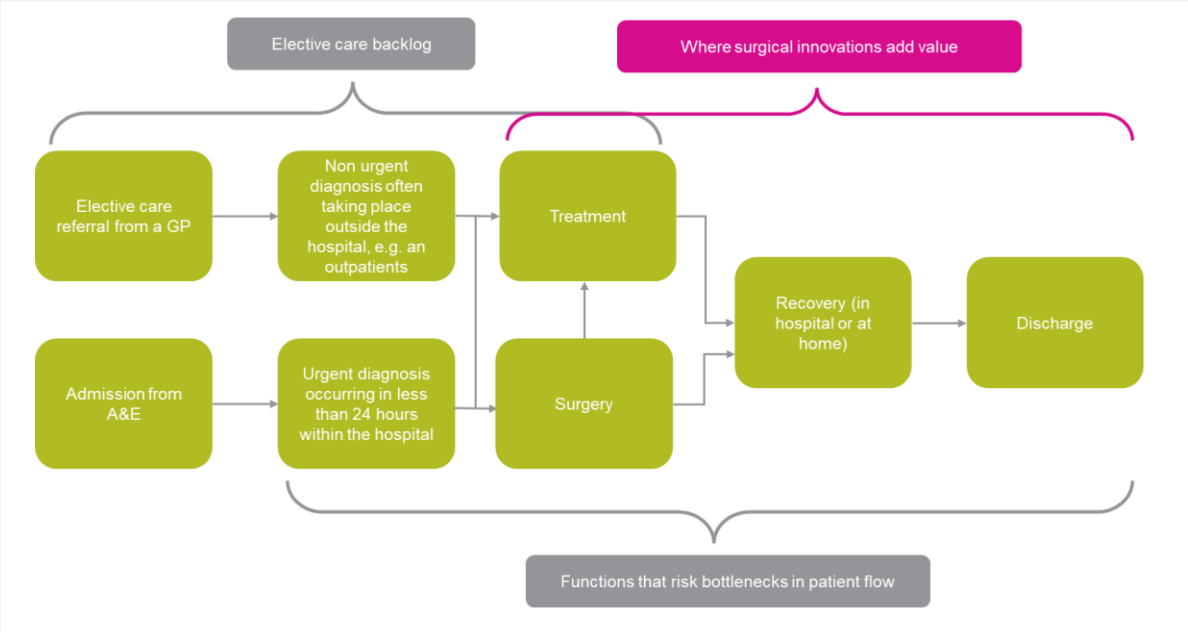
[7] NHS England: monthly RTT data collection, 'Incomplete-Commissioner-Aug24-XLSX-4M-55892', 10 October 2024.
[8] The King's Fund, 'Accident and Emergency (A&E) Waiting Times', 29 May 2024.
[9] S Rees and H Hassan, 'The A&E Crisis: What's Really Driving Poor Performance?' (Reform, 8 February 2023).

Figure 1: Simplified overview of the patient flow



3. Innovating the delivery of surgery

Despite the complexity of hospitals, the efficiency and pace of surgery – and the associated recovery time – could play a significant role in restoring the efficiency of elective and emergency care for patients.

Over the last 50 years in particular, surgical innovations have improved patient outcomes, reduced complication rates, length of hospital stay, and have decreased both morbidity and mortality.[10] Indeed, over the last ten years there has been an ongoing migration from invasive, to less invasive and even non-invasive procedures, often removing the need for general anaesthesia.[11]

While all of these innovations are significant, robotic assisted surgery is consistently highlighted across the literature as one of the leading innovations in the operating theatre. Robotic assisted surgeries were first introduced in the UK in the late 1990s, and since then over 12 million robotics assisted surgeries have been performed across 70 countries.[12] The number of robotic assisted surgeries carried out each year is quickly growing in the UK, increasing, on average, 41 per cent each year between 2021 and 2023.[13]

Minimally invasive robotics assisted surgery builds on developments made through laparoscopies – the most common surgical method for minimally invasive surgeries. While laparoscopies are associated with much lower mortality than open surgery, it also presents a number of challenges for surgeons: counterintuitive hand movements, long instruments working through fixed entry points exacerbating small movements or tremors, limited range of motion of instruments requiring ergonomically challenging positions for surgeons, and 2D optics sometimes causing a loss of depth perception.[14]

Rather than being autonomous systems, surgeons operate a robotic system's interactive mechanical arms from a console positioned behind the patient. They are designed to reproduce the hand motions of a surgeon but with greater precision, allowing better-than-human performance.[15] Greater precision is achieved by eliminating hand tremors, increasing range of movement and enhanced vision. It is therefore minimally invasive as greater precision means smaller surgical cuts can be made, which in turn leads to fewer complications and improves recovery times.

