JURNAL ECONOMINA
e-ISSN: 2963-1181
Volume 5, Number 8, August 2026
Homepage: ejournal.45mataram.ac.id/index.php/economina

Unveiling the Canvas of Collaboration: Exploring Challenges for AI Innovation in Scotland's Healthcare

Karina Dewi Oktaviani[1]
[1]The University of Edinburgh, United Kingdom

**Corresponding Author: karinadewioktaviani@gmail.com*

Article History

Received: 23-07-2026
Revised: 06-08-2026
Published: 30-08-2026

ABSTRACT

The healthcare landscape is undergoing change, driven by a significant shift towards digital health services aimed at improving care efficiency, within the context of heightened healthcare demands and financial constraints. Open Innovation emerges as a pivotal concept, fostering collaboration between healthcare providers and external partners to drive the creation of innovative healthcare products and services. Concurrently, Artificial Intelligence (AI) emerges as a transformative tool, offering potential to reshape disease management and streamline healthcare operations. However, a notable gap exists in comprehending the nuances of AI innovations and their associated challenges, particularly within collaborative innovation frameworks. Employing a qualitative case study design, this study focuses on Scotland's healthcare innovation landscape, utilising semi-structured interviews with the stakeholders. The findings reveal six challenges in collaborative AI innovations: funding, problem definition, human resources, governance, regulation, and data quality and access. The study also presents recommended strategies for stakeholders to enhance the innovation process. Moreover, the research highlights that contest-based collaborations and strategic partnerships offer distinct models with trade-offs relating to expertise and inclusivity, underlining the significance of understanding these challenges for effective collaborative AI innovation in healthcare.

Keywords: Open Innovation, Healthcare, Collaboration, Artificial Intelligence (AI), Challenges

INTRODUCTION

Healthcare systems in developed countries are increasingly required to respond to multiple and often competing pressures. On the one hand, healthcare organisations face substantial environmental and financial constraints, including rising operational costs, limited resources, demographic changes, and growing demands for more sustainable service delivery. On the other hand, they are expected to maintain effective, accessible, safe, and high-quality healthcare services for increasingly diverse patient populations (Bullinger et al., 2012; Keller et al., 2013). These pressures have encouraged healthcare providers and policymakers to

reconsider conventional service-delivery models and explore more innovative approaches. Consequently, healthcare delivery is undergoing a rapid transformation, characterised by a decisive shift from conventional methods towards digitally enabled health services (Kowatsch, 2019). Within this changing environment, Open Innovation has emerged as a relevant strategy for addressing complex contemporary challenges because it enables organisations to move beyond their institutional boundaries and collaborate with external stakeholders in developing new products, technologies, processes, and services (West & Bogers, 2017). In healthcare, such collaboration may involve public healthcare organisations, universities, technology companies, consultants, government agencies, healthcare professionals, patients, and other stakeholders whose resources and expertise can support the development of innovative solutions.

Artificial Intelligence (AI) has become one of the most prominent digital technologies being harnessed to address global healthcare challenges. Its capabilities offer considerable opportunities to transform disease detection, diagnosis, clinical decision-making, treatment planning, patient monitoring, administrative processes, and overall healthcare efficiency (Mehta et al., 2020; Lee & Lee, 2020; Safavi & Kalis, 2019). However, the implementation of AI in healthcare is not a straightforward technological process. The deployment of AI-based systems requires continuous methodological refinement and adaptation to specific organisational, clinical, regulatory, ethical, and social contexts (Petersson et al., 2022). Although expectations regarding the potential contribution of AI to healthcare remain high (Mehta et al., 2019), its capabilities have not yet been fully utilised across healthcare systems (Davenport & Kalakota, 2019; Nigris et al., 2020). Many AI applications remain at the stages of experimentation, research, prototype development, validation, or limited clinical testing, with relatively few being fully integrated into routine clinical practice (Kelly et al., 2019). This situation demonstrates a significant gap between the development of AI technologies and their successful adoption in real-world healthcare settings. It also indicates an incomplete understanding of the challenges affecting AI innovation, particularly in collaborative arrangements where multiple actors must coordinate their knowledge, resources, responsibilities, interests, and expectations.

The development and implementation of AI-based healthcare innovations generally require contributions from multiple organisations because no single institution is likely to possess all the technical, clinical, regulatory, financial, ethical, and operational capabilities necessary to develop and implement a complex AI solution independently. Collaborative open innovation therefore provides an important mechanism through which healthcare organisations can access external knowledge, specialist expertise, technologies, infrastructure, and complementary resources. Collaborative open innovation refers to the process through which organisations strengthen their innovation capabilities by partnering with external entities, including universities, suppliers, consultants, customers, public institutions, and technology developers (Gallaud, 2013). Resource-based and knowledge-based perspectives explain organisational openness as a means of accessing and utilising external resources and complementary knowledge that may not be available internally (Mowery et al., 1996; Teng, 2000). The primary purpose of such collaboration is to obtain partners' knowledge, competencies, technologies, networks, and practical experience (Gallaud, 2013). In AI-driven healthcare innovation, effective collaboration may allow participating organisations to combine complementary expertise, distribute costs and risks, accelerate experimentation,

strengthen clinical relevance, and improve the likelihood that technological solutions will respond to actual healthcare needs.

