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Evaluating AI and Robotics in NHS Intensive Care: Clinical and Operational Implications

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Summary
The National Health Service (NHS) is the United Kingdom's largest public organisation and is currently undergoing strategic change in response to operational and workforce demands. Artificial Intelligence (AI), Robotics and immersive technology in the form of Augmented Reality (AR) and Virtual Reality (VR), are currently seen as part of the potential solution to organisation-wide challenges the NHS is facing. Despite their potential, the mentioned forms of innovation and technology are suffering from fragmented implementation and isolated piloting which is stifling the potential of how such technologies can help the NHS. Intensive Care Units (ICUs) are a high-cost, high-pressure and high-risk environment where cognitive load on clinicians, strain on the workforce and operational inefficiencies are all found. This results in such a setting being a relevant area of the NHS for digital transformation to be implemented to its fullest and showcase the benefits of a change process. With the NHS moving from analogue processes to digital systems as proposed within the 10-year 'Fit for the Future' strategy (FFTF), this development paper frames a mixed-methods study examining the strategic and practical implementation of AI, VR/AR and Robotics in a practice-based setting. The study aims to assess the impact of the aforementioned technologies on workflow efficiency, sustainability and clinical decision-making whilst also analysing barriers to organisation-wide, scalable adoption. This paper contributes towards the very foundation of the debate on digital transformation within healthcare, whether it is enough to simply use new technologies within healthcare or whether organisational reconfigurations are needed.

Keywords: Digital Transformation, Artificial Intelligence, Robotics, Virtual Reality, Augmented Reality, Intensive care, Healthcare, United Kingdom.

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Introduction

Intensive Care Units (ICUs) within the NHS represent one of the most physically demanding, intensive and cognitively taxing care environments within the healthcare sector. It is estimated that ICU professionals working within critical illness environments, can be required to digest up to 1300 pieces of information a day (Manor-Shulman et al., 2008). This is also coupled with the fact that Intensivists across the healthcare sector on occasions must make up to 100 decisions a day that can impact the care of just a single patient (McKenzie et al., 2015). Whilst this is expected within high pressure environments, the key discussion point arises when it is considered that 41% of surveyed NHS staff reported high levels of stress and burnout during

2024 (NHS Employers, 2025). This necessitates examination of how sustained stress among ICU professionals can be lowered to increase efficiency and positive patient outcomes. A way in which this may be achieved is by undergoing organisational reconfiguration, through AI and technology implementation.

Although the rise of AI has experienced rapid cross-sector adoption over the past 3-5 years, the healthcare industry particularly in the UK has not adopted the technology or made full use of its potential. AI tools have been available within the NHS, but adoption remains fragmented and has yet to translate into consistent system-wide efficiency gains, this is despite many questioning the efficiency of the NHS as it stands. Warner and Zaranko (2023) from the Institute of Fiscal Studies state that, "the NHS has more funding and more staff than pre-pandemic, but the number of patients being treated in hospital has increased by nowhere near the same amount. On the face of it, that implies that the system has become less productive". Off the back of such statements, further enquiry is needed into how efficiency can be increased, particularly for the purpose of this research, through AI. Based on evidence, it is fair to suggest that machine learning models can predict outcomes more accurately that traditional scoring methods within the NHS. Topol's (2019) deep medicine states that AI can support diagnostic prediction and assist with personalised care plans. Both of which are important within ICU departments especially when taking into the account the cognitive demand and overload upon ICU staff. This highlights a critical gap between the theoretical potential of AI-enabled decision support and its effective integration into NHS ICU and emergency care workflows.

Research Methodology

The study will implement a mixed-methods, practice-based approach within an NHS Intensive Care Unit setting. A practice-focussed research approach will be used to identify the organisational challenges of digital transformation and operational reconfiguration within an intense clinical environment. Quantitative data will be gathered from ICU operational metrics, workload data, and relevant NHS performance indicators to examine workflow efficiency and measurable outcomes. A stepped-wedge design will form a key part of the methodology, allowing AI-enabled interventions to be introduced in stages across different units. This phased rollout will enable comparison between pre- and post-implementation while ensuring that all sites ultimately receive the intervention throughout the data gathering process.

Qualitative data will be collected through semi-structured interviews and observational fieldwork to explore cultural barriers, workforce capability, and implementation obstacles. Thematic analysis will be used to interpret qualitative findings, assess impact, wider transformation opportunities, and barriers to organisational change.

Findings and Discussion

1. Operational Strain and Performance Pressure

Considering the performance pressure on NHS staff and operational strain the organisation has due to demand, Topol (2019) discusses the benefits of AI within healthcare by mentioning the analysis capabilities in reference to X-rays and MRI scans. Notably, waiting times for X-rays and other key diagnostic tests are one of the most regular delays within the NHS as patients can wait up to 6 weeks for test results and feedback. This goes on to cause delays for treatment (NHS England, 2025) meaning that patients are receiving treatment for results that are up to 6 weeks old in which changes in condition can occur. Whilst ICU is of paramount importance to

the NHS, the effective implementation of AI can begin in services where the need for specialist expertise is lower. An example of this is A&E. According to The King's Fund (2024), the NHS regularly fails to meet the 4-hour standard for seeing patients in A&E, with only 72% of patients seen within the benchmark time. Machine learning algorithms such as LightGBM have the capability to forecast department occupancy 24 hours in advance, which could be of significant use to NHS departments during peak seasonal pressures, examples being the winter season when colds, sickness bugs and viruses tend to spread. The NHS currently has access to AI forecasting tools (NHS England, 2025), yet the continued failure to meet targets suggests that barriers such as workforce capability, organisational readiness, and change resistance may limit the translation of digital forecasting into operational performance gains. Workforce capability remains a central factor in digital transformation, aligning with Rogers' Diffusion of Innovation Theory (1962), which remains relevant to contemporary technology implementation.