Since the 1990s, surgical robotic systems have evolved considerably, making them adaptable to various procedures. Modern surgical robotic systems are equipped with highly dexterous arms, integrated with enhanced visualisation using high definition video images. Haptic feedback systems have also allowed surgeons to determine the consistency of the tissues they are operating upon, without physical contact, preventing injuries due to the

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[10] Royal College of Surgeons, 'Surgical Innovation, New Techniques and Technologies: A Guide to Good Practice', February 2019.
[11] Y Kopelman et al, 'Trends in Evolving Technologies in the Operating Room of the Future', *Journal of The Society of Laparoscopic & Robotic Surgeons*, April 2013.
[12] Royal College of Surgeons, 'Robotic-Assisted Surgery: A Pathway to the Future', July 2023.
[13] PHIN, 'A Helping Hand: The Use of Robot-Assisted Surgery in the UK', October 2024.
[14] Lori Weinberg, Sanjay Rao, and Pedro F. Escobar, 'Robotic Surgery in Gynecology: An Updated Systematic Review', *Obstetrics and Gynecology International* 2011 (2011): 1–29, https://doi.org/10.1155/2011/852061.
[15] Y Kopelman et al, 'Trends in Evolving Technologies in the Operating Room of the Future'.

application of minimal force.[16] Some surgeons have also pioneered the concept of remote telesurgery using robotic systems which can be operated from a different location than the patient, allowing advanced surgical procedures in more remote or distant locations.[17]

This innovation in surgical technique has also been complemented by innovation in administrative management of surgery.[18] This has included waitlist management, preoperative management and operating theatre efficiency (for example, high volume low complex lists seen in the High Intensity Theatre ((HIT)) lists at Guy's and St Thomas' Hospital).[19]

The most common types of minimally invasive surgeries that robotic surgical systems are used for include: urology, colorectal, and gynaecology. Ear, nose and throat robotics assisted surgeries, although less common, are a type of minimally invasive surgery in which the advantages of using robotics assisted systems are especially profound.

Beyond minimally invasive surgeries, robotics assisted systems are commonly, especially in the independent sector, used for orthopaedic and hard tissue surgeries e.g. hip and knee replacements.[20] Barts Health NHS Trust have recently further expanded their use of robotic assisted surgery, giving patients wider access to kidney transplant and colorectal robotics surgeries.[21]

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16 S Chatterjee et al, 'Advancements in Robotic Surgery: Innovations, Challenges and Future Prospects', *Journal of Robotic Surgery*, 17 January 2024.
17 Y Kopelman et al, 'Trends in Evolving Technologies in the Operating Room of the Future'.
18 NSW Government and Critical Intelligence Unit, 'Approaches to Reduce Surgical Waiting Time and Waitlist', 12 July 2024.
19 *NHS Staff Find Innovative Way to Tackle Surgery Waiting Lists* (NHS Guy's and St Thomas' Foundation Trust, 2022).
20 Ibid.
21 M Downing, NHS Barts Health Trust, 'Robotic Surgery to Be Expanded to Help More Patients', 9 April 2024.

4. Explaining a robotic surgical system

There are several robotic surgical systems currently available all with different designs. These systems are generally composed of three parts: the surgeon's console, the patient cart and the vision cart. Included below are some images of the da Vinci© system, the first robotic surgical system to be used in England.

Figure 2: an example of a robotic assisted surgery set up, depicting a da Vinci surgical system

Depicting a surgeon's console (far left), the patient cart (middle, above the patient bed) and the vision cart (far right, with screen).

Source: 'Newsroom', Intuitive Surgical Operations, Inc. website, copyright notice: © 2025 Intuitive Surgical Operations, Inc.

The surgeon's console

The surgeon sits at the surgeon's console (depicted in Figure 3), operating the patient cart. Space permitting, the surgeon and the console will be situated inside the operating theatre, but otherwise it can be outside. The da Vinci system converts the surgeon's hand movements into movements that mimic those of open or laparoscopic surgery, but with better-than-human precision and dexterity.

Using the pedals of the console, the surgeon directs non-movement functions of the patient cart, such as energy usage. All of this is carried out while the surgeon is comfortably seated with armrests and adjustable height and eye pieces.

Figure 3: a surgeon seated at and operating the surgeon's console, depicting a da Vinci surgical system

Source: 'Newsroom', Intuitive Surgical Operations, Inc. website, copyright notice: © 2025 Intuitive Surgical Operations, Inc.

The patient cart

As depicted in Figure 2, the typical robotic system's patient cart has multiple robotic arms – the instruments for surgery and the camera. These arms are tools the surgeon controls from the surgeon's console. The patient cart will be in the operating theatre, situated next to the patient bed and over the patient.

The vision cart

The vision cart will be situated in the operating theatre, facilitating the communication between the patient cart and surgeon's console. Through the vision system (the vision tower and the camera in the patient cart), the surgeon's console displays better-than-reality, magnified, 3D high-definition vision of the surgical site for the surgeon.