The growing importance of collaboration is also reflected in the transformation of the healthcare ecosystem from a centralised model of value creation towards a more open, interconnected, and collaborative innovation system (Bessant et al., 2012). One of the main frameworks supporting this transformation is the triple-helix model, which brings together academia, industry, and government. The triple-helix concept, initially developed by Etzkowitz, describes university–industry–government relationships as important drivers of economic growth, technological development, and innovation-policy design (Okuyama et al., 2019). Within this framework, universities generate research, knowledge, and technologies; industry contributes production capabilities, commercial expertise, and technological application; while government provides regulatory direction, institutional stability, and mechanisms that facilitate contractual relationships and exchanges (Etzkowitz, 2003). Although these actors generally share an interest in creating successful innovation, they may simultaneously pursue different institutional priorities, incentives, objectives, and expected outcomes (Dankbaar, 2019). As a result, collaborative innovation may generate tensions relating to communication, trust, decision-making, governance, accountability, data sharing, intellectual property, resource allocation, organisational culture, and the ownership of innovation outcomes. These challenges are particularly important in healthcare, where innovation processes must accommodate strict clinical standards, patient-safety requirements, data-protection obligations, and complex organisational structures (Kelly & Young, 2017; Kievit et al., 2018).

Scotland provides a relevant setting in which to examine these issues because it has demonstrated a proactive commitment to harnessing the potential of AI through a national strategy designed to achieve wider social and economic outcomes through collaboration (Digital Scotland, 2021). Initiatives such as the Scottish AI Alliance, the Scottish AI Playbook, and the Industrial Centre for Artificial Intelligence Research in Digital Diagnostics (iCAIRD) demonstrate Scotland's commitment to fostering AI innovation through partnerships among academia, the National Health Service, government, and industry. These initiatives have created opportunities for researchers, clinicians, technology developers, policymakers, and commercial organisations to jointly develop and evaluate AI-based healthcare solutions. Nevertheless, substantial challenges remain. Although several commercial AI systems are being evaluated in NHS environments, most AI applications remain within research, development, validation, or trial stages rather than being routinely adopted in clinical practice (NHSX, 2019; NICE, 2020; Ibex Medical Analytics, 2020). The limited transition from research and testing into routine implementation highlights the need to understand not only the technical performance of AI systems but also the organisational and collaborative conditions that influence their adoption.

Healthcare systems potentially possess a favourable environment for AI development because they combine data-intensive processes, large volumes of clinical information, specialist medical knowledge, and growing access to advanced digital technologies (Jiang et al., 2017). However, these advantages do not automatically lead to successful AI implementation. Fragmented datasets, inconsistent data quality, limited interoperability, privacy and security concerns, complex regulatory requirements, and unclear accountability arrangements continue to constrain the adoption of AI in healthcare (Petersson et al., 2022;

Panesar, 2019). Furthermore, healthcare digitalisation and AI adoption continue to lag behind those of several other sectors, despite the potentially transformative value of these technologies (Laurenza et al., 2018). Existing studies have frequently examined the technological, ethical, regulatory, or clinical dimensions of healthcare AI separately. Comparatively less attention has been devoted to understanding how these issues interact within collaborative innovation processes involving organisations with different interests, professional cultures, operational procedures, and institutional responsibilities. This gap is important because even technically effective AI systems may fail to progress towards routine clinical use when collaboration, governance, resource coordination, and stakeholder alignment are inadequately managed.

The motivation for this study originated from the author's direct involvement in a management consultancy project examining a co-innovation production model in healthcare based on a triple-helix open innovation framework. Through this professional experience, the author observed both the considerable potential of AI in healthcare and the complexity of transforming an innovative technological concept into a solution that can be safely, effectively, and sustainably adopted. Accordingly, this study seeks to investigate the key challenges encountered during the development and implementation of AI-driven healthcare innovations within Scotland's healthcare system, particularly when these innovations are created through partnerships involving healthcare organisations, academia, government, and industry. Using a qualitative case-study methodology, the research is guided by the following primary question: "What are the key challenges that arise from collaborative innovation in AI-driven healthcare innovations, and how can organisations effectively address and overcome these challenges?" To answer this question, the study has three interrelated objectives: to identify the principal challenges arising from collaborative efforts in AI-driven healthcare innovation; to analyse how these challenges influence the AI innovation process, including development, validation, adoption, implementation, and clinical integration; and to propose effective strategies for addressing and mitigating the identified challenges. By examining technological barriers alongside organisational and interinstitutional relationships, the study aims to provide practical and theoretical insights into the conditions required for effective, ethical, and sustainable AI-driven healthcare innovation.