2. AI within non-clinical processes

Though technology implementation within clinical care has the potential to help the NHS, beyond direct clinical care, AI demonstrates potential within non-clinical and operational processes. Human resources, patient administration and finance are examples of such areas. With NHS budget growth at 2.6% in 2025 (British Medical Association, 2025), closer examination of efficiency is required whilst taking into account that productivity is also very important. Evidence indicates that nurses spend more than 20 hours a week on non-patient facing tasks (Nursing Notes, 2023). These could include producing documentation manually, summarising documentation before administering medication and data entry. Robotic Process Automation (RPA) offers the potential to automate high-volume, rule-based tasks, reducing manual documentation and data transfer processes. Data transfer is particularly relevant considering trust-wide collaboration efforts (NHS Professionals, 2021).

3. Human Resource Sustainability through Robotics

When considering sustainability of the workforce from a physical perspective, physical operations may also benefit from robotics. Disinfection, medication delivery and waste removal have demonstrated practical value within NHS settings (University Hospitals of Derby and Burton NHS Trust, 2020). Mehler-Klamt et al. (2024) found that robot-assisted mobilisation reduced physical workload for nurses within ICU environments. Similarly, Teng et al. (2022) reported positive impacts of robotics within ICU workflows internationally. International evidence suggests that a third of musculoskeletal injuries are disproportionately linked to patient handling roles, a majority of these were suffered by nurses and nursing aides (Pompeii et al, 2009). Robotics can potentially reduce physical strain and free clinicians to focus on complex decision-making tasks, leading to decreased cognitive load which as discussed, is an ongoing problem for clinicians. Alzoubi et al. (2024) found that higher workload and burnout negatively impacted healthcare quality, suggesting that workload reduction may improve performance outcomes resulting in an increase in productivity and not just efficiency.

4. Immersive Technology and Organisational Capability

Moving away from robotics, Virtual Reality (VR) and Augmented Reality (AR) present opportunities to improve training and education within healthcare. The Topol Review (2019) highlighted the potential of immersive technologies to transform education and professional development. Barsom et al. (2016) reinforced this point within surgical settings. VR and AR

offer task-relevant, work-based training environments which may reduce cognitive load when appropriately designed (Makransky and Petersen, 2019). Condino et al. (2018) demonstrated how AR systems enable real-time visualisation within the clinical field of view, supporting task execution. Radianti et al (2020) emphasised that immersive VR is particularly valuable in environments where errors are costly. However, the effectiveness of such technologies depends heavily on instructional design rather than technology alone (Radianti et al, 2020). This reinforces the wider discussion that digital transformation is not solely about technology adoption but about organisational processes and structural reconfiguration (Besson and Rowe, 2012; Warner and Wäger, 2019).

5. Overcoming Barriers and Recommendations

The barriers that are prominent against effective AI and robotics implementation within the NHS are not solely related to technological capability but are more closely related to the readiness of the organisation. This can be for a number of reasons including limited funds to support implementation, culture and staff resistance as well as the need for governance reconfiguration and liability policies.

- The implementation of technology and the strategic reconfiguration of the organisation must be accompanied by training and the development of staff. This is to ensure that staff are capable of using technology to its full potential for the benefit of their role, but also to ensure staff are comfortable with the changes taking place as they do. The latter will go some way to lowering staff resistance.
- Reinforce governance structures laying out responsibility pathways and accountability frameworks before implementation of change. Also conduct trust-wide risk assessments within all departments identifying technical and socio-technical consequences if change is incorrectly implemented.
- It is recommended that implementation and organisational change takes place in incremental phases rather than a large scale overhaul. Policies and procedures must be updated before any change is started but must be open to development and change as obstacles and barriers to large scale adoption are uncovered during the change process.

Conclusion and recommendations

The NHS has the possibility to implement responsible digital transformation within the healthcare sector. To do this, it is not only technological development and deployment in the form of AI, Robotics and immersive technology that will need to take place. Governance clarity, readiness of the organisation and workforce development needs to be addressed, if this can be done, resistance to change from staff will decrease which is also an area to consider.

This paper has given an evidence-based approach to analysing digital transformation within an ICU setting, a clinical setting that will assess the impact of change on cognitive load and operational efficiency. Lessons learned from this setting will be able to be shared organisation-wide whether it be lessons on how repetitive tasks can be made more efficient, or lessons on how high-pressure tasks can be made more manageable through collaboration with technology.

If implemented responsibly and through careful consideration of liability and patient outcomes, digital transformation and organisational reconfiguration can result in clinical efficiency whilst raising productivity and financial sustainability for the long term. A key recommendation is that implementation should be phased before large-scale adoption takes place, it is

recommended that this is done using a stepped-wedge approach. Alongside this approach, Governance, accountability and liability frameworks should be produced to ensure responsible deployment considering high-risk settings.

Finally, future research should analyse scalability across similar high-pressure settings within the NHS, Namely A&E as well as surgical units. Studies should also be conducted comparing trust readiness and analysing variations between trusts that may increase barriers to digital transformation.

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