5. The benefits of robotic assisted surgery

5.1 Clinical and patient value

5.1.1 Surgical advantages

Robotic systems enable far greater precision in surgical procedures (in combination with the surgeon's expertise) than is possible by hand. This results in numerous surgical benefits, chiefly relating to enhanced accuracy, reduced blood loss, less pain, minimised tissue damage, and smaller incisions. Surgeons can perform intricate tasks with submillimetre accuracy surpassing what is possible for human performance alone. Such precision, as well as enhanced dexterity, reduces the risk of surgical errors, improving patient outcomes.[22]

These clinical advantages translate into better clinical outcomes for patients. For example, patients typically experience less postoperative pain – a direct consequence of less tissue handling and reduced incision size.[23] This in turn means fewer pain management prescriptions and faster recovery times, often precluding the need to stay overnight in hospital, resulting in increased patient satisfaction.

5.1.2 Reduced complications

Surgical procedures carried out with robotic systems are often associated with lower rates of intraoperative complications.

The combination of optimised precision, enhanced dexterity, and robotics systems inability to experience human fatigue, substantially reduces the likelihood of complications. RAS' 3D-imagining systems also enable a surgeon to have better vision during surgery, compared to open or laparoscopic surgeries.

Altogether, some evidence suggests this results in a lower risk of intraoperative complications, such as unintended damage to organs or tissues and reduced patient blood loss.[24]

RAS has lower postoperative infection rates compared to open or laparoscopic surgeries.[25] Smaller incisions ensure the patient's internal tissue is less likely to be contaminated and is exposed less to the external environment, reducing infection risk. This is especially beneficial in complex surgeries where infections can cause severe postoperative complications and long recovery times.

Complications are also minimised by a reduction in post-operative blood clots. A study recently published in the Journal of the American Medical Association found that robotic assisted surgery revealed a "striking" four-fold reduction in the prevalence of blood clots – a

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[22] Sian E. Batley et al., 'Post-Operative Pain Management in Patients Undergoing Robotic Urological Surgery', *Current Urology* 9, no. 1 (February 2016): 5–11, https://doi.org/10.1159/000442843.
[23] Batley et al.
[24] George Koulaouzidis et al., 'Robotic-Assisted Solutions for Invasive Cardiology, Cardiac Surgery and Routine On-Ward Tasks: A Narrative Review', *Journal of Cardiovascular Development and Disease* 10, no. 9 (18 September 2023): 399, https://doi.org/10.3390/jcdd10090399.
[25] Weinberg, Rao, and Escobar, 'Robotic Surgery in Gynecology'.

significant cause of health decline and morbidity – compared to patients who had open surgery. This means patients benefit from "far fewer complications, early mobilisation and a quicker return to normal life."[26]

5.1.3 Improving gender equity

RAS not only improves outcomes, but early evidence suggests it improves access for more inaccessible medical domains such as gynaecology. Gynaecology is a field which benefits extensively from RAS because of the number of surgeries that use laparoscopy rather than open surgery. Indeed while minimally invasive surgery revolutionised the management of gynaecologic disorders over the last 30 years, the most substantial improvements have come with the advent of robotic assisted surgery.[27]

It is also the specialism which has seen the largest increase in elective waiting lists. Combined with optimised operational management, such as High Intensity Theatre lists, RAS can significantly improve access. The surgical team at Chelsea and Westminster hospital safely completed 30 robotic assisted hysterectomies in one weekend, more than five times the usual number of patients.[28] The increase in access is however, restricted to hospitals that have robotic systems. As explored below, this tends to be limited to hospitals that can afford them or surgeons that can effectively make the business case for them, rather than where clinical demand is most acute.

An additional improved outcome is a reduced risk of loss of function of reproductive organs during ovarian or uterine surgeries.[29] Gynaecological RAS patients are also less likely to require unplanned transition to open surgery, compared to laparoscopic patients, protecting patients from the additional risks of open surgery.

5.2 Operational value

An increasingly ageing, multi-morbid population dominates healthcare use and expenditure. In addition to suffering from more health issues in the first instance, this demographic increases surgical complexity and takes longer to recover from operations. These patients tend to stay longer on wards, and as more complex patients, they can often be moved between wards due to evolving needs requiring different specialists. This adds further 'congestion' to the hospital's patient flow, so any innovation that can minimise the length of stay in hospital is transformational. As their use of the health system continues to increase, embracing innovations that expedite recovery times becomes essential.