RESEARCH METHODS

Based on the gap in understanding challenges in collaborative innovation for AI deployment in healthcare, a qualitative case study research design was employed in this study. This study takes an inductive view by trying to generate theories from the research (Bryman and Bell, 2019). A single-case study with embedded units was chosen as it allows the researcher to look at the subunits within the larger case (Yin, 2003). As healthcare stakeholders are conducting collaborations of different types, conducting a case study with embedded units allows for exploring the research question within case analyses, between case analyses, and cross-case analyses (Yin, 2003). The case study is about AI innovation within Scotland's healthcare with embedded two units of analysis on challenge-based and partnership-based innovation.

This study uses an interpretivist epistemological position as described by Bryman and Bell (2019) as "the stress is on the understanding of the social world through an examination of the interpretation of that world by participants". The ontological position taken for this

study is constructionist, thinking of social properties as the outcomes of the interactions between individuals rather than as a phenomenon separate from those involved in their construction (Bryman and Bell, 2019).

Data were collected through interviews, documentation, and archival records. Primary data was collected through semi-structured interviews with triple-helix actors in the healthcare ecosystem. The semi-structured interview was chosen for this study as it allows the researcher to discuss topics other than the initial list if needed, allowing new questions to emerge in the process (Myers, 2020). The interviews were conducted 30-45 minutes online and face-to-face using Ms Team. Sampling was done through purposeful sampling and snowballing sampling.

All respondents must fit the criteria below to answer the research question: 1. have been involved/are involved in a collaborative environment in AI innovation. 2. the AI innovation is/was in the healthcare sector. 3. the innovative collaboration was/is conducted in Scotland.

Data were analysed using thematic analysis that identifies data through patterns of themes within data (Maguire & Delahunt, 2017). Thematic analysis was chosen as it is flexible and can be used to analyse a wide range of qualitative data (Bryman & Bell, 2019). After transcribing the interview data, these key themes were noted and thematically coded on an Excel sheet to corroborate the main findings. These key themes were divided into six key challenges of healthcare AI innovations: funding, problem definition, human resources, governance, data quality and access, and regulation.

This study is ethically approved through the University of Edinburgh level two CAHSS application. Pseudonyms were used with no identifiable personal data to maintain privacy and anonymity throughout the research process.

RESULTS AND DISCUSSION

1. Forms of Collaborative Innovation in Scotland's Healthcare Sector

The results show that healthcare providers in Scotland are strongly committed to harnessing the potential of Artificial Intelligence (AI) to improve diagnostic processes, accelerate patient treatment, and enhance the quality and efficiency of healthcare services. Respondent 3A described these collaborative arrangements as mechanisms that bring together academia, industry, and healthcare providers, particularly the National Health Service (NHS), to achieve shared healthcare innovation objectives. Despite pursuing a common objective, each actor contributes different resources, competencies, and institutional interests. Consequently, the structure of collaboration influences how healthcare problems are defined, how resources are allocated, how decisions are made, and how AI innovations progress from development to clinical implementation.

Two principal forms of collaborative AI innovation were identified: contest-based collaboration and strategic partnership collaboration. These models differ in terms of their objectives, funding arrangements, duration, scope of activities, stakeholder composition, and governance structures. Contest-based collaboration generally provides an open mechanism through which several companies can propose solutions to a defined healthcare challenge. Strategic partnerships, by contrast, involve more selective and long-term relationships among healthcare providers, academic institutions, and technology companies.

a. Contest-Based Collaboration

Contest-based collaboration in Scotland's healthcare sector is primarily implemented through the Small Business Research Initiative (SBRI). SBRI is a competition-based programme that invites small and medium-sized enterprises to propose innovative ideas and technologies in response to specific challenges identified by NHS organisations (SBRI Healthcare, n.d.). This approach enables healthcare providers to explore and compare several potential solutions before proceeding to commercial procurement.

Respondent 2B explained that SBRI aims to "build out the functional, technical, and clinical requirements required for particular services" and operates through "pre-commercial procurement." This finding indicates that contest-based collaboration is not intended to result immediately in the purchase of a particular product. Instead, it enables healthcare providers to evaluate the clinical relevance, technical feasibility, and potential value of proposed solutions while retaining the freedom to select the product that offers the greatest value for healthcare delivery.