The nature of surgical demand is also changing. For instance, the demand for more intensive orthopaedic procedures (hip and knee replacements) is set to increase by almost 40 per cent by 2060,[30] and the majority of the increase in demand will be among patients aged 70 and over.[31]

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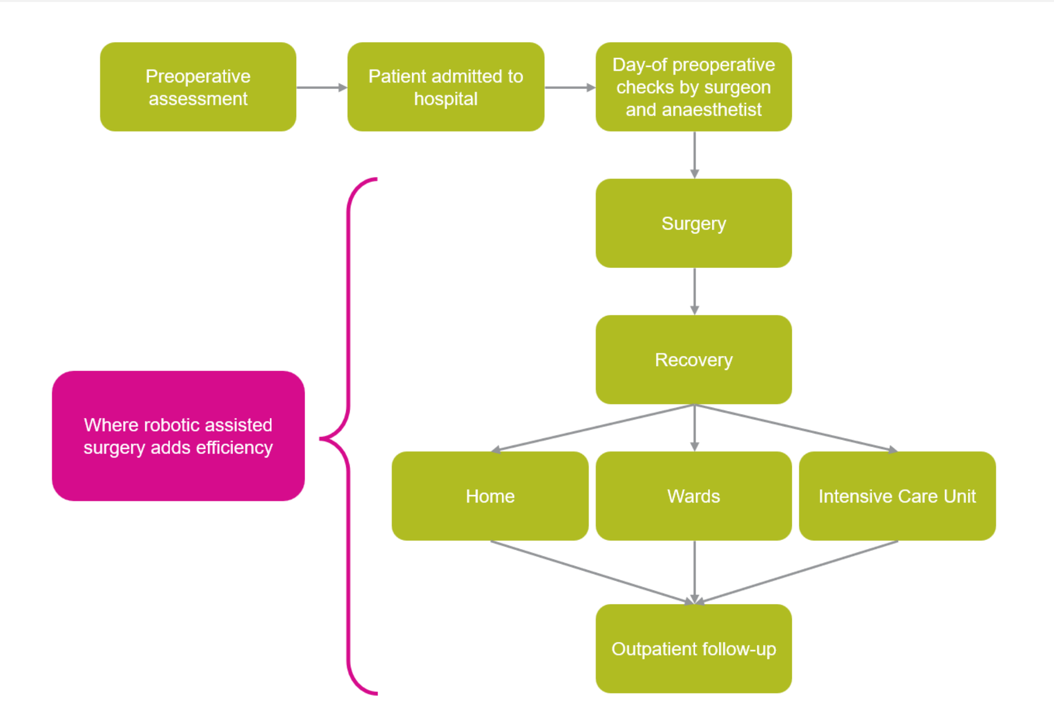
[26] UCL News, 'Robotic Surgery Is Safer and Improves Patient Recovery Time', 15 May 2022.
[27] Weinberg, Rao, and Escobar, 'Robotic Surgery in Gynecology'.
[28] 'Chelsea and Westminster Hospital Cuts Waiting Lists with Record Number of Robotic Surgeries', *Chelsea and Westminster Hospital NHS Foundation Trust*, 26 September 2024.
[29] Kavyanjali Reddy et al., 'Advancements in Robotic Surgery: A Comprehensive Overview of Current Utilizations and Upcoming Frontiers', *Cureus*, 12 December 2023, https://doi.org/10.7759/cureus.50415.
[30]GS Matharu et al, 'Projections for Primary Hip and Knee Replacement Surgery up to the Year 2060: An Analysis Based on Data from The National Joint Registry for England, Wales, Northern Ireland and the Isle of Man', *The Annals of The Royal College of Surgeons of England*, December 2021.
[31] Ibid.

5.2.1 Improved patient flow

Patient flow through the various processes of surgery varies patient to patient, especially in postoperative care. Bearing this in mind, a generalised patient flow through the surgical process is depicted in Figure 3.

Figure 3: Typical patient flow through the surgery process



Patient pathways vary significantly from the point of surgery: some patients move to wards, some are discharged home, and a small number of patients move to intensive care units. Postoperative care is provided not only in hospitals, but also once patients are discharged, commonly including pain management, wound care, physical therapy and follow-up appointments.

Across this surgical flow, RAS shortens the time involved at every interval. Indeed across general surgeries, gynaecological surgeries, urological surgeries, cardiac surgeries, spinal surgeries, orthopaedic surgeries, and head and neck surgeries, RAS is associated with shorter recovery times.[32]

For total hip replacements, the average number of days spent in hospital for RAS patients was 5.14 days versus 8.11 days for current conventional methods.[33] Similarly, robotic assisted hysterectomy patients stayed in hospital on average 1 day, compared to 1.6 days for laparoscopic patients.[34]

[32] Reddy et al., 'Advancements in Robotic Surgery'.
[33] James Griffin et al., 'UK Robotic Arthroplasty Clinical and Cost Effectiveness Randomised Controlled Trial for Hips (RACER-Hip): A Study Protocol', *BMJ Open* 13, no. 10 (October 2023): e079328, https://doi.org/10.1136/bmjopen-2023-079328.
[34] Weinberg, Rao, and Escobar, 'Robotic Surgery in Gynecology'.

Sasha Stamenkovic, a Consultant Thoracic Surgeon at St Bartholomew's, stated that patients who have benefitted from robotic assisted surgery for chest tumours and lung cancer are "going home in better condition and earlier.[35]

Several randomised control trials (RCT) have assessed the health utility and clinical outcomes of RAS versus other types of surgeries.[36] For example, two groups of patients having radical cystectomies (the removal of the bladder and nearby lymph nodes): one group had RAS and the other had open surgery. In its findings, it concluded that patients who had RAS recover far more quickly and spend significantly (20 per cent) less time in hospitals.[37]

If patients spend less time in hospital recovering from surgical procedures, that frees up pressure on bed occupancy. For instance, in 2022 Milton Keynes University Hospital conducted a study of the impact of adopting the Versius Surgical Robotic System, finding, among other benefits, shorter recovery times and surgical staff wellbeing. Significantly, 450 bed days were saved annually.[38]

5.2.2 Staff retention

Retention in the surgical community is a challenge. In 2023, the Royal College of Surgeons (RCS) conducted a workforce census to identify key challenges facing the surgical workforce and found that around 50 per cent of respondents had considered leaving the workforce in the past year.[39]

One of the difficulties for many surgeons is work related musculoskeletal problems. A major benefit of RAS is that surgeons are able to sit down to conduct the surgery, making performing surgery more comfortable and reducing the incidence of work-related musculoskeletal problems in surgeons.

96 per cent of surgeons reported they have experienced at least one work-related musculoskeletal complaint in the last year, with 34 per cent reporting pain in four body parts.[40] The most common symptoms or conditions reported by surgeons performing minimally invasive surgeries are: pain in the neck, back, arm, shoulder and leg; degenerative cervical and lumbar spine conditions; damage to the rotator cuff; and carpal tunnel syndrome.[41] The three primary reasons for the development of these symptoms or conditions are: prolonged standing; uncomfortable postures required for surgeries; or the need to use inflexible equipment that fails to account for variations between surgeons, such as having a smaller glove size or shorter elbow height.[42]

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[35] M Downing and NHS Barts Health Trust, 'Robotic Surgery to Be Expanded to Help More Patients'.
[36] Yogita S. Patel et al., 'Robotic Lobectomy Is Cost-Effective and Provides Comparable Health Utility Scores to Video-Assisted Lobectomy: Early Results of the RAVAL Trial', *Annals of Surgery*, 8 August 2023, https://doi.org/10.1097/SLA.0000000000006073.
[37] J Catto et al, 'Effect of Robot-Assisted Radical Cystectomy With Intracorporeal Urinary Diversion vs Open Radical Cystectomy on 90-Day Morbidity and Mortality Among Patients With Bladder Cancer', *The Journal of the American Medical Association*, 15 May 2022.
[38] CMR Surgical, 'Milton Keynes University Hospital: Versius® Robotic Assisted Surgery Case Study', February 2022.
[39] Ibid.
[40] Andreea Luciana Rață et al., 'Work-Related Musculoskeletal Complaints in Surgeons', *Healthcare* 9, no. 11 (31 October 2021): 1482, https://doi.org/10.3390/healthcare9111482.
[41] Anumithra Amirthanayagam et al., 'Impact of Minimally Invasive Surgery on Surgeon Health (ISSUE) Study: Protocol of a Single-Arm Observational Study Conducted in the Live Surgery Setting', *BMJ Open* 13, no. 3 (March 2023): e066765, https://doi.org/10.1136/bmjopen-2022-066765.
[42] Amirthanayagam et al.

Early evidence indicates RAS – which surgeons perform seated at the surgeon's console – is associated with a lower rate of musculoskeletal problems for surgeons.[43] These benefits are especially evident in RAS compared to laparoscopic surgeries for patients with obesity, which is especially ergonomically demanding for surgeons.[44]

However, it is also worth nothing these musculoskeletal benefits may not be equally realised for all surgeons. The surgeon console seems to work less well for shorter surgeons, who are typically female.[45] These surgeons sometimes struggle to reach the pedals from the chair, forcing them into awkward or less comfortable postures, potentially increasing the risk of musculoskeletal problems.[46] However, this problem could easily be resolved by minorly redesigning the surgeon's console, either ensuring the chair can lower further or the pedal platform's height is adjustable.[47]

Another factor contributing to workforce retention issues for surgeons is high stress levels. RAS seems to also have a positive impact on this challenge. A recent study compared the stress of two surgeons during their twenty surgical activities via robotic assisted and more invasive, non-robotic approaches. The study revealed that RAS produced less stimulation of the autonomic nervous system, leading to less stress for the surgeons. [48]

Of course, surgery is not just conducted by surgeons but a wide range of staff including nurses, operating department practitioners, and healthcare assistants. As explored in the following section, if not trained sufficiently, RAS may pose problems for the wellbeing, and therefore retention, of crucial non-surgeon surgical staff.