According to Respondent 1A, SBRI collaboration is generally conducted in three phases. Phase 1 focuses on discovery, during which participating companies investigate the healthcare problem and its organisational context. Phase 2 involves the development and evaluation of prototypes. Phase 3 focuses on real-world testing and implementation. This phased approach enables healthcare problems to be gradually translated into technically viable and clinically relevant AI solutions.

b. Strategic Partnership Collaboration

Strategic partnership collaboration generally develops through longer-term relationships between healthcare providers, academic institutions, and technology companies. Respondent 3A described this process as "identifying stakeholders and systems that have similar problems but also opportunities." From the perspective of technology companies, partnership formation therefore involves identifying organisations capable of supporting the development, validation, adoption, and implementation of their technological vision.

Respondent 2B described the partnership process as follows:

> "How do you build those collaborations through network opportunities, being able to define and describe what's currently happening and be able to pull partners in to iterate and refine what's been done already."

This statement shows that strategic partnerships are developed through professional networks, shared problem identification, and the continuous refinement of existing ideas or technologies. Unlike contest-based collaboration, which begins with an openly announced healthcare challenge, strategic partnerships are more likely to emerge through established relationships and the identification of complementary institutional interests.

The principal differences between the two forms of collaboration are presented in Table 1.

Dimension	Contest-Based Collaboration	Strategic Partnership Collaboration
Aims	To develop the functional, technical, and clinical requirements needed for specific healthcare services	To generate research and outputs that support the adoption of AI innovations
Stage	Pre-commercial procurement	Product development for commercial purposes
Scope of	Technical feasibility studies, prototype	Co-design, clinical investigation, and the

activities	development and evaluation, and opportunities for real-world testing	development of technically viable and clinically explainable products
Funding	250,000–500,000	More than 1,000,000
Time	Several months to several years	Several years
Stakeholders	SMEs, healthcare providers, and academia or healthcare professionals	Start-ups or established companies, healthcare providers, and academia or healthcare professionals

Table 1. Differences Between Contest-Based Collaboration and Strategic Partnership Collaboration

The comparison shows that contest-based collaboration is generally narrower in scope, more competition-oriented, and focused on technical feasibility and prototype development. Strategic partnerships involve higher funding, longer timescales, selected organisational relationships, and more extensive clinical investigation and product-development activities.

These differences may be understood through the openness of innovation networks. Pisano and Verganti (2008) argue that collaboration networks differ according to whether participation is open or restricted. Open collaboration is appropriate when the difference between the best and average solutions is relatively limited and when the consequences of failing to identify an exceptional solution are comparatively minor. In contrast, closed collaboration may be more appropriate for complex problems that require specialised expertise, sustained interaction, and extensive and costly evaluation (Pisano & Verganti, 2008).

Accordingly, neither collaboration model is universally superior. Contest-based collaboration can generate a wider range of ideas and provide opportunities for SMEs, whereas strategic partnerships can support deeper stakeholder engagement, organisational continuity, clinical validation, and long-term product refinement. The suitability of each model depends on the complexity of the healthcare problem, the maturity of the technology, the level of clinical engagement required, and the availability of financial and organisational resources.

2. Key Challenges in Collaborative AI Innovation

The results identify six major challenges affecting collaborative AI innovation in Scotland's healthcare sector: funding constraints, vague problem definition, limited human resources, fragmented governance, difficulties related to data quality and access, and regulatory uncertainty.

Challenge	Description	Respondents
Funding	Insufficient funding to support AI development and healthcare staff participation	1A, 2A, 2B, 3A
Problem definition	Vague or overly broad healthcare problem statements	3C
Human resources	Limited knowledge and competencies and insufficient clinician engagement time	1A, 2A, 2B, 3A, 3B
Governance	Unclear and fragmented innovation pathways	2A, 2B, 3A, 3B
Data quality and access	Slow and time-consuming processes for accessing appropriate healthcare data	1A, 2A, 2B, 3A, 3B
Regulation	Unclear requirements for implementing AI products in healthcare	3A

Table 2. Key Challenges of Collaborative AI Innovation in Scotland's Healthcare Sector

a. Funding Constraints

Funding emerged as one of the most prominent challenges in AI innovation. Four of the six respondents identified financial limitations that affected not only technological development but also the ability of healthcare organisations to allocate staff and resources to collaborative activities.

Respondent 1A explained that funding in contest-based collaboration was insufficient to cover the cost of backfilling healthcare employees who needed to dedicate additional time to communicating with AI companies. Respondent 2A similarly emphasised the importance of prioritising and ring-fencing funds specifically for healthcare providers participating in innovation projects.

Respondent 3A highlighted differences between the financial and administrative requirements of contest-based and strategic collaborations:

"SBRI (contest-based collaboration) is a very small company focused, therefore it's relatively not too burdensome in terms of what you [the AI company] need to provide. I think the academic type of research funding (strategic partnership) is very burdensome and therefore you've got to provide a lot of detail and evidence."