5.5 Financial value

Since RAS reduces complications and bed occupancy through faster recovery times, there is a clear return on investment across the patient pathway.

But it should be said that maximum financial value is derived from RAS when there are significant economies of scale. These are not always straightforward to achieve since RAS requires specialist skill which is not yet widespread or standardised (as explored in the next chapter.) Where comprehensive training – and therefore economies of scale – is not available, it undermines the return on investment.

Comprehensive data on cost effectiveness is not easily available due to how hospitals measure costings, which is explored below. Nevertheless, research from 2022 found that Robotic Assisted Radical Prostatectomy was more cost effective to treat localised prostate

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[43] Amirthanayagam et al.
[44] Amirthanayagam et al.
[45] Mija Ruth Lee and Gyusung Isaiah Lee, 'Does a Robotic Surgery Approach Offer Optimal Ergonomics to Gynecologic Surgeons?: A Comprehensive Ergonomics Survey Study in Gynecologic Robotic Surgery', *Journal of Gynecologic Oncology* 28, no. 5 (2017): e70, https://doi.org/10.3802/jgo.2017.28.e70.
[46] Lee and Lee.
[47] Lee and Lee.
[48] A Mazella et al, 'How Much Stress Does a Surgeon Endure? The Effects of the Robotic Approach on the Autonomic Nervous System of a Surgeon in the Modern Era of Thoracic Surgery', *Cancers (Basel)*, February 2023.

cancer – it cost £1,785 less per patient and had 0.24 more Quality Adjusted Life Years gained.[49]

Within the theatre, financial value is derived from the need for less staff in the theatre and shortened operating time. When combined with administrative optimisation, such as High Intensity Theatre (HIT) lists, this enables significant cost efficiencies. Beyond the theatre, as discussed, it can reduce bed occupancy, the need for drug prescriptions, and staffing requirements. And beyond the hospital, lower postoperative complications can result in ongoing cost savings by avoiding expensive healthcare interventions down the line, such as additional surgeries, extensive rehabilitation, and community nursing appointments.

These benefits, combined with RAS operating at scale with a commensurately trained workforce, could collectively add up to sizeable savings. But a future strategy for RAS should consider how to maximise the cost effectiveness of robotic assisted surgery aligned with where patient demand is most acute: it may be that in the short term, robotic assisted surgery would most efficiently be applied to high-volume, low-complexity surgeries to reduce backlogs, such as those seen in HIT lists.

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[49] Muhieddine Labban et al., 'Cost-Effectiveness of Robotic-Assisted Radical Prostatectomy for Localized Prostate Cancer in the UK', *JAMA Network Open* 5, no. 4 (4 April 2022): e225740, https://doi.org/10.1001/jamanetworkopen.2022.5740.

6. Barriers to adoption

Despite significant advances in RAS, adoption has been slow in the UK. Adopting robotic assisted surgery often hinges on a range of factors converging: chiefly having the available funds and accessing training.

But it was also clear from some of the interviews for this paper that it required having uniquely motivated surgeons who consistently made the case for them. Essentially, as with much of the innovation in the NHS, it continues to happen in pockets rather than across the system.

It is estimated that 49,000 surgeries and procedures were performed using robotic surgical systems in 2022 in England. It is starting to scale quickly, given this represents a 341 per cent increase since 2016.[50] However, when compared to the total number of surgeries that occur annually, 4,685,106, this figure is tiny.[51]

The US, for example, completed 876,000 robotic assisted surgeries in 2020.[52] This is 17 times the number of robotic assisted surgeries in the UK in 2022, despite only having six times the size of the UK's population.

6.1 Capital investment and cost effectiveness

A significant barrier to adoption is due to cost. But the problem is not simply pure cost but how to establish *cost effectiveness,* justify the investment and make the case to decision makers.

Robotic systems have high up-front costs. Different da Vinci robotic systems have different prices, and the exact prices are commercially confidential, but they range from £1 million to £2 million depending on the robotic system model and its configuration. Though high up-front costs are not necessarily an issue – that is the entire premise of capital investment, spending to produce a return in the long term that outweighs its initial cash cost. But establishing this return is difficult, particularly in a fiscal context where NHS capital budgets are continuously raided to assist with day-to-day running costs.[53]

Given that there is no set budget to procure robotic systems, the purchase and use of them is based on local availability and resources. This means that hospital trusts with greater cash flows are likely to be the only ones who can afford to adopt robotic assisted surgery. Or, in some cases, crowdfunding from charities and trusts enable purchase.[54]

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[50] PHIN, 'Sharp Growth in Robot-Assisted Surgery in UK Hospitals', 26 March 2024.

[51]T Dobbs et al, 'Surgical Activity in England and Wales during the COVID-19 Pandemic: A Nationwide Observational Cohort Study', *British Journal of Anaesthesia*, June 2021.

[52] Kayla R. Rizzo et al., 'Status of Robotic Assisted Surgery (RAS) and the Effects of Coronavirus (COVID-19) on RAS in the Department of Defense (DoD)', *Journal of Robotic Surgery* 17, no. 2 (23 June 2022): 413–17, https://doi.org/10.1007/s11701-022-01432-7.

[53] Darzi, *Independent Investigation of the NHS in England*.

[54] NHS Confederation, 'Cutting-Edge LungVision Bronchoscopic Navigation System', *27 July 2023*, n.d.

In England, only 32 per cent of acute NHS trusts have at least one surgical robotic system.[55] While there is no national RAS register, a recent study found significant regional variation in the use and application of RAS.[56] The study showed that robotic assisted surgery centres in England are generally located in large hospitals in urban areas, with seven centres located in London. This has led to a fragmented, ad-hoc approach to the use and availability of RAS, and, given the benefits of robotic assisted surgery, this risks perpetuating inequalities in healthcare.

To compound this, while the evidence for reduced recovery time is compelling and a clear testament to the potential return the *overall hospital* could get from robotic assisted surgery, that is not how cash savings are calculated *within hospitals*. Costings are calculated for procedures within departments rather than across the patient pathway (for example in reduced bed occupancy). The return on investment also occurs across the health system not just within hospitals: it can reduce the need for district nursing appointments, for example.

When a procedure is performed, it is coded, and each code has a reimbursement attached (the tariff.) Most surgical procedures have the same tariff value whether they are robotic assisted, laparoscopy or open surgery, unless the procedure is more complex. As capital budgets are squeezed, hospitals have focused more on their running costs, and if the tariffs which fund procedures do not actively incentivise robotic assisted surgery as a more cost-efficient option, this further undermines the case for a return on investment. Hospitals often have a relatively simple approach to accounting: “beans in and beans out” according to one interviewee.

Another challenge is that new technology, like a robotics system for RAS, will only be adopted in hospitals if a successful business case is made to the hospital’s management. Consequently, how open-minded to innovation the hospital’s management are is one significant determinant of the likelihood of RAS being adopted.[57] However, even if a hospital’s management are open-minded, the process to present a business case for a new technology is complex and long-winded.

The clinician’s business case must include comprehensive research demonstrating the positive effect of adoption for: clinical outcomes, patient experience, the workforce and cost-effectiveness.[58] It is also advised, to give the best chance of a successful business case, that the proposing clinician collaborates with relevant clinical and non-clinical team members to gain their support for the case.[59] The complexity and challenge of this process is a barrier to RAS being scaled nationally, and means its adoption often relies on uniquely motivated surgeons.

Further, the likely success of a potential business case in a hospital depends significantly on the level of engagement of the hospital’s chief executive. These individual- and relationship-specific elements likely contribute to the fragmented, ad-hoc approach currently seen in the use and availability of RAS.

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[55] K Lam et al, ‘Uptake and Accessibility of Surgical Robotics in England’, *The International Journal of Medical Robotics and Computer Assisted Surgery*, 2021.
[56] K Lam et al.
[57] Louisa Lawrie et al., ‘Barriers and Enablers to the Effective Implementation of Robotic Assisted Surgery’, ed. Rajagopalan Srinivasan, *PLOS ONE* 17, no. 8 (29 August 2022): e0273696, https://doi.org/10.1371/journal.pone.0273696.
[58] Healthcare Financial Management Association, ‘Briefing / A Guide to Business Cases for Digital Projects’, Web Page, 18 October 2024.
[59] Healthcare Financial Management Association.

Da Vinci Robotic System

The first da Vinci robotic system was introduced to the UK in 2001, after being adopted at St Mary's hospital, London. It was initially used for high-volume, standard surgical procedures. Since then, the UK has increased its da Vinci uptake. As of 2022 there were 115, and they are used in a number of different specialities: gynaecology, ENT, colorectal, thoracic and urology.

The da Vinci robotic system enables surgeons to extend the capabilities of their eyes and hands. The da Vinci vision system provides 3D high-definition views and offers surgeons the ability to see an area magnified 10 times, compared to the naked human eye. It also provides tools which move like a human hand, but with a far greater range of motion and contains system's built-in tremor-filtration technology.

Cost: Between £1 – £2 million depending on the system model and its configuration.