This finding indicates that SBRI funding may be relatively accessible to small companies but may not provide sufficient resources to support the full participation of healthcare organisations. In contrast, strategic partnership funding may offer greater financial support but usually requires more extensive documentation, evidence, and administrative work.

The findings are consistent with the Cooksey Review of UK Health Research Funding, which raised concerns regarding the effectiveness of ring-fencing research funds and the potential reduction of support for basic science because of an emphasis on applied research (Cooksey, 2006). In healthcare AI innovation, funding mechanisms must therefore balance technological development, academic research, commercialisation, and the operational capacity of healthcare organisations.

Addressing this challenge requires streamlined funding mechanisms, dedicated budgets for healthcare-provider participation, and clearer guidance regarding available innovation pathways. Healthcare innovation teams may also explore programmes such as the National Institute for Health Research Invention for Innovation programme, the NHS Innovation Accelerator, the Clinical Entrepreneur Programme, and Innovate UK funding schemes (Arora et al., 2021).

Nevertheless, the availability of multiple funding sources alone may not resolve the problem. Funding arrangements must also provide protected time for clinicians and other healthcare employees to engage in problem definition, co-design, testing, validation, and evaluation. Without sufficient clinical participation, AI solutions may lack relevance to actual healthcare needs.

b. Problem Definition and Resource Allocation

The results demonstrate that accurately defining a healthcare problem is a critical stage of the AI innovation process. A vague or overly broad problem statement can create uncertainty regarding the intended users, clinical objectives, technological specifications, expected outcomes, and context of implementation. Respondent 1A described the use of the Double Diamond approach in contest-based collaboration:

> "It was very much around the application of the double diamond and the real opportunity for discovery of the companies to find out then in more detail what the problem to be solved is. And with that, the potential resources that could be drawn upon to assist them in developing their prototype solution."

The discovery phase therefore provides companies with an opportunity to engage with healthcare professionals, investigate the healthcare problem, and identify the resources needed to develop an appropriate prototype. However, the results show that AI companies may begin projects without sufficient knowledge of NHS systems and clinical practices. Respondent 3B explained:

> "We [the AI company] also end up designing systems where we're pitching an idea, although the co-design allows you to reduce the risk to some extent, we [the AI company] don't have access to understand how doable these things are on the NHS [healthcare provider] side. But certainly, in the initial stages, I didn't have as much idea."

This statement indicates that co-design can reduce uncertainty, but only when technology developers have adequate access to healthcare professionals and organisational information. Without this access, companies may design technologically advanced products that cannot be easily implemented within NHS systems. Respondent 3C highlighted the risks associated with an unclear problem statement:

> "Because they're spending a lot of money on multiple firms innovating on a problem, and if they come in with a vague or broad problem statement then the risk is that the people who are coming in to solve the problem, who don't have the domain knowledge, they're going to spend a lot of time trying to understand the problem in the space."

This finding supports Piller and West's (2014) argument that problems presented through collaborative innovation contests must be described precisely and in a way that can be understood by participants from different knowledge domains. In the context of healthcare AI, clearly defining the problem can reduce uncertainty, prevent the inefficient use of funding, and improve the alignment between technological solutions and clinical needs.

c. Human Resources and Stakeholder Competencies

Human resources represent another significant challenge in collaborative AI innovation. The results identify two related issues: limited knowledge and competencies among participating stakeholders and insufficient time for healthcare professionals to engage with technology companies.

Respondent 2A stated that SMEs face a comparatively high risk of failure because they may lack a proven track record and have limited experience working with healthcare data, NHS procedures, or clinical settings. At the same time, healthcare professionals possess clinical expertise but may not have the technical capacity to independently develop AI products.

Respondent 2B explained:

> "As a clinician scientist, our ability to build AI to the specification and requirements that are required to deliver it into the NHS is incredibly limited. Therefore, you need to be able to build a company or work with a company that can build products in this sort of area."

The finding illustrates the complementary nature of collaborative innovation. Clinicians contribute clinical knowledge and an understanding of healthcare requirements, whereas technology companies provide software-development capabilities, engineering expertise, and product-development experience. Nevertheless, healthcare providers also face substantial staffing pressures. Respondent 2A stated that "there is a massive problem with staffing in the health service." These shortages limit the capacity of healthcare professionals to participate consistently in innovation activities.

Respondent 1A described the burden created when several companies simultaneously required access to healthcare staff:

> "When you're dealing with five companies who are all wanting quite a lot of time with our staff and that was a big strain on the staff. Consequently, it impacted the likelihood of success, with the staff spreading themselves thinly to meet the enquiries from five different companies."