Versius Surgical Robotic System

Milton Keynes University Hospital implement and expanded their RAS programme after adopting the British-made Versius robotic system. Like the da Vinci system, the Versius robotic system works by mimicking the human arm joints, but providing surgeons with up to four times more rotation than the human wrist. It can be used in a number of different specialities, including: general surgery, gynaecology, colorectal, thoracic, and urology

Cost: Between £1.2 – £1.5 million.[60]

6.2 Training

From operating the robotic system to adapting well established techniques from open surgery, extensive training is required to conduct robotic assisted surgery. The required training is one factor limiting the rate at which RAS is scaled – not because it is not available, but because it is provided differently in each hospital, with no overarching guidelines or regulation.

Despite the rapid growth in RAS, there are no formal NHS guidelines or processes for providing robotic assisted surgery or for introducing RAS to hospitals, and similar is true across Europe. Aside from being another obstacle to scaling these across the system, unregulated adoption also has the potential to lead to varied accessibility, variable outcomes and possible patient harm.

There are currently no established protocols or minimum requirements for surgeons training in robotic assisted surgery, of either established surgeons or surgeons in training. Up until recently, competence was based on case observations by proctors, usually designated by the company providing the robotic system. But these were not always based on agreed metrics and clinical outcomes, but rather case volume.

Surgical staff that are not surgeons – who make up a crucial part of the operating theatre – must also be trained. Notably, if the surgeon has to operate the robotics system from outside the operating theatre due to space constraints, so is physically separated from their team inside the theatre, communication is then reliant on the proper functioning of speakers and

[60] C Metcalfe, 'Robot Surgeons Provide Many Benefits, but How Autonomous Should They Be?', *The Observer*, 18 June 2023.

microphones. This can result in communication problems causing workflow disruptions. There is some evidence workflow disruptions, along with training related issues, can result in increased stress levels in non-surgeon surgical staff.[61]

There are some pockets of innovation in robotic assisted surgery training, such as Newcastle Hospitals' partnership with Intuitive, which will support surgical trainees from across the North East of England to learn robotic assisted surgery sooner in a surgeon's career.[62] But this is the first of its kind in the UK and in Europe that will allow all trainees to become proficient in robotic assisted surgery by the time they complete surgical training. In the absence of standardised training, regulation and incentives to learn, this means it relies on surgeons who are particularly interested in RAS and actively pursuing training.

Another area that could require necessary training is change management and process re-engineering. Implementing technology in healthcare settings is often inhibited in the short term by having to review clinical workflows, which requires re-engineering pre-existing processes, for example, members of the surgical team having to reposition themselves and redistribute tasks. Clinicians are not specifically trained in change management and the effectiveness of this process often relies on the surgeon's willingness and ability to use the technology. [63]

Overall, this is generally a positive process as anecdotal evidence from surgeons has revealed they actually need less staff in the theatre than they did with laparoscopy or open surgery. Over time, these changes could result in a reconfiguration of roles and the emergence of new specialisations (such as "robotic surgical nurse").[64] Nevertheless, such innovation can slow down the process in the short term as members of the team adjust, which can disincentivise making the initial investment.

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[61] Ken Catchpole et al., 'Human Factors in Robotic Assisted Surgery: Lessons from Studies "in the Wild"', *Applied Ergonomics* 78 (July 2019): 270–76, https://doi.org/10.1016/j.apergo.2018.02.011.
[62] 'UK's First Robotic Surgery Training Programme for Surgical Trainees Launched in the North East', *The Newcastle upon Tyne Hospitals NHS Foundation Trust*, 6 June 2023.
[63] Royal College of Surgeons, 'Robotic-Assisted Surgery: A Pathway to the Future'.
[64] R Fadden, 'What Robotic Surgery Reveals About Organizational Change', 16 July 2024.

7. The future of robotic assisted surgery

Throughout the history of the NHS, innovation in healthcare has continually improved health outcomes and has enabled people to live longer, healthier lives. The increasing sophistication of hospitals has been critical to this, caring for some of the sickest people in society and ensuring the overall effectiveness of the health system. Continuing to innovate how medical care is delivered is fundamental and robotic surgical systems will play an important role in such innovation.

Yet despite the well-established benefits of robotic assisted surgery, and the well-established problems in hospitals they can address, it remains a novel innovation within the operating theatre.

Accelerating their adoption is no small task, and this is limited further by the current fiscal context. As hospitals crumble and tech infrastructure remains suboptimal, how to use limited capital investment will involve difficult trade-offs. Scaling RAS across the health system will require decision makers to adopt a decisive, coordinated strategy towards RAS, expanding across all layers of the health system, from national policymakers down to surgical teams on the ground.

However given their well-evidenced benefits – to patients, clinicians and the system itself – it is difficult to imagine a future where robotic surgical systems do not play an integral role in the operating theatre. Policymakers would be remiss to not grasp this opportunity.

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