This result indicates that contest-based collaboration can create an unintended duplication of work because several participating companies request similar information, explanations, and feedback from the same healthcare employees. When staff members must distribute their time across multiple projects, the depth and quality of engagement may decrease.

The Scottish Government has attempted to address gaps in the digital competencies required to support AI innovation through the Digital Economy Skills Action Plan launched in March 2023 (Skills Development Scotland, 2023). However, skills development must be supported by sufficient staffing, protected clinician time, cross-disciplinary communication, and mechanisms that allow healthcare professionals and technology developers to collaborate effectively.

d. Governance and Innovation Pathways

Governance was identified as a major challenge by four of the six respondents. Although Scotland's healthcare system has made considerable efforts to support innovation and experimentation, the findings indicate an absence of clearly established pathways through which successful AI innovations can be adopted, procured, implemented, and scaled.

Respondent 3B highlighted the complexity of healthcare governance:

> "And challenges are generally in the healthcare sector, the clinical pathways are very complex and technical system integration is complex. Different health boards have their own procedures. There's a lot of risk aversion, so they don't like to take risks even in the innovation department, and it's very heavy on governance."

This statement demonstrates that governance difficulties result from complex clinical pathways, technical-integration requirements, differences between health-board procedures, and organisational risk aversion. Consequently, an AI product successfully tested within one health board may still face substantial barriers when introduced into another.

Respondent 3A similarly observed:

> "There are no real clear, established pathways that, if their innovation is proven successful, show how that is adopted and scaled. It's still very difficult, particularly the procurement rules for the adoption of innovation."

The result indicates that demonstrating the technical or clinical effectiveness of an AI product does not automatically lead to its implementation. Innovators must continue to

navigate procurement procedures, governance requirements, system integration, accountability, and risk-management processes. Arora et al. (2021) propose the establishment of a clearly identifiable "front door" that can help innovators navigate overlapping and fragmented innovation pathways. In Scotland, such a mechanism could provide coordinated guidance concerning funding, evaluation, data access, technical integration, regulation, procurement, adoption, and scaling. Effective governance should therefore not simply involve adding more administrative controls. It should provide a transparent, proportionate, and coordinated pathway that enables responsible innovation while maintaining patient safety and institutional accountability.

e. Data Quality and Access

The results demonstrate that high-quality data and appropriate data access are fundamental to the development, training, validation, and evaluation of AI technologies. However, external companies often face lengthy and complex procedures when attempting to access healthcare data.

Respondent 2A stated:

> "The problem is, if you're an external company wanting to come and access data, the safeguards weren't in place."

This finding indicates that restricted data access is not necessarily caused by an unwillingness to collaborate. It also results from inadequate infrastructure and safeguards for providing technology companies with secure and ethical access to patient information.

The consequences of these limitations were illustrated by the SBRI project concerning multimorbidity in acute care, which was paused for two years because of delays in establishing safe data-access arrangements. This case demonstrates that AI projects may be significantly delayed even when technological expertise, collaborative partners, and funding are available.

The Scottish Government responded to these challenges by establishing Research Data Scotland in 2021 to support collaborative data-driven research and innovation. In 2022, it also introduced the Value of Data Programme to strengthen data-management practices. These initiatives represent important steps towards improving healthcare data infrastructure. However, their practical value depends on whether they can facilitate timely data access while maintaining privacy, security, ethical standards, and public trust.

f. AI Regulation

Regulatory uncertainty was identified as a challenge affecting both contest-based collaboration and strategic partnerships. Organisations developing AI healthcare products remain uncertain about the regulatory requirements that must be fulfilled before their technologies can be implemented in clinical practice.

Respondent 3A stated:

> "I would say regulation, especially in AI, is a challenging area. So, I would say the regulations in the UK and potentially Europe and globally as well are still a little bit behind the state of the art in terms of AI implementation."

This finding reflects a perceived gap between the rapid development of AI technologies and the ability of regulatory frameworks to respond to emerging applications. The results also indicate that Scotland currently lacks AI-specific internal healthcare policies and guidelines. This absence may create uncertainty regarding validation, accountability,

data governance, performance monitoring, and the conditions under which AI products can be used in healthcare services.

Regulatory uncertainty is closely related to governance and organisational risk aversion. Healthcare providers may be reluctant to adopt innovative technologies when accountability structures and implementation standards are unclear. Therefore, the development of AI-specific guidance is necessary to clarify responsibilities, validation standards, data requirements, risk-management processes, and post-implementation monitoring.

Overall, the results show that collaborative AI innovation in Scotland's healthcare sector is affected by interconnected financial, organisational, technological, regulatory, and human-resource challenges. Funding limitations reduce the capacity of healthcare professionals to participate in innovation activities. Inadequate stakeholder engagement can lead to vague problem definitions and poorly aligned technological solutions. Fragmented governance and regulatory uncertainty impede adoption and scaling, while insufficient data infrastructure delays development and validation.

These findings demonstrate that successful AI innovation cannot be achieved solely through technological advancement. It requires an integrated innovation pathway that aligns technological capabilities with healthcare priorities, clinical expertise, organisational resources, ethical data access, regulatory expectations, and clearly defined implementation mechanisms. Contest-based collaboration and strategic partnerships can both contribute to AI innovation, but their effectiveness depends on whether their structures are appropriate for the complexity and maturity of the healthcare challenge being addressed.

CONCLUSION AND SUGGESTIONS

This study concludes that collaborative innovation in Artificial Intelligence within Scotland's healthcare sector is influenced by interconnected financial, organisational, technological, regulatory, and human-resource challenges. Funding was identified as a major factor affecting the feasibility, continuity, and progress of AI projects, particularly because healthcare organisations often lack sufficient resources to provide protected staff time and operational support for collaborative activities. Clear problem definition is equally important, as vague or overly broad problem statements may lead to inefficient resource allocation, prolonged development processes, and AI solutions that are insufficiently aligned with actual clinical needs. Governance and regulation also emerged as significant and interrelated challenges because the absence of clear innovation pathways creates uncertainty regarding how successful AI products can be validated, procured, adopted, implemented, and scaled. In addition, the quality and accessibility of healthcare data remain essential to AI development, training, and validation, although fragmented datasets, slow access procedures, and inadequate safeguards may substantially delay innovation.

The findings also reveal important differences between contest-based collaboration and strategic partnership collaboration. Contest-based collaboration, such as that conducted through SBRI, generally focuses on pre-commercial procurement, technical feasibility, and rapid prototype development involving several competing organisations. Strategic partnerships, by contrast, tend to involve longer-term relationships, greater funding, deeper stakeholder engagement, more extensive clinical investigations, and product development for potential commercial adoption. Neither collaboration model is inherently superior because its

effectiveness depends on the complexity of the healthcare problem, the maturity of the technology, the required level of clinical involvement, and the availability of financial and organisational resources. Therefore, healthcare providers and policymakers should select the collaboration model according to the characteristics of the innovation project, provide dedicated funding for both technology developers and healthcare organisations, define healthcare problems through structured discovery and co-design, and establish a coordinated innovation pathway that offers clear guidance on funding, data access, ethical approval, regulation, procurement, implementation, and scaling. Clearer AI-specific policies are also needed to address validation, accountability, patient safety, data protection, risk management, transparency, and post-implementation monitoring.

This study nevertheless has several limitations. Data collection was conducted during the summer period, when several important stakeholders were unavailable, resulting in a limited number of interview participants and a narrower range of perspectives. Government representatives were also absent from the interviews, requiring the study to rely on publicly available information to examine governmental initiatives and strategies related to AI innovation. Future research should therefore involve a larger and more diverse group of participants, including representatives from government, healthcare boards, regulatory bodies, funding organisations, academic institutions, technology companies, healthcare professionals, and patients. Further studies should also examine the complete AI innovation pathway, from problem identification and product development to validation, procurement, clinical implementation, scaling, and post-implementation evaluation. Comparative research across different health boards, collaboration models, and AI applications would provide a more comprehensive and credible understanding of the conditions required for effective, ethical, and sustainable AI innovation in Scotland’s healthcare system.

REFERENCE

Arora, A., Bayrak, N., & Langley, J. (2021). AI in the UK healthcare system: Governing collaboration to harness the technology's potential. Technological Forecasting and Social Change, 167, 120693.

Barnett, J., Vasileiou, K., Djemil, F., Brooks, L., & Young, T. (2011). Understanding innovators' experiences of barriers and facilitators in implementation and diffusion of healthcare service innovations: A qualitative study. BMC Health Services Research, 11, 342.

Bessant, J., Moeslein, K., & Kunne, C. (2012). Opening up healthcare innovation: Innovation solutions for a 21st century healthcare system. AIM Advanced Institute of Management Research.

Bryman, A., & Bell, E. (2019). Business research methods (5th ed.). Oxford University Press.

Bullinger, A. C., Rass, M., Adamczyk, S., Moeslein, K. M., & Sohn, S. (2012). Open innovation in health care: Analysis of an open health platform. Health Policy, 105(2-3), 165-175.

Cooksey, D. (2006). A review of UK health research funding. HM Treasury.

Dankbaar, B. (2019). Design rules for 'triple helix' organizations. Technology Innovation Management Review, 9(11), 54-63.

Das, T. K., & Teng, B. S. (2000). A resource-based theory of strategic alliances. Journal of Management, 26(1), 31-61.

Davenport, T. H., & Kalakota, R. (2019). The potential for artificial intelligence in healthcare. Future Healthcare Journal, 6(2), 94-98.

Digital Scotland. (2021). Scotland's AI strategy: Public engagement report.

Etzkowitz, H. (2003). Triple helix: A manifesto for innovation, incubation and growth. SNS Press.

Gallaud, D. (2013). Collaboration in open innovation practices: How different actors engage in the journey of discovering and developing ideas. R&D Management, 43(5), 440-457.

Ibex Medical Analytics. (2020). Ibex Medical Analytics wins UK award to accelerate adoption of AI powered cancer detection in the NHS.

Jiang, F., Jiang, Y., Zhi, H., Dong, Y., Li, H., Ma, S., Wang, Y., Dong, Q., Shen, H., & Wang, Y. (2017). Artificial intelligence in healthcare: Past, present and future. Stroke and Vascular Neurology, 2(4), 230-243.

Keller, C., Edenius, M., & Lindblad, S. (2013). Open service innovation in health care: What can we learn from open innovation communities? In Managing Open Innovation Technologies (pp. 239-251). Springer.

Kelly, C. J., Karthikesalingam, A., Suleyman, M., Corrado, G., & King, D. (2019). Key challenges for delivering clinical impact with artificial intelligence. BMC Medicine, 17(1), 1-9.

Kelly, C. J., & Young, A. J. (2017). Promoting innovation in healthcare. Future Healthcare Journal, 4(2), 121-125.

Kievit, P. J., Oomes, J., Schoorl, M., & Bartels, P. (2018). The missing link: Toward an assessment of innovation capacity in health care organizations. International Journal of Quality Innovation, 4(1), 1-18.

Kowatsch, T., Otto, L., Harperink, S., Cotti, A., & Schlieter, H. (2019). A design and evaluation framework for digital health interventions. IT - Information Technology, 61(5-6), 253-263.

Laurenza, D., et al. (2018). The effect of digital technologies adoption in healthcare industry: A case based analysis. Business Process Management Journal.

Lee, S. M., & Lee, D. (2020). Healthcare wearable devices: An analysis of key factors for continuous use intention. Service Business, 14(4), 503-531.

Maguire, M., & Delahunt, B. (2017). Doing a thematic analysis: A practical, step-by-step guide for learning and teaching scholars. All Ireland Journal of Higher Education, 9(3), 3351-33514.

Mehta, M. C., Katz, I. T., & Jha, A. K. (2020). Transforming global health with AI. The New England Journal of Medicine, 382(9), 791-793.

Mowery, D. C., Oxley, J. E., & Silverman, B. S. (1996). Strategic alliances and interfirm knowledge transfer. Strategic Management Journal, 17(S2), 77-91.

Myers, M. D. (2020). Qualitative research in business and management. Sage Publications.

NHSX. (2019). Artificial intelligence: How to get it right. NHS England.

NICE (National Institute for Health and Care Excellence). (2020). Innovative technology to detect abnormal heart rhythms recommended by NICE for NHS use while further data is collected.

Nigris, S. de, Gomez-Gonzalez, E., Gomez, E., Martens, B., Iglesias Portela, M., Vespe, M., et al. (2020). Artificial intelligence and digital transformation: Early lessons from the COVID-19 crisis. Publications Office of the European Union.

Okuyama, J. H. H., Galvao, T. F., Crozatti, M. T. L., & Silva, M. T. (2019). Health professionals' perception of patient safety culture in a university hospital in Sao Paulo: A cross-sectional study applying the Hospital Survey on Patient Safety Culture. Sao Paulo Medical Journal, 137(3), 216-222.

Panesar, A. S. (2019). Machine learning and AI for healthcare. Apress.

Petersson, L., Larsson, I., Nygren, J. M., Nilsen, P., Neher, M., Reed, J. E., Tyskbo, D., & Svedberg, P. (2022). Challenges to implementing artificial intelligence in healthcare: A qualitative interview study with healthcare leaders in Sweden. BMC Health Services Research, 22(1), 1-16.

Piller, F. T., & West, J. (2014). Firms, users, and innovation: An interactive model of coupled open innovation. Research Policy, 43(3), 578-592.

Pisano, G., & Verganti, R. (2008). Which kind of collaboration is right for you? Harvard Business Review, 86(12), 78-86.

Safavi, K., & Kalis, B. (2019). How AI can change the future of health care. Harvard Business Review.

Skills Development Scotland. (2023). Digital economy skills action plan.

West, J., & Bogers, M. (2017). Open innovation: Current status and research opportunities. Innovation: Organization & Management, 19(1), 43-50.

Yin, R. K. (2003). Case study research: Design and methods (3rd ed.). Sage Publications.